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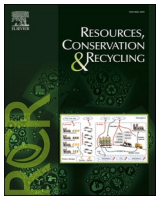

Review

Conceptualizing the Circular Economy (Revisited): An Analysis of 221 Definitions

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ABSTRACT

In the past decade, use of the circular economy (CE) concept by scholars and practitioners has grown steadily. In a 2017 article, Kirchherr et al. found that the CE concept is interpreted and implemented in a variety of ways. While multiple interpretations of CE can enrich scholarly perspectives, differentiation and fragmentation can also impede consolidation of the concept. Some scholarship has discussed these trends in context-specific cases, but no large-scale, systematic study has analysed whether such consolidation has taken place across the field. This article fills this gap by analysing 221 recent CE definitions, making several notable findings. First, the concept has seen both consolidation and differentiation in the past five years. Second, definitional trends are emerging that potentially have more meaning for scholarship than for practice. Third, scholars increasingly recommend a fundamental systemic shift to enable CE, particularly within supply chains. Fourth, sustainable development is frequently considered the principal aim of CE, but questions linger about whether CE can mutually support environmental sustainability and economic development. Finally, recent studies argue that CE transition relies on a broad alliance of stakeholders, including producers, consumers, policymakers, and scholars. This study contributes an updated systematic analysis of CE definitions and conceptualizations that serves as an empirical snapshot of current scholarly thinking. It thereby provides a basis for further research on whether conceptual consolidation is needed and how it can be facilitated for practical purposes.

1. Introduction

The circular economy (CE) concept continues to interest both scholars and practitioners (Kirchherr, 2021; Köhler et al., 2019; Vecchio et al., 2022). A Scopus query in late 2021 returned more than 13,000 documents containing the term 'circular economy' – 7800 (ca. 60 percent) appeared in 2020 or 2021. Meanwhile, numerous large-scale CE policy efforts have been launched (e.g., in the European Union (EU) and China; Hartley et al., 2020; Milios, 2021), and the private sector – from large corporations to start-ups – are experimenting with the concept (Aminoff & Pihlajamaa, 2020; Brown et al., 2021; Henry et al., 2020). A broad alliance of stakeholders seems committed to fostering CE transition, even as the challenge of this transition remains formidable (the most recent *Circularity Gap Report* finds that the world is currently only 8.6 percent circular (Circle Economy, 2021)).

As CE grows in popularity, its interpretation and implementation by numerous actors can obscure and fragment its conceptualization. Indeed, a systematic analysis by Kirchherr et al. (2017) found 95 different CE definitions. Numerous scholarly efforts have investigated the prospects of a consensus conceptualization of CE (Merli et al., 2018; Nobre & Tavares, 2021; Prieto-Sandoval et al., 2018). However, no study since Kirchherr et al. (2017) was published has systemically analysed whether such a consensus has been forged. This is the gap that the new study seeks to fill. According to Kirchherr et al. (2017, p. 228), "knowledge accumulation regarding the CE is difficult if scholar A conceptualizes the 'how-to' of CE as recycling, while scholar B considers

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Table 1
Reviews of the CE concept (*carried over from Kirchherr et al. (2017)).

#	Study	Focus
1*	Ghisellini et al. (2016)	Summary of 155 CE studies
2*	Lewandowski (2016)	Conceptualization of circular business models
3*	Lieder and Rashid (2016)	Summary of CE literature on manufacturing
4*	Sauvé et al. (2016)	Comparison of CE, sustainable development, environmental sciences
5*	Blomsma and Brennan (2017)	Tracing emergence of CE concept
6*	Geissdoerfer et al. (2017)	Comparison of CE concept and sustainability
7*	Murray et al. (2017)	Comparison of CE concept and sustainable business
8	Kirchherr et al. (2017)	Analysis of 114 definitions of CE
9	Geisendorf and Pietrulla (2018)	Comparison of CE and related concepts (e.g., cradle-to-cradle, blue economy, regenerative design)
10	Kalmykova et al. (2018)	Review of theoretical approaches, strategies, and implementation cases of CE
11	Lahti et al. (2018)	Review of main theories related to CE
12	Merli et al. (2018)	Analysis of scholarly approaches to CE through examination of 565 studies
13	Helander et al. (2019)	Review of CE indicators for environmental pressures
14	Lüdeke-Freund et al. (2019)	Review of CE business model patterns observed through 26 studies
15	Millar et al. (2019)	Review of studies examining conceptual link between CE and sustainable development
16	Saidani et al. (2019)	Review and classification of 55 sets of CE indicators
17	Awan et al. (2020)	Analysis of 26 CE definitions
18	Friant et al. (2020)	Review of 72 CE concepts and narratives
19	Roos Lindgreen et al. (2020)	Review of 74 micro-level academic assessment approaches to CE
20	Rosa et al. (2020)	Review of connections between CE concept and Industry 4.0 concept
21	Alhawari et al. (2021)	Review of CE definitions across 91 studies
22	Arruda et al. (2021)	Review of CE perspectives and perspectives from articles published between 2015 and 2020
23	De Pascale et al. (2021)	Review of 61 CE measurement indicators across 137 studies
24	Goyal et al. (2021)	Derivation of conceptual framework for CE from 33 top-cited articles
25	Henry et al. (2021)	Review of connections between CE concept and sharing economy concept
26	Tavera Romero et al. (2021)	Review of connections between CE concept and Industry 4.0 concept
27	Alcalde-Calonge et al. (2022)	Review of evolution of CE research from its origins
28	Anaruma et al. (2022)	Review of evolution of CE research in 21st Century
29	Castro et al. (2022)	Review of definitions concerning CE rebound
30	Corvellec et al. (2022)	Review of critiques of CE
31	Khan et al. (2022)	Review of 91 studies concerning CE transition
32	Kuzma et al. (2022)	Review of 125 articles concerning CE indicators with respect to innovation
33	Dzhengiz et al. (2023)	Critical review of assumptions underlying CE concept

Source: Compilation of author team

the 'how-to' as reducing, reusing and recycling." Accordingly, a concept with multiple fragmented and often contested understandings may experience conceptual deadlock and eventual collapse (Blomsma & Brennan, 2017; Dahlsrud, 2008). Examples are the concepts of social entrepreneurship, corporate social responsibility (CSR), 'smartness' and smart cities, and even sustainability itself – all of which have arguably suffered to some degree from conceptual contestation and resulting ambiguity (see Dahlsrud, 2008; Zahra et al., 2009).

By canvassing literature proposing definitions of CE, this study provides an empirical snapshot of current scholarly understandings about CE and thereby aims to provide a basis for further research on whether conceptual consolidation is needed and how it can be facilitated for practical purposes. Hence, the research question answered in this study is: "What are current understandings of the CE concept in the academic community?" To answer this question, we analyse 221 definitions of CE, all published in academic articles appearing after the publication of Kirchherr et al. (2017). By replicating the methodological approach of Kirchherr et al. (2017), this study is comparable to the previous study and aims to establish a longitudinal history that, after several iterations, can provide insights into the evolution of CE over time and into the behaviour of newly emergent policy concepts overall. A literature search revealed no similar effort, since Kirchherr et al. (2017), to derive a comprehensive definition of CE using systematic methods in terms of sampling, coding, and interpretation. In large part, the numerous existing reviews of CE literature typically serve the needs of narrowly specified research and rarely constitute the sole purpose of their respective studies. Nevertheless, several studies have attempted to review CE and related issues from a conceptual perspective (Table 1).

The contribution of this replication study is evidence that understandings about CE have become, at once, differentiated and consolidated since 2017. The practical implication is that CE definitions currently popular in the academic community may be less applicable for practitioners than were definitions common five or more years ago. Five other notable findings emerge: (i) scholars now increasingly insist that CE necessitates a fundamental systemic shift, particularly with regards to existing supply chains; (ii) CE is not considered an end goal unto itself but a means to accomplish sustainable development; (iii) some studies question whether the CE concept can reconcile environmental sustainability with economic development; (iv) technology, skills, and capabilities for CE are receiving increased attention; and (v) studies emphasize that a broad alliance of stakeholders – not only consumers and producers but also policymakers and scholars – is needed to foster CE transition, which may complicate CE implementation. This study finds empirical evidence of these trends in influential literature about CE and proposes how a new conceptualization can help bridge the theory-praxis gap in a way that balances the need for more detailed studies with the need for a broader consensus about the term overall. The remainder of this article is organized as follows: Section 2 outlines methods, Section 3 discusses results regarding core principles, aims, and enablers of CE, and Section 4 summarizes findings and discusses limitations and avenues for further research.

2. Methods

In this section, we first explain our methodological approach for identifying the sample set of studies to be analysed and coded. We then outline the development of the coding framework, followed by an explanation of the coding procedure. Methodologically, this is a replication of the Kirchherr et al. (2017) study, therefore we attempted to maintain the methods of the Kirchherr et al. study as closely as possible. This approach facilitates a systematic comparison of definitions identified by this study to those identified by the previous study. While this section aims to sufficiently explain the methods, further explanations, as needed, can be found in the original Kirchherr et al. (2017) article.

Sample development: The superset of articles was determined by searching portals (i.e., Scopus and Web of Science) using the search string 'circular economy' for all publications appearing between 2017 and 2021. Those published before September 2017, and thus prior to the publication of Kirchherr et al. (2017), were not included. The result was a list of 6566 publications (each having a unique DOI) that made at least one reference to the term 'circular economy' in its title, abstract, or keywords. In a deviation from the methods of the 2017 publication, we did not include studies appearing in non-academic and non-peer reviewed publications. The justification is that the field of CE research has matured in recent years, with practitioner reports no longer playing a significant role in the academic development of CE conceptualizations.

This study strengthens the sample development criteria used by Kirchherr et al. (2017) in several ways. First, from the original 6566 studies in the superset, the sample subset designated for coding was determined through a desired confidence level of 95 percent and an allowed margin of error of five percent – leading to a subset totalling 364

Table 2
Coding framework (obtained via an iterative process) (Source: Compilation of author team).

Coding dimension	Coded to the dimension if …
Core principles	
4R framework	Explicit reference to the 4R framework/all 4R dimensions (reduce, reuse, recycle, recover) or any x-R framework that includes 4R?
3R	Explicit reference to the 3R framework/all 3R dimensions (reduce, reuse, recycle) or any x-R framework that includes 3R?
Reduce	Discussion around refusing, rethinking, redesigning (including prolonging the lifespan of products), minimization, digitization and so reduction and/or prevention of resource use and preserving of natural capital? Explicit reference to any x-R framework that includes "reduce"?
Reuse	Discussion around reusing (excluding waste), closing the loop, cycling, repairing and/or refurbishing of resources? Explicit reference to any x-R framework that includes "reuse"?
Recycle	Discussion around remanufacturing, recycling, closing the loop, cycling and/or reuse of waste? Explicit reference to any x-R framework that includes "recycle"?
Recover	Discussion around incineration of materials with energy recovery? Explicit reference to any x-R framework that includes "recover"?
Waste hierarchy	Indication of an order or ranking of the various Rs mentioned, e.g., via words such as "first", "alternatively" or "least desirable"?
Supply/value chains	Explicit reference to required changes in the supply/value chains or logistics towards the CE?
System perspective	Discussion around CE as a system
Micro systems perspective	Discussion around product level changes, firms and/or consumers and their preferences?
Meso-systems perspective	Discussion around CE at the local/regional level and/or eco-industrial parks?
Macro- systems perspective	Discussion around CE at the global and/or national level and/or the overall industry/ economic structure?
System change / paradigm shift	Description of the CE as a system change, paradigm shift, circular disruption and/or alternative model?
Restorative/regenerative	Explicit reference to CE being restorative and/or regenerative?
Renewable resources	Discussion around renewable resources being a part of the CE?
Technical/biological cycles	Explicit reference to the technical and/or biological (nutrient) cycles?
Aims	
Sustainable development	Explicit reference to sustainability and/or sustainable development?
Environmental quality	Discussion around how CE aims to maintain, protect and/or restore the environment and/or resource efficiency/enable transition towards low carbon economy?
Economic development	Discussion around how CE aims to reduce costs, maintain, protect, transform and/or strengthen/make more competitive the economy and add economic benefits to businesses/consumers?
Social equity	Discussion around how CE aims to protect, transform, strengthen and/or develop the circular society/ socio-economic system and/or human well-being/health and create jobs?
Decoupling economic growth from resource extraction	Discussion around the separation of economic growth from resource depletion/negative environmental consequences?
Future generations (time dimension)	Discussion of future generations and/or the long-term perspective of CE?
Value maintenance/life-time extension	Discussion around CE practices being aimed at maintaining the value of resources / materials and/or extending the life-time of resources / materials to achieve resource efficiency and to avoid resource scarcity eventually?
Waste reduction/elimination/ minimization	Discussion around CE practices / actions reducing or eliminating the amount of waste (produced) in line with the concepts such as zero-waste?
Enablers	
Consumers (demand side)	Explicit mentioning of consumption/consumer perspective/consumers or any entities responsible for increased demands as drivers of CE?
Producers/distributors/ businesses/industries (supply side)	Explicit mentioning of production/producer or distribution perspective /producers and similar stakeholders like businesses/firms/industries/ organizations as drivers of CE?
Policy	Explicit mentioning of policy(making)/policy perspective/governmental bodies as drivers of CE?
Science/academia	Explicit mentioning of science/academia/ scholars as drivers of CE?
Business models	Explicit mentioning of business models (including specific type of business model such as product-as-a-service)?
Technologies	Explicit mentioning of technologies / technological innovations as drivers of CE?

codable articles. Second, to account for the most influential academic contributions, the subset was selected using a two-fold approach: 80 percent (N=291) of the subset constitutes articles randomly selected from amongst the top-cited articles in the superset (i.e., those representing 80 percent of total citations across the superset). The remaining 20 percent (N=73) of the subset constitutes articles randomly selected from amongst the least-cited articles (i.e., those representing the bottom-20 percent of the superset in citation count). The selection of articles by citation count is consistent with one of the aims of this study – to review CE definitions that are influential in the literature and thus potentially more visible in practice. At the same time, we have ensured that articles with less influence, as defined by citation count, have an opportunity to be included.

We encountered articles that could not be coded for various reasons. Some were not accessible due to language (only English language publications were considered). Others contained the keyword 'circular economy' but did not refer meaningfully to the concept (Kirchherr (2022) has called this phenomenon "recycled research – scholarship that stamps the latest academic buzzword on otherwise sound work from a related research stream"). In other instances, an article contained text loosely related to the term 'circular economy' but did not specify the term. The culling of such articles led to a final set of 221.

Coding framework: The function of the coding framework that is utilized throughout this study is to make the definitions at hand comparable, as also outlined in Kirchherr et al. (2017); in other words: coding within a coding framework allows to highlight how definitions differ or are close to one another. Most of the 221 definitions found in the appendix to this paper differ in words. However, they differ much less in substance. To provide an example: Multiple definitions may relate to the coding dimension 'social equity'. However, some definitions may use the term 'social sustainability' or 'social justice' instead of 'social equity', albeit meaning the same. Via the coding, all these terms are coded within the coding framework into the coding dimension 'social equity', with the coding thus highlighting how these definitions are closer to each other than from a perfunctory first sight (that only takes into account the exact wording). Table 2 provides an overview of the coding framework, while Table 3 and Table 4 in the appendix elaborate further on coding rules and the coding procedure adopted for this work to make definitions comparable.

The coding framework in Kirchherr et al. (2017) contained 17 dimensions across the three clusters ('Core principles,' 'Aims,' and 'Enablers'). The new study's coding framework was extended to 30

The circular economy (CE) is a regenerative economic system which necessitates a paradigm shift to replace the 'end of life' concept with reducing, alternatively reusing, recycling, and recovering materials throughout the supply chain, with the aim to promote value maintenance and sustainable development, creating environmental quality, economic development, and social equity, to the benefit of current and future generations. It is enabled by an alliance of stakeholders (industry, consumers, policymakers, academia) and their technological innovations and capabilities.

Legend: Core principles Aims Enablers

Fig. 1. Verbal depiction of coding framework.

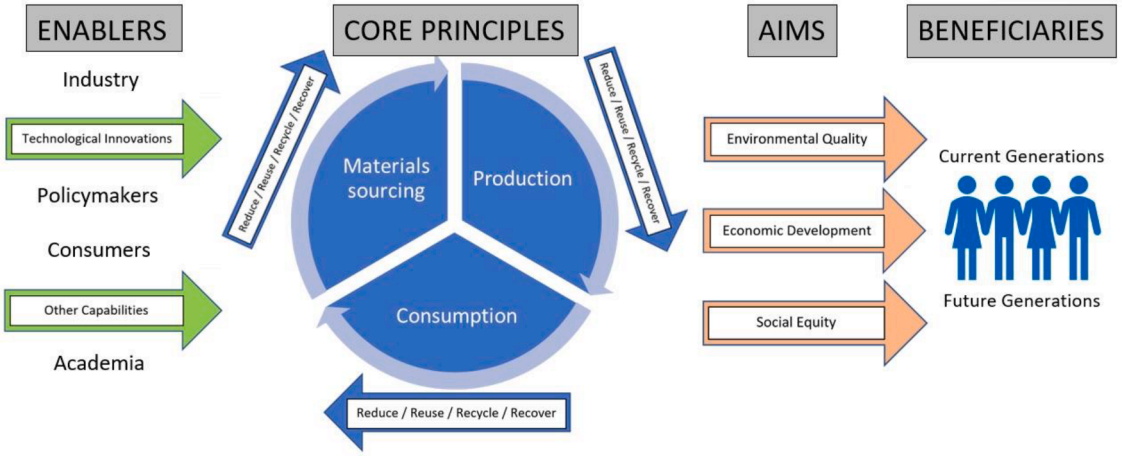

Fig. 2. Graphical depiction of coding framework.

dimensions across the same clusters. Some of the 13 additional dimensions were originally intended for use in the Kirchherr et al. (2017) study before being removed before the final analysis. In the new analysis, the dataset from Kirchherr et al. (2017) was re-coded with updated dimensions, where possible, to enable consistent comparison across all articles.

From an interpretive perspective, most coding efforts require some degree of subjectivity. We acknowledge the challenge of determining uniqueness amongst more than 200 definitions of CE. Indeed, most definitions overlap at a high level conceptually and substantively, while

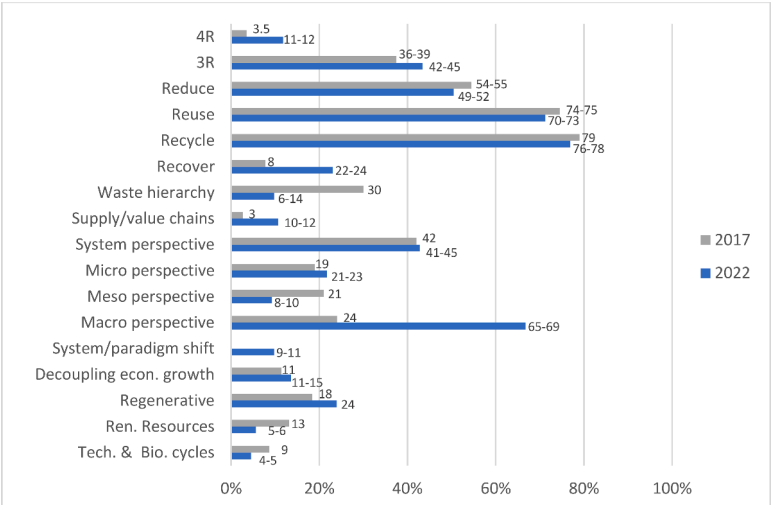

Fig. 3. Coding results regarding CE core principles

many also overlap terminologically. Distinctions may therefore be minimal in many cases, with only differences in wording making definitions appear unique. For this reason, the coding exercise categorizes and clusters definitions on terminological grounds. We isolate differences according to identified principles, aims, and enablers as focus areas of individual definitions (e.g., product life-cycle stages, environmental and social purposes, and technologies). Fig. 1 is a verbal depiction of the coding framework that articulates the three clusters. Fig. 2 is a graphical depiction of the same, illustrating relationships amongst actors, strategies, actions, and outcomes.

Coding procedure: 221 definitions regarding the term 'circular economy' were coded. All of these definitions can be found in the appendix. Where existing, clear and full definitions were analysed. However, authors often face space restrictions and an adopted definition may not reflect an author's full understanding of the concept. As such, for any given study we also coded any descriptions of the term 'circular economy' found in neighbouring text or tables. The intent was to best capture the respective author's full understanding of CE.

Manual coding of definitions, as also undertaken by Kirchherr et al. (2017), was used to capture definitional nuance (in contrast to the often 'blunt' approach of automated coding). However, we acknowledge that manual coding raises questions regarding reliability. To best avoid related bias, every definition in the sample was coded by two authors based on an initial set of coding rules (taken from Kirchherr et al. (2017)). Divergent coding results were reviewed by both coders, and coding rules were then reconsidered (leading in some cases to amendments or additions). This process aimed to strengthen inter-coder reliability. The eventual discrepancy in coding results was below a five percent difference threshold for 26 of the 30 dimensions and below a 10 percent difference threshold for the remaining four dimensions. These discrepancies, where arising, are noted in the following section.

3. Results and discussion

This section presents and discusses the results, structured in three subsections that respectively address (i) CE core principles, (ii) CE aims, and (iii) CE enablers. We also compare the new findings (2017–2022) with those of the original study (Kirchherr et al., 2017).

3.1. Core principles

R principles: Core principles coded for this study (Fig. 3) exhibit many similarities with those identified by Kirchherr et al. (2017). Explicit mentions of the 3R framework slightly increased (36–39 percent in 2017 versus 42–45 percent in 2022), while individual R components slightly decreased in frequency of mentions (reduce: 54–55 percent in 2017 versus 49–52 percent in 2022; reuse: 74–75 percent in 2017 versus 70–73 percent in 2022; recycle: 79 percent in 2017 versus 76–78 percent in 2022). Meanwhile, the 4R framework is more frequently mentioned in newer CE definitions (3.5 percent in 2017 versus 11–12 percent in 2022), driven largely by more frequent mentions of the coding dimension 'recover' (8 percent in 2017 and 22–24 percent in 2022).

To the present coding framework we added several core principles popularized in CE studies by the Ellen MacArthur Foundation (hereafter, 'EMF') (2013). First, we coded for the technological and biological cycles, as first introduced through the Foundation's butterfly diagram. In the technical cycle, products are reused, repaired, remanufactured, and recycled; in the biological cycle, biodegradable materials are returned to the earth through processes like composting and anaerobic digestion (EMF, 2013). Recoding of the Kirchherr et al. (2017) definitions showcased that both cycles appeared in nine percent of definitions in the original study but only 4–5 percent of definitions in the new study. Second, we coded for 'renewable energy sources,' as included in EMF's (2013) CE definition (found to be the most frequently used definition in the Kirchherr et al. (2017) study). This coding item appeared in 13 percent of definitions in the 2017 dataset versus 5–6 percent in the new dataset. A possible explanation for both of these decreases is that the EMF's CE studies, which arguably generated initial momentum in CE research (Geissdoerfer et al., 2017; J. Kirchherr et al., 2017), have gradually lost relevance in scholarship over time with the emergence of a dedicated subfield of CE research.

In addition to coding dimensions for the technological and biological cycles and 'renewable energy sources,' this study also coded the term 'regenerative.' The CE definition by EMF (2013) used this term in reference to building natural capital. 'Regenerative' appeared in 24–25 percent of definitions in the new dataset, as against 18 percent in the 2017 dataset (based on re-coding). The increase in frequency of mentions from 2017 to 2022 may be explained by the popularity of an article by Geissdoerfer et al. (2017) – the most cited in the CE literature – which defined the CE as a 'regenerative system.'

Systems perspective: The systems perspective, as reflected in CE definitions, was similarly represented across the two studies (42 percent in 2017 and 41–45 percent in 2022). Kirchherr et al. (2017) differentiated between micro-, meso-, and macro-systems for a CE. The micro-perspective – focused on product level changes, firms, and consumers – was mentioned by 19 percent of articles in 2017 and 21–23 percent in 2022. However, we found that the meso-perspective – referring largely to the establishment and maintenance of eco-industrial parks (EIPs) – was featured much less frequently in the 2022 dataset (8–10 percent) than in the 2017 dataset (21 percent). One possible explanation is that the EIP concept, originally popularized in the early 2000s (Chertow, 2003; 2007), has lost salience and been replaced by the

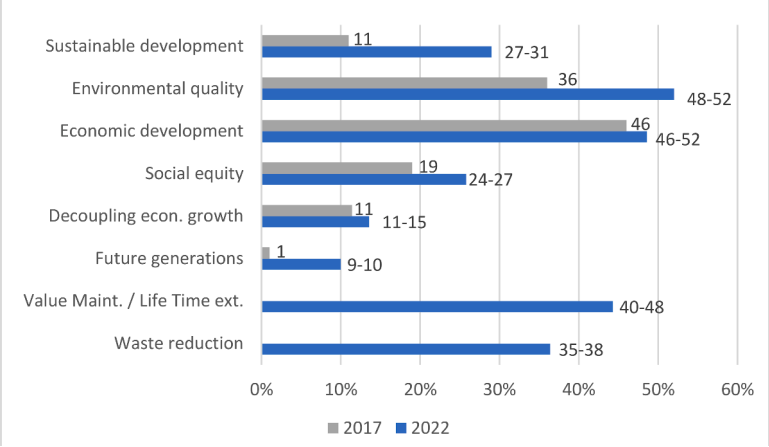

Fig. 4. Coding results regarding CE aims

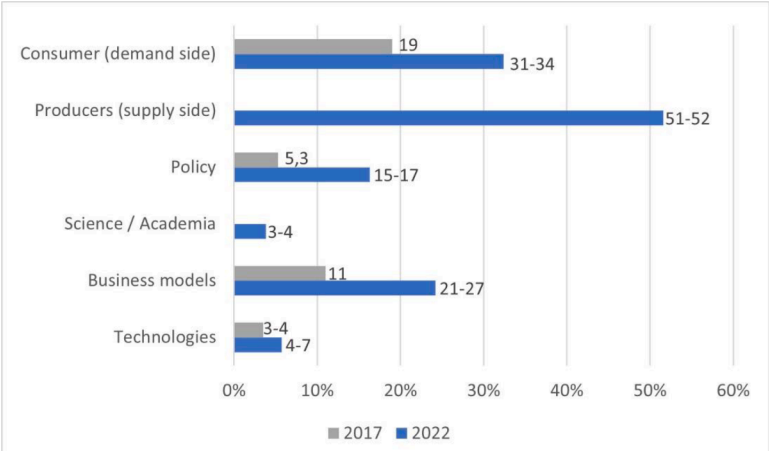

Fig. 5. Coding results regarding CE enablers.

CE concept (which is more encompassing). Mentions of the macro-perspective almost tripled in the new study (24 percent in 2017 to 65–69 percent in 2022). This increase likely reflects an emerging trend in which CE is viewed as a complex system requiring fundamental macro-level changes.

Regarding the CE systems perspective, we found the term 'supply chains' used in 10–12 percent of definitions in the 2022 study. On this basis, we added the term as a new coding dimension. When recoding the 2017 definitions, we found that these terms were mentioned in only 3 percent of definitions. One example of a definition that includes 'supply chains' is Tseng et al. (2018), who investigate how digitization and big data approaches facilitate collaboration across a supply chain in implementing CE. In our discussions with practitioners for this study, the concept of re-engineering supply chains was frequently mentioned, suggesting that a supply chain perspective may be increasingly crucial for CE implementation.

In a final notable finding regarding core principles, 9–11 percent of definitions not only discussed CE from a systems perspective but also called for a fundamental shift in the current linear 'take-make-dispose' model. This apparent preference accords with recent discussions about CE, including a special issue of the journal *Business Strategy and the Environment* addressing the concept of 'circular disruption' (Blomsma et al., 2022; Kirchherr et al., 2022). While in-principle support for fundamental changes to the current economic system may be common amongst scholars, this arguably revolutionary idea may alienate some practitioners who view incremental modifications as a more feasible strategy.

3.2. Aims

Sustainability: A core finding by Kirchherr et al. (2017) was that only 11 percent of CE definitions referred to sustainable development as a principal aim. This significantly changed in the new study – sustainable development is mentioned in 27–31 percent of definitions – a threefold increase (Fig. 4). In accordance with this trend, we observe that all three dimensions of sustainability are mentioned more frequently in the new set of definitions – environmental quality (36 percent in 2017 and 48–52 percent in 2022), economic development (46 percent in 2017 and 46–52 percent in 2022),[1] and social equity and related topics (19 percent in 2017 and 24–27 percent in 2022).

Social topics appeared in detail throughout the new set of CE definitions, including human health, well-being, and development, 'just' transitions, and the concept of a circular society (all coded under the dimension 'social equity'). Example contributions to discussions about the social dimensions of CE transitions are Schröder et al. (2020) on human development and circular justice, and Calisto Friant et al. (2020) and Jaeger-Erben et al. (2021) on circular society. A critical analysis of the potentially negative social impacts of CE implementation in emerging economies is provided by Repp et al. (2021).

We introduced the dimension 'decoupling economic growth from resource depletion' into the coding framework, as the concept was found in 11–16 percent of definitions in the new dataset; no meaningful mentions were found in the 2017 set of definitions. Mentions of degrowth and economic sufficiency were also coded into this dimension. Notable contributions to this debate include Bocken & Short (2020), Hobson (2020), and Hobson & Lynch (2016), with these and other studies challenging whether environmental protection and economic growth can be reconciled through the CE concept. Coding results indicate that the promotion of degrowth and economic sufficiency remains a niche, whereas these concepts appear to be gaining visibility in the field overall (e.g., as topics addressed in recent CE conferences).

Finally, a notable difference in findings between the 2017 study and the new study emerges when considering the dimension 'future generations.' While reference to this coding dimension was found in only one of 114 definitions in the 2017 study, it appeared in 9–11 percent of definitions in the new study. Accordingly, a literature stream that conceptualizes circular futures has emerged (Bauwens et al., 2020; Liaros, 2021; Lowe & Genovese, 2022), and this research may have already begun to influence understandings about CE. Although the increasing frequency of mentions in this coding dimension is notable, 'future generations' as a concept remains under-conceptualized in the new set of CE definitions and is therefore a potential area for future CE research.

Value maintenance/waste reduction: 'Value maintenance' and 'waste reduction' were not considered as coding dimensions by Kirchherr et al. (2017). However, we chose to include them in the new framework, as they appeared in 40–48 percent of the definitions analysed. Indeed, many studies argue that extending product value and thus increasing resource efficiency is one of the core aims of CE (Kümmerer et al., 2020; Xavier et al., 2021). We also included 'waste reduction/elimination' in the coding framework as a new dimension that was mentioned in 35–38 percent of the definitions (Ferasso et al., 2020). It can be considered intuitive to claim value maintenance and waste reduction as core aims of the CE concept. However, we also note that a recently developed strand of literature maintains that resource efficiency and waste reduction do not always strengthen sustainability (Blum et al., 2020; Zink & Geyer, 2017). We would therefore suggest that future research continue to examine whether and the degree to which CE is a vehicle for sustainable

[1] We renamed the coding dimension 'economic prosperity' to 'economic development,' after determining that the latter term is more neutral and thus more capable of resonating in current debates about degrowth (discussed later in this section).

development.

3.3. Enablers

We added multiple coding dimensions in the category 'enablers,' as the 2017 study included only two dimensions for the category (consumers and business models). These additions were the result, in part, of our identification of a broader landscape of stakeholders in our set of definitions – including not only business models/producers and consumers, but also policymakers and academia. We also coded for 'technology' and 'capabilities' as more concrete conceptualizations of the influence of these stakeholders (Fig. 5). Our additional categories suggest the importance recognizing broadening actor alliances, a trend that can both enable and complicate CE implementation.

Business models: As done in the 2017 study, we coded for the dimension 'business models,' whose mentions more than doubled from 11 percent in 2017 to 21–27 percent in 2022. The lack of attention to business models in the CE literature, discussed originally by Lieder et al. (2017), appears to have been gradually overcome. Indeed, research on circular business models has emerged as one of the most vibrant sub-fields of current CE research. However, practitioners we interviewed maintain that more (applied) research on this topic is still needed. We also note that more recent CE definitions mention not only business models but also a broader array of firm types, including producers and distributors. As such, we added the coding dimension 'producers (supply side),' which was mentioned in 51–52 percent of definitions.

Consumers: In our study, the dimension 'consumers' represents the demand side of CE. Gallaud & Laperche (2016) consider consumers to be the most crucial enabler of circular business models, and some studies argue that lagging consumer uptake is a core barrier to CE implementation (Hartley et al., 2021; de Jesus & Mendonça, 2018). Given consumers' potential roles as CE enablers, increasing mentions of consumers in CE definitions is notable: from 19 percent in 2017 to 31–34 percent in 2022. Definitions included not only consumer responsibility and awareness but also circular consumption practices. This coding dimension appears to be integrating into mainstream CE conceptualizations.

Policymakers/academia: The mainstream scholarship (e.g., Hartley et al. (2020) and Milios (2021)) now argues that successful CE transition requires political and policy support. Indeed, multiple CE policy initiatives have recently been undertaken, with an exemplary case being the European Commission's 2020 Circular Economy Action Plan. As such, we coded for a new dimension, 'policy,' which appeared in 15–17 percent of definitions; recoding of the 2017 definitions found a five percent incidence, highlighting a significant increase in this dimension over time. Recent studies of mission-orientated CE (e.g., Reike et al. (2022)) also regard academia as a core actor in CE transition. Therefore, we added 'academia' as a coding dimension but found it mentioned in only four percent of definitions (it was entirely unmentioned in the 2017 dataset).

Technology and innovation/capabilities: In our discussions with practitioners, technology and innovation were suggested as enablers for CE. However, these factors were mentioned in only 4–7 percent of definitions in the new dataset (e.g., Pagoropoulos et al. (2017)), while recoding of the original dataset revealed mentions in only 3–4 percent of definitions. Notwithstanding this limited recognition, technology and innovation may be an important area for future CE research. Practitioners also frequently mentioned the need for specific capabilities to enable CE. While several articles have recently addressed this topic (Galvão et al., 2020; Iacovidou et al., 2020; Scarpellini et al., 2020; Sumter et al., 2020), we found CE capabilities mentioned in only one study (of 221) and entirely unmentioned in the 2017 dataset.

Upscaling: It is important also to consider the cross-cutting concept of 'upscaling,' as it relates to multiple enablers and can be seen as a higher-order strategic tool for CE transition. In a study of the upscaling of environmental policy and circularity concepts in China, Luo and Leipold (2022) reference the World Bank (Mundial, 2004) definition of upscaling: "expanding, adapting and sustaining successful policies, programs or projects in different places and over time to reach a greater number of people." Other studies making use of the term 'upscaling' include Sehnem (2022) in a study about foodtech businesses, Janssen and Van Diepen (2021) in a study about the role of shared values in CE upscaling, Milios (2020) in a study about the EU Circular Economy Action Plan, and in various other studies concerning specific industries, products, materials, and national contexts (Arora et al., 2021; Doyle et al., 2022; Jurgilevich et al., 2016; Lazarevic et al., 2022; Ten Brink et al., 2018). There appear to be no broad, influential, or highly cited review studies focused specifically on the role of upscaling in CE transition. Nevertheless, the concept contributes nuance to practical understandings of CE transition, including those covered by the 'enablers' category, by highlighting the opportunities and challenges of systemic change. Indeed, CE transition can be seen as fundamentally systemic in nature, and upscaling from individual pilot projects or firm-level and industry-level innovations to a more universal context is essential in order to capture synergistic benefits. Inherent in the concept of upscaling is also a dimension of integration – namely, that CE transition may happen 'universally' or globally within a sector but not necessarily across multiple sectors; avoiding the 'siloed' approach to CE transition requires policymakers to think in multiple scales, both horizontally and vertically. For these reasons, 'upscaling' is considered an enabler in this study's definitional framework for CE.

In closing, core factors identified in the definitions examined by this study support the following meta-definition: "The circular economy is a regenerative economic system which necessitates a paradigm shift to replace the 'end of life' concept with reducing, alternatively reusing, recycling, and recovering materials throughout the supply chain, with the aim to promote value maintenance and sustainable development, creating environmental quality, economic development, and social equity, to the benefit of current and future generations. It is enabled by an alliance of stakeholders (industry, consumers, policymakers, academia) and their technological innovations and capabilities."

4. Conclusion

In a recent article, Kirchherr (2022) complains that much of the CE literature constitutes 'scholarly bullshit' – that is, scholarship "so pointless and unnecessary that even the scholar producing it cannot justify its existence" (Kirchherr, 2022; p. 2). In particular, the critique maintains that too much CE literature lacks applicability. This study has aimed to highlight the applicability of existing research where it can be found, and suggests pathways for applicability in future research, by providing a snapshot of how the literature defines CE and the degree to which the field has come to a consensus conceptualization. The past decade has seen a rapid increase in the number of CE studies, with focus areas becoming increasingly narrow in scope (industry-specific) and context (country-specific) – a potential threat to broader applicability. As the literature evolves in its chase down these empirical 'rabbit holes,' it is essential that the field maintain and foster a higher-level perspective that recognizes the importance of a basic shared understanding about CE.

Clearer, more relevant, and more practically actionable conceptualizations of CE can help maintain the connection between CE research and practice. On one hand, evidence-based policymaking for CE can and should rely on research rather than exclusively on the input of businesses and lobbying groups; on the other hand, research itself is improved when conduits of information exchange with the public sector and industry are strengthened. amongst academics, policymakers, and the private sector, each has something to gain from the other. To this end, this study has examined 221 definitions of CE (made comparable via a coding framework, inspired by Kirchherr et al. (2017)) to determine whether and how current research, in general, has coalesced around shared understandings of the CE concept. Such work helps

Table 3
Example phrases per coding dimensions (derived from 2017 paper).

Coding dimension	Coded to the dimension if …	Example phrase
Core principles		
4R framework	Explicit reference to the 4R framework/all 4R dimensions (reduce, reuse, recycle, recover) or any x-R framework that includes 4R?	"includes the 4Rs" "It proposes a system where 4Rs provide alternatives to the use of raw virgin materials, making sustainability more likely."
3R	Explicit reference to the 3R framework/all 3R dimensions (reduce, reuse, recycle) or any x-R framework that includes 3R?	"This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling."
Reduce	Discussion around refusing, rethinking, redesigning (including prolonging the lifespan of products), minimization, digitization and so reduction and/or prevention of resource use and preserving of natural capital? Explicit reference to any x-R framework that includes "reduce"?	"the reduction of resources"
Reuse	Discussion around reusing (excluding waste), closing the loop, cycling, repairing and/or refurbishing of resources? Explicit reference to any x-R framework that includes "reuse"?	"products could be repaired, reused"
Recycle	Discussion around remanufacturing, recycling, closing the loop, cycling and/or reuse of waste? Explicit reference to any x-R framework that includes "recycle"?	"where the wastes are reused" "from restoration and recycling" "waste as a resource"
Recover	Discussion around incineration of materials with energy recovery? Explicit reference to any x-R framework that includes "recover"?	"by-products, (…), and energy are cycled back into the overall production stream"
Waste hierarchy	Indication of an order or ranking of the various Rs mentioned, e.g. via words such as "first", "alternatively" or "least desirable"?	"if reuse or repairs are not possible, they can be recycled or recovered from the waste stream"
Supply/value chains	Explicit reference to required changes in the supply/value chains or logistics towards the CE?	"Closing the loop in these cases involves corporate decisions amongst multiple supply chain players across different industries that comprise the multiple-supply-chain network"
Systems perspective	Discussion around CE as a system?	"a circular economy is an industrial system"
Micro-systems perspective	Discussion around product level changes, firms and/or consumers and their preferences?	"CE will ensure that byproducts are identified in individual enterprises and used effectively either internally through cleaner production (CP)"
Meso-systems perspective	Discussion around CE at the local/regional level and/or eco-industrial parks?	"At the regional level, circular economy emphasizes structuring a substance recycling eco-industrial park"
Macro- systems perspective	Discussion around CE at the global and/or national level and/or the overall industry/economic structure?	"the development of a CE emphasizes adjusting industrial composition and structure"
System change/ paradigm shift	Description of the CE as a system change, paradigm shift, circular disruption and/or alternative model?	"Although 'circular economy' and 'sustainability' are two different concepts, both integrate noneconomic aspects into the development model with a system change/design at their core"
Decoupling economic growth from resource extraction	Discussion around the separation of economic growth from resource depletion/negative environmental consequences?	"since it aims to decouple economic growth from resource extraction"
Restorative/regenerative	Explicit reference to CE being restorative and/or regenerative?	The CE is an industrial system that is restorative or regenerative by intention and design
Renewable resources	Discussion around renewable resources being a part of the CE?	"CE (…) operates by default on renewable energy"
Technical/biological cycles	Explicit reference to the technical and/or biological (nutrient) cycles?	"and value at all times, distinguishing between technical and biological cycles" "Both technical and biological materials from end-of-life products will be properly treated, (…) these materials can safely be released into the biosphere
Aims		
Sustainable development	Explicit reference to sustainability and/or sustainable development?	"sustainable development created by promoting a circular economy (CE)"
Environmental quality	Discussion around how CE aims to maintain, protect and/or restore the environment and/or resource efficiency/enable transition towards low carbon economy?	"environmental conservation"
Economic development	Discussion around how CE aims to reduce costs, maintain, protect, transform and/or strengthen/make more competitive the economy and add economic benefits to businesses/consumers?	"secure continued economic growth"
Social equity	Discussion around how CE aims to protect, transform, strengthen and/or develop the circular society/ socio-economic system and/or human well-being/health and create jobs?	"maximize (…) human well-being"
Future generations (time dimension)	Discussion of future generations and/or the long-term perspective of CE?	"contributing to long-term sustainability"
Value maintenance/life-time extension	Discussion around CE practices being aimed at maintaining the value of resources / materials and/or extending the life-time of resources / materials to achieve resource efficiency and to avoid resource scarcity eventually?	"the CE covers a group of activities or circular strategies that intend to extend the product lifetime and close materials flows" "The Circular Economy is divided into two business models, the reuse and product lifetime extension model and the recycling for material recovery model (Stahel, 2015)."
Waste reduction/ elimination/minimization	Discussion around CE practices / actions reducing or eliminating the amount of waste (produced) in line with the concepts such as zero-waste?	"there is a need for the transition from linear to circular economy which focuses on waste reduction and closely monitors the consumption of resources by encouraging practices such as reuse, recycle, remanufacturing and refurbishment"
Enablers		
Consumers (demand side)	Explicit mentioning of consumption/consumer perspective/consumers or any entities responsible for increased demands as drivers of CE?	"rethinking (…) consumption" "made by policy, business and civil society representatives"
Producers/distributors/ businesses/industries (supply side)	Explicit mentioning of production/producer or distribution perspective /producers and similar stakeholders like businesses/firms/industries/ organizations as drivers of CE?	"CE proposes to replace wasteful and inefficient linear and open-ended cycles of production" "CE (…),bases on the establishment of closed production systems, where resources are reused and kept in a loop of production and usage"

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Table 3 (*continued*)

Coding dimension	Coded to the dimension if …	Example phrase
		"Key features include elimination of waste through industrial symbiosis, superior product design, appropriate business models and reverse logistics systems"
Policy	Explicit mentioning of policy(making)/policy perspective/ governmental bodies as drivers of CE?	"The transition to a circular economy has shifted from a vision (Boulding 1966) to actual policy making."
		"In the European Union, the 'circular economy' has been introduced as a high-level strategy to move our societies beyond these limits."
Science/academia	Explicit mentioning of science/academia/scholars as drivers of CE?	"The CE has received increased attention in recent years by policy makers, industry and science."
		"Scholars and practitioners have documented how the CE paradigm"
Business models	Explicit mentioning of business models (including specific type of business model such as product-as-a-service)?	"…a Circular Economy can be achieved through a framework based on three strategies, namely narrowing, slowing, closing resource loops and three pillars, namely technical innovation, business model innovation and collaboration…"
Technologies	Explicit mentioning of technologies/ technological innovations as drivers of CE?	"Digital technologies leverage this transition through data collection, analysis and integration"

advance the development of frameworks for CE action in the public and private sectors – whether universally or tailored to local context. It also helps chart a course for further research that maintains a broad conceptual perspective in a field that is experiencing a proliferation of research contributions.

In comparison with the 2017 study, the 221 definitions in this study reflect an understanding of CE this both more consolidated and more differentiated. As one author of this article described it, the trunk of the CE tree has strengthened, while various new leaves have appeared. This may be the expected pattern in the evolution of any new concept; as additional scholarly attention is applied to it, there can be both a centralizing/homogenizing effect and a disintegrating effect. With the obvious or easy applications of the concept exhausted, additional studies go into greater detail on narrower topics; at the same time, other studies – like this one – take the opportunity to reflect more generally on the progress of research on the concept. This trend has implications for the translation of research into practice. However, CE conceptualizations in 2022 may be less mainstream from a practitioner perspective than 2017 conceptualizations. The remainder of the conclusion discusses anticipated trends in core principals, aims, enablers, and policies.

Consensus has grown regarding the core principles underpinning CE, with 70–80 percent of articles recognizing 'reuse' and 'recycle' as the two fundamental principles of CE, similar to the 2017 analysis. Most notably, an increasing share of definitions now also features calls for fundamental systemic shifts to foster CE transition. As such, CE seems less capable of being implemented through only incremental changes. Nevertheless, significant reconfiguration of supply chains is a topic that appears in only one out of ten definitions – remaining a minor consideration overall.

A major shift regarding aims is evident in the new set of definitions. While only one out of ten definitions highlighted sustainable development as an aim of CE in Kirchherr et al. (2017), sustainable development appears in one out of three definitions in the new study. However, fewer authors agree that economic prosperity should be an aim of CE. While the idea of 'future generations' appears relatively infrequently, the increase from 2017 is notable: from less than 1 percent of definitions in 2017 to roughly 10 percent in 2022. Further, roughly 40 percent of definitions mention value maintenance and resource efficiency as an aim of CE; this focus may become increasingly relevant amidst supply chain disruptions, production localization, and increasing resource scarcity.

The largest shift since 2017 is within CE enablers. The 2017 study did not find frequent mentions of enablers; where mentions were made, they focused largely on consumers and business models. By contrast, a broad set of enablers is apparent in the new study. The alliance for CE that is now suggested includes not only consumers and producers but also policymakers and scholars. Furthermore, technological innovation and capabilities are highlighted as foundations for the function of alliance parties.

Finally, the importance of a consensus definition of CE is clear for policymaking. It provides a common basis of assumptions and targets on which policymaking can be developed, strengthening the ability to integrate policy efforts across political jurisdictions (e.g., states, countries, and regions), industries (e.g., construction, textiles, and technology), and across life-cycle stages and other issue areas (e.g., extraction, processing, and end-of-life management). A consensus understanding can also assist companies in aligning CE adoption activities with those of other partners and suppliers, and also provides researchers with a basis on which to build research that interacts discursively across contexts, industries, and disciplines. Given that the scale of CE transition is fundamentally broad, it is crucial that differing and contested understandings of the concept do not create barriers to implementation and definitional refinement.

Lastly, there are several limitations that invite future research. First, we acknowledge that the selection procedure for sampling requires some judgement and expression of preference on the part of the authors. We chose to focus most of our attention on what we considered to be the most influential studies of CE with respect to conceptualization; to this end, our criterion was number of citations. This may be considered a 'blunt' criterion in that the number of times an article is cited depends on

Table 4
Coding procedure. (derived from 2017 paper).

Process step	Activity
1	Development of initial coding framework (including coding rules), based upon coders' practical knowledge on the topic and preliminary skimming of relevant literature
2	Independent coding of set of definitions by both coders; searching for additional possible coding dimensions within definitions during coding
3	Comparison of coding results; discussion of definitions that at least one coder did not find straight-forward to code based on initial coding rules and discussion of diverging results; refinement of coding rules based on this discussion; discussion on and alignment regarding additional coding dimensions for coding framework
4	Independent coding of set of definitions by both coders based on revised coding framework
5	Comparison of coding results; discussion of diverging results; finalization of results (ultimate results can include diverging results)

Note: The depicted coding procedure is illustrative. Additional definitions were added and coding framework was further revised based upon anonymous feedback on this paper from reviewers at *Resources, Conservation and Recycling.*

Table 5
Definitions of the circular economy.

#	Source	Definition
1	Kalmykova, Y., Sadagopan, M., Rosado, L. (2018, p. 190)	The topic of circular economy (CE) is high on the political agenda and in particular in Europe (EC, 2014a,b, 2015a), it is expected to promote economic growth by creating new businesses and job opportunities, saving materials' cost, dampening price volatility, improving security of supply while at the same time reducing environmental pressures and impacts. It has been estimated that eco-design, waste prevention and reuse can bring net savings for EU businesses of up to EUR 600 billion, while at the same time reduce greenhouse gas emissions. Moreover, the additional measures to increase resource productivity by 30% by 2030 could boost GDP by nearly 1% and also create 2 million additional jobs (EC, 2014a,b).
2	D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lähtinen, K., Korhonen, J., Leskinen, P., Matthies, B.D., Toppinen, A. (2017, p. 717)	The concept of CE draws from the ideas of industrial ecology and industrial metabolism formulated during the 1970′s and 1980′s through a rethinking of the industrial processes (Frosch and Gallopoulos, 1989). Popularised during the 90′s, the framing of CE contemplates that, in opposition to linear economy, economic actors would exert no net effects on the environment. This goal is mainly pursued by redesigning the life cycle of the 'product', with the aim to have minimal input and minimal production of system 'waste'. This involves a system for achieving net reductions at the organizational supply chain and industrial levels (Murray et al., 2015; The Ellen MacArthur Foundation, 2012). Since the underlying idea is the transformation of a certain industry by-product into a resource for a second industry, there is a strong emphasis on inter-sectorial dynamics and cooperation.
3	Reike, D., Vermeulen, W.J.V., Witjes, S. (2017, p. 246)	As this article shows, large differences manifest itself globally with regard to CE, yet the potential ascribed to CE of breaking the global "take-make-consume and dispose' pattern of growth — a linear model based on the assumption that resources are abundant, available, easy to source and cheap to dispose of (…)" (EEA 2016, p. 9) is widely shared amongst different societal actors across the globe. The move towards a more circular economic model can hence be interpreted as confrontation with these untenable assumptions. CE is widely posed as alternative model of production and consumption, a growth strategy enabling the 'decoupling' of resource use from economic growth, thereby contributing to sustainable development (UNEP, 2011; McKinsey and Company, 2015; EC, 2015; OECD, 2016; EMAF, 2016a,b; Ghisellini et al., 2014; Geissdoerfer et al., 2017).
4	Urbinati, A., Chiaroni, D., Chiesa, V. (2017, 487)	In this respect, the fashion of Circular Economy is in the fact that it aims at overcoming the dominant linear take, make, disposal economy model, i.e. "a traditional open-ended economy model developed with no built-in tendency to recycle, which is reflected by treating the environment as a waste reservoir" (Su et al., 2013). Circular Economy, indeed, bases on the establishment of closed production systems, where resources are reused and kept in a loop of production and usage, allowing generating more value and for a longer period.
5	Ferronato, Navarro; Torretta, Vincenzo (2019, 1060, p. 18)	Therefore, the activity of the informal sector contributes directly to the recovery of the materials and the reduction of environmental contamination. This practice is in accordance with the circular economy (CE) principles. The objective of the CE is closing of material loops, to prevent waste from final disposal, and transforming the resulting residual streams into new secondary resources [140]. It proposes a system where 4Rs provide alternatives to the use of raw virgin materials, making sustainability more likely [141]. The CE typically includes economic processes such as "reverse logistics" or "take back" programs that recover wastes for beneficial reuse, avoiding final disposal costs, often reducing raw material costs and even generating incomes [142]. Therefore, the inclusion of the informal sector represents a key strategy for improving the CE concepts, improving social, environmental and economic sustainability [143].
6	Tseng, M.-L., Tan, R.R., Chiu, A.S.F., Chien, C.-F., Kuo, T.C. (2018, p. 146)	Instead, cross-industry networks of multiple supply chains have evolved in the circular economy (CE) model since the early 2000s, using approaches such as industrial and urban symbiosis. However, the implementation of such sustainable industrial networks with matrix-like structures is not straightforward. Closing the loop in these cases involves corporate decisions amongst multiple supply chain players across different industries that comprise the multiple-supply-chain network. To efficiently use resources according to preventive 3Rs (recycle, reduce and reuse) strategies in the matrix-like structure of these sustainable industrial networks with interconnected supply chains, the corporate world must now re-evaluate the triple-bottom-line (TBL) decision-making pattern amongst cross-industry corporate groups.
7	Nascimento, D.L.M., Alencastro, V., Quelhas, O.L.G., Caiado, R.G.G., Garza-Reyes, J.A., Lona, L.R., Tortorella, G. (2018, 609)	The Ellen MacArthur Foundation (2013, p. 14) defined CE as 'an industrial economy that is restorative or regenerative by intention and design'. However, the term was complemented by Bouldings (1966) work, which describes the planet Earth as a closed and circular system with limited assimilative capacity where, ideally, the economy and the environment should coexist in equilibrium (Geissdoerfer et al, 2017a). In such circumstances, the idea of 'circularity' has emerged to rethink how we use resources not only for production and economic systems but how to tackle resource scarcity as human population grows and demands, therefore, grows as well. The CE concepts are now considered to be a potential solution to deal with the challenges of waste generation and resource scarcity and to sustain economic benefits (Genovese et al., 2017b; Lieder and Rashid, 2016b).
8	Geueke, B., Groh, K., Muncke, J. (2018, p. 492)	The circular economy promotes closing loops in industrial systems, minimizing waste, and reducing raw material and energy inputs (European Environment Agency, 2016; Stahel, 2016). Over the past years, the concept has gained importance in policy making (EC, 2017; The Standing Committee of the National People's Congress China, 2008) and has been increasingly implemented in production, consumption and waste sectors all over the world (Ghisellini et al., 2016). Practical solutions aiming at a circular economy include eco-design, waste prevention programs, and extending the lifetime of products (European Environment Agency, 2016). "Reduce, reuse and recycle" are three important waste management options. The reduction principle targets the minimization of raw material use, energy input, and waste production whereas the reuse principle refers to the repeated use of products or components for their intended purpose (Ghisellini et al., 2016).

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Table 5 (*continued*)

#	Source	Definition
9	Nußholz, J.L.K. (2017, 1810, p. 1)	The circular economy is a paradigm that suggests a redesign of the current linear economic system, largely based on linear resource flows, towards closed-loop resource flows that can preserve the embedded environmental and economic value in products over time [3–5]. The circular economy has the potential to lead to increased resource efficiency and generate environmental gains through reduced raw material extraction and waste generation [3,6].
10	Fisher, O., Watson, N., Porcu, L., Bacon, D., Rigley, M., Gomes, R.L. (2018, p. 54)	The circular economy has emerged as an alternative economic model that supports growth, while minimising environmental impacts from production and consumption. The Waste and Resources Action Program charity offers a clear definition of the circular model: "A circular economy is an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life." [6]
11	Kjaer, L.L., Pigosso, D.C.A., Niero, M., Bech, N.M., McAloone, T.C. (2018, p. 22)	"The circular economy provides multiple value creation mechanisms that are decoupled from the consumption of finite resources" (Ellen MacArthur Foundation 2015a, 22). Circular economy (CE) is increasingly seen as a solution to tackle the current resource scarcity issue while ensuring economic growth and job creation (EC 2015). CE is often linked to the performance economy, where goods are sold as services through business models based on renting, leasing, and sharing, while the manufacturer retains ownership of the product (Stahel 2010). The idea of using "a mix of tangible products and intangible services designed and combined so that they are jointly capable of fulfilling final customer needs" (Tukker and Tischner 2006a, 1552) is at the core of the product/service-system (PSS) concept.
12	Hahladakis, J.N., Iacovidou, E. (2018, p. 1394)	With concepts such as dematerialisation, factor 4, factor 10, eco-efficiency and industrial ecology becoming ever increasingly attractive to businesses, getting the accreditation of becoming more 'sustainable' and/or 'green' requires a shift towards more systemic practices. This is what the circular economy (CE) aims to achieve of which systemic doing so are often overlooked or not properly accounted. However, these technicalities control to a large extent the successful transition from a linear to a circular economy; amongst them, the ability of materials, components and products (MCPs) to be properly recovered and redistributed for reuse, recycling, or recovery (Fig. 1).
13	Suárez-Eiroa, B., Fernández, E., Méndez-Martínez, G., Soto-Oñate, D. (2019, p. 953)	Sustained economic growth based on a linear production model is not feasible in a planet with finite resources and a limited capacity to absorb wastes (Bonciu, 2014). Despite efforts to address the ecological question since the 60′s, pressures on the global environment have been constantly growing (Valdivielso, 2008), and even some planetary boundaries have been already exceeded (Rockstrom et al., 2009; Steffen et al., 2015 €). In this context, circular economy (CE) is regarded as an alternative which may give rise to economic and ecological benefits (EC, 2014).
14	Van Eygen, E., Laner, D., Fellner, J. (2018, p. 55)	This is part of the broader initiative to increase resource efficiency and reduce resource dependency (EC, 2011), and plastics are one of the five priority areas in the EU action plan for the circular economy (EC, 2015b). This circular economy concept, which foresees a production and consumption system where materials are circulated as wastes are re-used, recycled and recovered, has been increasingly promoted by many governments and international organizations (EEA, 2014; Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2016; Ghisellini et al., 2016; Haas et al., 2015; Lieder and Rashid, 2016; Winans et al., 2017)
15	Rosa, P., Sassanelli, C., Urbinati, A., Chiaroni, D., Terzi, S. (2019, 1662)	CE is a commonly agreed term (Winans, Kendall, and Deng 2017). The CE is an industrial system that is restorative or regenerative by intention and design. This concept replaces the 'end-of-life' concept with restoration, shifts to the use of renewable energy, eliminates the use of toxic chemicals (which impair reuse), and aims for the elimination of waste through the superior design of materials, products, systems, and within this, business models (The Ellen MacArthur Foundation 2013; Bocken et al. 2016; Okorie et al. 2018). The CE allows the decoupling of economic growth from finite resource constraints, by providing opportunities for business regarding new ways of creating value, generating revenue, reducing costs, being resilient, and creating legitimacy (Manninen et al. 2018).
16	Naqvi, S.R., Prabhakara, H.M., Bramer, E.A., Dierkes, W., Akkerman, R., Brem, G. (2018, p. 118)	The developed industrial countries are generating a considerable amount of polymeric waste (Bhadra et al., 2017; Yazdanbakhsh et al., 2018; Holgersson et al., 2017; Das and Tiwari, 2018). The resources are depleted through a conventional process of materials which results in economic loss (Naqvi et al., 2018). The circular economy brought an emerging concept which restores and regenerates the material by an efficient design (Zhong and Pearce, 2018). This concept aims to protect products and materials at their highest effective utility while minimising negative impacts (Akanbi et al., 2018).
17	Akanbi, L.A., Oyedele, L.O., Akinade, O.O., Ajayi, A.O., Davila Delgado, M., Bilal, M., Bello, S.A. (2018, p. 176)	CE is defined "as a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops" (Geissdoerfer et al., 2017). Based on these definitions, CE is therefore a way of achieving sustainable development. Rashid et al. (2013) describe the implementation of circular economy principle in business models and supply chains as a requirement for sustainable manufacturing for enhanced economic and environmental performance of nations. The European Commission noted that circular economic systems are of immense benefit for sustainability development across Europe and encouraged member states to adopt it (COM, 2014). To promote the concept of CE in the built environment, the Waste and Resources Action Programme (WRAP) has provided a number of good practice guidance that must be embraced by the industry. These include BIM, design out waste, design for deconstruction, offsite construction, sustainable procurement, fairness, inclusion and respect (WRAP, 2013).
18	Kurilova-Palisaitiene, J., Sundin, E., Poksinska, B. (2017, p. 325)	Remanufacturing can be described as a series of manufacturing steps applied to an end-of-use part or product in order to return it to like-new or better performance, with warranty to match (CRR, 2007). Remanufacturing is becoming a critical element of a circular economy, where products are developed, manufactured, used, and recovered to prevent any sort of waste and reduce the extraction of raw materials.
19	Corona, B., Shen, L., Reike, D., Rosales Carreón, J., Worrell, E. (2019, 104,498, p. 2)	It is, therefore, important to agree with the definition and goals of CE before a CE strategy can be assessed. Here, we embrace the definition of CE proposed by Kirchherr et al. (2017, p. 229): "an

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Table 5 (*continued*)

#	Source	Definition
		economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers". We endorse this definition because it respects the waste hierarchy while connecting the CE concept with the ultimate goal of sustainable development.
20	Yadav, G., Luthra, S., Jakhar, S.K., Mangla, S.K., Rai, D.P. (2020, 120,112, p. 2)	Industry 4.0 specifically focuses on cyber physical systems to build smart factories for sustainable future; while circular economy mainly emphasises over the adoption of 6R's. amongst the organisations (Merli et al., 2018). Similarly, inclusion of industry 4.0 and circular economy practices in manufacturing organisations has become necessary if the organisation wants to compete at global level.
21	Rosa, P., Sassanelli, C., Terzi, S. (2019, 117,696, p. 2)	CE is often framed in the wider concept of sustainability (Merli et al., 2018). Considering the report of The Ellen MacArthur Foundation (2015), CE is defined as a global economic model minimizing the negative effects of finite resources consumption, by focusing on intelligent design of materials, products and systems. Inspired by the concept of closed-loop economy, the CE paradigm was introduced at the end of the '80 s (Pearce and Turner, 1991; Stahel et al., 1981) to minimise emissions, resource use, pollution and waste, and maximise the resource efficiency of material assets. However, only in the last years its relevance was amplified worldwide, by an increasing interest of people in environmental impacts of products and processes and the sustainable use of natural resources (Reuter et al., 2013). Before the introduction of CE, a traditional linear (open-ended) economy was the only existing paradigm, treating the environment as a waste reservoir (Su et al., 2013). Products followed a linear lifecycle that, starting from conceptualization and design, went through development, in service and finished with disposal. Progressively, these old production and consumption patterns have been substituted by closed-loop ones - completely focused on resource efficiency and waste reduction - able to better balance and harmonize economy, environment and societal needs.
22	Baldassarre, B., Schepers, M., Bocken, N., Cuppen, E., Korevaar, G., Calabretta, G. (2019, p. 447)	The Circular Economy (CE) is a concept based on ideas that date back decades and refers to an industrial system that is restorative or regenerative by intention and design (MacArthur, 2013). The CE may be defined as "a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" (Geissdoerfer et al., 2017; Lüdeke-freund et al., 2018). Ultimately CE is an umbrella concept based on five principles: design out waste, building resiliency through diversity, rely on renewable energy, waste is food, think in systems (Blomsma and Brennan, 2017; Lewandowski, 2016; MacArthur, 2013). Going a layer deeper, we find that the transition to a Circular Economy can be achieved through a framework based on three strategies, namely narrowing, slowing, closing resource loops and three pillars, namely technical innovation, business model innovation and collaboration (Bocken, de Pauw, Bakker and van der Grinten, 2016; Kraaijenhagen et al., 2016; McDonough and Braungart, 2002; Stahel, 1994).
23	Leal Filho, W., Ellams, D., Han, S., Tyler, D., Boiten, V.J., Paco, A., Moora, H., Balogun, A.-L. (2019, p. 11)	The reuse and recycling of textiles could be considered as a route to socioeconomic benefits and a means of boosting a nation's economy (Cuc and Vidovic, 2011). Indeed, the advocacy for a "circular economy" (Ellen McArthur Foundation, 2016), in which materials continue to circulate in the economic system in a cascade of reuse and recycling, has been gaining strength as it is translated into commitments made by policy, business and civil society representatives.
24	Garcia-Muiña, F.E., González-Sánchez, R., Ferrari, A.M., Settembre-Blundo, D. (2018, 255, p. 2)	Circular economy means a different approach to production methods. In other words, it goes from a linear process that sees the use of raw materials and the generation of production waste that is thrown away, to a model that regenerates itself, transforming what is commonly considered waste into a resource. A passage that is first and foremost cultural (Lieder and Rashid 2016). The transition to a circular economy is a revolution and an opportunity: It is a question of enhancing what is hidden in waste and production waste.
25	Lopes de Sousa Jabbour, A.B., Rojas Luiz, J.V., Rojas Luiz, O., Jabbour, C.J. C., Ndubisi, N.O., Caldeira de Oliveira, J.H., Junior, F.H. (2019, p,. 1526)	The circular economy (CE) is a system of production and consumption which aims to keep products, components, materials, and energy in circulation in order to continue adding, recreating, and maintaining their value over a long time period. The circular economy is restorative, regenerative, and disruptive to economic systems and, consequently, it involves changes in the structure of design and production (Esposito et al., 2018; Hopkinson et al., 2018).
26	Leipold, S., Petit-Boix, A. (2018, p. 1125)	In the European Union, the 'circular economy' has been introduced as a high-level strategy to move our societies beyond these limits (European Commisssion, 2015). In the eyes of European policy makers, the European business community plays a crucial role in this process. Scholarly work and political programs assume that businesses will take up political ideas and apply new business models and practices based on circular economy principles, thus moving our societies to a circular economy (Geissdoerfer et al., 2017).
27	Ghisellini, P., Ji, X., Liu, G., Ulgiati, S. (2018, p. 422)	According to Charonis (2012), CE cannot be considered an alternative to the economic growth model. However, it cannot be disregarded that CE is a type of green economy consistent with the "weak sustainability" path (Sauve et al., 2016). In fact, CE takes into account the relationships of the economic system with the environment (Naustdalslid, 2014) and provides an opportunity to design economic patterns aimed at increased efficiency of production (and consumption), by means of appropriate use, reuse and exchange of resources, and do more with less (Ghisellini et al., 2016).
28	Zucchella, A., Previtali, P. (2018, p. 275)	As a result of their literature analysis, the authors point out similarities and differences and provide a definition of circular economy "as a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" (ibid, p. 777). This paper acknowledges this definition, which enables the issue of the circular economy and its business models to be

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#	Source	Definition
		positioned as a specific field, with solutions aimed at "closing the loop of resources," inside the broader sustainability agenda.
29	Liu, Z., Adams, M., Walker, T.R. (2018, p. 22)	Early circular economy (CE) strategies were initially designed to focus on waste management, but gradually evolved to include more systematic approaches for the whole economy, largely driven by the Ellen MacArthur Foundation. Under current CE systems, products are designed to be restorative and regenerative, where products are utilized at their highest value. CE principles include the 3Rs (reduce, reuse, recycle), but have been extended to include the 6Rs (reuse, recycle, re-design, remanufacture, reduce, recover).
30	Gupta, S., Chen, H., Hazen, B.T., Kaur, S., Santibañez Gonzalez, E.D.R. (2018, p. 466)	Per the World Economic Forum (2014), circular economy is a concept that emphasizes a restorative and regenerative approach to business operations. It is fundamentally rooted in the preservation and enhancement of the natural resources, circulation of materials and used products along with explicating the negative externalities for increasing the effectiveness of overall sustainable business operations (World Economic Forum, 2014).
31	Zhang, A., Venkatesh, V.G., Liu, Y., Wan, M., Qu, T., Huisingh, D. (2019, 118,198, p. 1)	CE is now widely recognized as a sustainable alternative to the dominant linear (extract-make-dispose) economic model. A transition to CE requires a paradigm shift to an innovative and more sustainable supply chain ecosystem (Zanella et al., 2014; Farooque and Zhang, 2017; Batista et al., 2018).
32	D'Amato, D., Veijonaho, S., Toppinen, A. (2018, 101,848, p. 2)	The circular economy, rooted in five decades of ideas regarding industrial ecology and metabolism, is focused on improving the efficiency and recycling capacity of the current consumption-production system through input reductions, eco-design, improved practices, waste reuse and recycling (Kirchherr et al., 2017; Korhonen et al., 2018b; Murray et al., 2015; the Ellen MacArthur Foundation, 2012).
33	Alcayaga, A., Wiener, M., Hansen, E.G. (2019, p. 622)	The emerging concept of the Circular Economy (CE) has been proposed as an alternative to replace the current linear system of production by placing emphasis on systems redesign and cyclical closed-loops (Murray et al., 2017). It holds great potential for developing more sustainable business practices that reduce the environmental and social impacts of the business-as-usual scenario (Ghisellini et al., 2016) and could drastically change the way products are designed, produced, used and brought back into circulation. The operationalisation of the CE covers a group of activities or circular strategies that intend to extend the product lifetime and close materials flows (Blomsma and Brennan, 2017). However, there are implementation gaps, e.g., the lack of information transparency along the value chain (EMF, 2016) and the transactional style of common sales operations (Stahel, 2010), that hinder its full deployment. In this context, the pervasive connectivity of the Internet of Things (IoT) is a promising development to address implementation challenges, as it is unlocking new opportunities for businesses to gain insights about their products and customers during and beyond the use phase
34	Sousa-Zomer, T.T., Magalhães, L., Zancul, E., Cauchick-Miguel, P.A. (2018, p. 3)	The concept of circular economy (CE) has been proposed as a promising economic avenue for addressing current environmental and socio-economic issues and creating a more sustainable society (Witjes and Lozano, 2016). In a CE, production is circular, i.e., raw materials and products re-enter the environment or are reused in successive production cycles (Ruggieri et al., 2016). As such, the CE system can be seen as environmentally and economically regenerative (Lieder and Rashid, 2016). Although the CE concept has become widespread, it has rarely been discussed in the business and sustainability literature (Murray et al., 2015). In fact, the adoption of CE around the world is still in its infancy, especially at the micro-level, mainly focusing on recycling rather than reuse (Ghisellini et al., 2016). Implementing practices aligned with CE concerns can transform the way companies do business, especially in the manufacturing sector (De los Rios and Charnley, 2016). The shift to a CE is associated with the need to implement innovative business models (Ruggieri et al., 2016), yet the adoption of such models in the industry has thus far been limited (Linder and Williander, 2017; Witjes and Lozano, 2016).
35	Giampietro, M. (2019, p. 144)	All the same, Kirchherr et al. report substantial agreement on the general message associated with the definitions scrutinized and provide a synthesis (rather than providing their own): "A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively re-using, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro-level (products, companies, consumers), meso-level (eco-industrial parks) and macro-level (city, region, national and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations" (Kirchherr et al., 2017).
36	Jakhar, S.K., Mangla, S.K., Luthra, S., Kusi-Sarpong, S. (2019, p. 904)	In recent years, industries are struggling to maintain a balance between their ecological impacts, people welfare and cost benefits in a value chain context. This drives managers to employ circular economy (CE) concepts to optimize resources and manage carbon emissions (Winans et al., 2017; Urbinati et al., 2017). Currently, industries are doing business by using the concepts of linear economy – make, use and disposal of products. Resource (material) flow is an imperative concept of value chain that allows manufacturer to produce required products. In management science, researchers and practitioners submitted linear production model as a mean of resource wastage in several ways. Considering, for example, waste generated during production processes, end-of-life waste and excessive use of energy. In view of growing need of resource depletion rates, industries needs to revolutionize for some novel economic model – CE facilitates in building a resource efficient and regenerative model by optimizing the resource used and waste generated (Guo et al., 2017; Mangla, Luthra, Mishra, Singh, Rana, Dora and Dwivedi, 2018).
37	Gu, Y., Wu, Y., Xu, M., Wang, H., Zuo, T. (2017, p. 347)	Circular economy (CE) is an increasingly popular regulatory policy to address resource scarcity and environmental pollution (Boulding, 1966; Ellen MacArthur Foundation, 2015; Geng et al., 2012). The Chinese government has introduced CE as a national regulatory policy and comprehensively promoted the CE development since 2005. In particular, China is ambitiously developing a new "Waste Resource Utilization Industry (WRUI)" to achieve economies of scale

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#	Source	Definition
		for secondary resource recycling. By the end of 2014, China had constructed 49 urban mineral demonstration bases, the main WRUI business income had achieved $55.8 billion (CNRRA, 2015), and more than 15 million laborers obtained employment opportunities in this industry (China Ministry of Commerce, 2015). The recycling of waste materials has strong positive externalities for resource recovery and environmental protection (Cao et al., 2016; Wen et al., 2015). To achieve a sustainable recycling-orientated CE system, there must be a means to guarantee that the externalities can be internalized (this will lead to the achievement of average profit by recycling companies). Otherwise, such a program will become a government burden and cause a serious fiscal deficit.
38	Kouhizadeh, M., Zhu, Q., Sarkis, J. (2020, p. 950)	CE principles seek to add value to materials and products, maximise their life-cycle length and regenerate them at their end-of-life. In most cases, transition to a circular economy requires rethinking and redesigning business models and routines. Digital technologies leverage this transition through data collection, analysis and integration (Pagoropoulos, Pigosso, and McAloone2017). Our basic supposition, for which we support in this article, is that blockchain is an emergent technology that can support the CE paradigm. We analyse the linkage of these two concepts. Although CE has been linked to a variety of other technological innovations, especially under the guise of Industry 4.0 (Jabbour et al.2019; Tseng et al.2018), we delve a bit deeper in this study. Some may consider blockchain technology to be within this umbrella term of Industry 4.0, but the breadth of the concept requires nuanced investigation as a complementary technology
39	Bao, Z., Lu, W. (2020, 138,264, p. 2)	Going beyond the 3Rs is the concept of the circular economy. Defined as "an industrial economy that is restorative or regenerative by intention and design" (EMF, 2013), it critiques the traditional linear economy and advocates proactive strategies, such as zero-waste design, restoration, and regeneration, organized in a closed loop. While achievement of the circular economy is a long way off, considerable progress has been made in developed countries. In Europe, for example, some countries have achieved zero or near zero landfilling, such as UK (Phillips et al., 2011), Netherlands (Scharff, 2014) and Germany (Aniekan and Ikechukwu, 2016).
40	Bernon, M., Tjahjono, B., Ripanti, E.F. (2018, p. 484)	The term CE is described by the Ellen MacArthur Foundation (EMF) as an industrial economy that is restorative and regenerative, aimed at keeping products, components and materials at their highest utility and value at all times. Unlike the linear economy model of 'take, make, dispose', CE aims to minimise the consumption of finite resources and raw materials in the manufacture of products. CE can be seen as an effort to foster sustainability and environmental protection, but the main difference between CE and sustainability is that CE puts emphasis on the maximum circulation of the content of end-of-life products, back to the point of production and use, in addition to reducing the environmental impact. Both technical and biological materials from end-of-life products will be properly treated, so that if inevitable, these materials can safely be released into the biosphere. The ultimate goal of CE is therefore twofold: maximising the recirculation and minimising the contents that could end up in landfill or incineration.
41	Bressanelli, G., Adrodegari, F., Perona, M., Saccani, N. (2018, p. 216)	The concept of Circular Economy (CE) has reached increasing attention amongst academia and practitioners as a mean to promote sustainability [1], since it aims to decouple economic growth from resource extraction and environmental losses [2]. Indeed, recent studies advocate that the application of the CE principles may increase the European GDP of about 11%, bringing to a net benefit of about € 1.8 trillion by 2030 without compromising the environment. In this context, Product-Service Systems (PSS) business models (BMs), in which the function or the utilization of a product is sold instead of the product itself, have been recognised as one possible enabling factor of the CE paradigm into companies [2–4].
42	Kane, G.M., Bakker, C.A., Balkenende, A.R. (2018, p. 38)	One of the core principles of the circular economy is that the value of products and the materials they are made of can be preserved by keeping them in the economic system, either by lengthening the life of the products formed from them, or "looping" them back in the system to be reused (Hollander et al., 2017).
43	Prieto-Sandoval, V., Ormazabal, M., Jaca, C., Viles, E. (2018, p. 1525)	One globally accepted solution is the circular economy (CE), a paradigm that aims to generate economic prosperity, protect the environment and prevent pollution (Prieto-Sandoval, Jaca García, & Ormazabal Goenaga, 2016). Within this paradigm, resources are taken from nature, transformed into products, distributed in the marketplace, consumed and then recovered through biological and technical cycles (McDonough & Braungart, 2002). In so doing, the flows of materials are closed, waste in industrial ecosystems is minimized, and symbiosis is fostered (Stahel, 2016). This economic model does not reject economic growth, but sets limits on the exploitation of resources; if human societies pursue growth, they should be limited to the closed-loop of resources and energy, with a minimum amount of emissions (Prieto-Sandoval, Jaca García, & Ormazabal Goenaga, 2016).
44	Mak, T.M.W., Xiong, X., Tsang, D.C.W., Yu, I.K.M., Poon, C.S. (2020, p. 122,497)	Circular economy" is defined as conservation of product value, materials and resources in the economy for a long period with the reduced waste generation, according to Circular Economy Action Plan (European Commission, 2015a). Raw materials including fossil carbons, minerals, metals, biomass will be produced to products, traded, utilised and then enter the waste hierarchy by sharing, reusing, redistributing and recycling (Carus and Dammer, 2018) (as illustrated in Fig. 1).
45	Hebrok, M., Heidenstrøm, N. (2019, p. 1435)	The concept of the 'circular economy' is central to European environmental thinking and policy making, and the transition to a more circular economy is a major goal toward developing a sustainable, low-carbon, resource-efficient and competitive economy in the EU (European Commission, 2015). The hope is that having a circular economy will help address the environmental impact of consumption and the linear path of acquisition, use and disposal; the aim here is to keep all materials within infinite loops, reducing waste and the use of virgin materials. The concept of a circular economy also encompasses waste prevention, which is

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#	Source	Definition
		placed at the top of the waste hierarchy. Thus, in the Circular Economy Action Plan (European Commission, 2015), it is stated clearly that food waste prevention is a priority area.
46	Lin, K.-Y. (2018, p. 730)	The circular economy has gradually developed from a narrow focus on waste to a wide range of economy-orientated activities in the closed raw material cycle, including production, distribution, and consumption (Su, Heshmati, Geng, & Yu, 2013). In the new circular economy (Ghisellini, Cialani, & Ulgiati, 2016), restoration and stabilization of waste and reuse of raw materials in the supply chain leads to economic growth to avoid environmental damage. The three guidelines for implementing the circular economy—reduction, reuse, and recycling—are related to raw materials and energy.
47	Zhu, J., Fan, C., Shi, H., Shi, L. (2018, p. 110)	Circular economy (CE) is certainly a catchphrase in recent years. It represents efforts to develop new business models that decouple of economic development from resource extraction and environmental impacts, differing from the traditional linear model of "take, make, dispose" (Ellen MacArthur Foundation 2013, 14–20)
48	Kümmerer, K., Clark, J.H., Zuin, V.G. (2020, p. 369)	In a CE, products should be used as long as possible until the end of their lives. Modern circularity thinking includes the design of products with adapted lifetime, reusability, ease of repair, and recycling ability—all made with renewable resources (3). The development and implementation of CE approaches in China (4), the United States (5), the European Union (1), and other countries (6) are supported by international organizations such as the World Health Organization (WHO) and the United Nations (UN) (2). These efforts will help address Earth's resource and waste challenges and contribute to sustainable development. However, greater success will have to come from changes at the product-design level, led by scientists who strive to decipher, at the atomic and molecular levels, how chemical products and their underpinning synthetic chemistry fit into a CE.
49	Mishra, J.L., Hopkinson, P.G., Tidridge, G. (2018, p. 509)	A formal definition of a circular economy as used in this paper is one that is 'restorative and regenerative by design, and aims to keep products, components, and materials at their highest utility and value at all times distinguishing between technical and biological cycles'.1 It is an economy designed to preserve and enhance natural capital, optimise resource yields, and minimise system risks by managing finite stocks and renewable flows (Webster 2013, 2015).
50	Sharma, Y.K., Mangla, S.K., Patil, P.P., Liu, S. (2019, p. 997)	Circular economy helps managers to focus on the economic, social and environment gains in a supply chain context (Hamprecht et al., 2005; Ross et al., 2012). Circular economy-based sustainability initiatives help to reduce the food wastage and impact of pollution and improve the overall performance through various R's (recycle, reuse, reduce, etc.) (Yong, 2007; Geng et al., 2013; Govindan and Hasanagic, 2018). Circular economy-based sustainability aspects also help in providing safer and higher quality food to the customers (Beske et al., 2014). Circular economy and sustainability may be implemented by up-gradating and modifying the existing technologies and processes in an FSC context. Circular economy helps organisations to reuse natural resources to extract the maximum value from them (Bergstrom and Randall, 2016; Bag et al., 2018). In a circular economy, product and its material are recovered, regenerated and reused at the end of their life. Circular economy may help organisations in achieving business sustainability in terms of higher material cost savings, improved brand image and increased profits
51	Salim, H.K., Stewart, R.A., Sahin, O., Dudley, M. (2019, p. 538)	Circular economy philosophy attempts to close the supply chain loop by reducing the need for virgin materials via reuse or recycle of existing materials (Sica et al., 2018). The paradigm uses eco-design and "Reduce, Reuse, Recycle" principles to minimise waste throughout a product's life-cycle (Kalmykova et al., 2018). Integrating the life-cycle perspective within the circular economy paradigm will shape PV systems as a truly sustainable source of energy
52	Gopinath, A., Bahurudeen, A., Appari, S., Nanthagopalan, P. (2018, p. 90)	Although 'circular economy' and 'sustainability' are two different concepts, both integrate noneconomic aspects into the development model with a system change/design at their core (Geissdoerfer et al., 2017). Almost all the industrial shifts towards a circular economy tend to be sustainable by virtue of its resource re-utilisation feature. These terms have become especially important for developing economies such as China, India, and Brazil since the success of the clean development mechanism (CDM) defined in the Kyoto protocol for sustainable development would largely hinge on the active involvement of these fast growing countries (Dechezlepretre et al., 2009).
53	Moktadir, M.A., Ahmadi, H.B., Sultana, R., Zohra, F.-T., Liou, J.J.H., Rezaei, J. (2020, 119,737, p. 2)	To incorporate the CE practices in supply chains, initially, the "3R" principles were introduced to reduce, reuse and recycle of the energy and materials consumptions (Huang et al., 2018; Wichai-utcha and Chavalparit, 2019). Currently, to improve the supply chain activities, 6R policies are introduced to literature, where additional three dimensions such as recover, redesign and remanufacture are considered (Ghisellini and Ulgiati, 2020). This 6R policy has become popular in developed countries and better results of the supply chains practices have been achieved. In addition, there are several concepts of CE that are existing in the literature, such as cradle to cradle (C2C) (Peterson, 2004), reverse logistics (Lu et al., 2020), closed loop supply chain (Mohtashami et al., 2020) and blue economy (Pauli, 2011).
54	Jacobi, N., Haas, W., Wiedenhofer, D., Mayer, A. (2018, p. 156)	The Circular Economy (CE) – viewed as concept by some, as framework by others – is being promoted as an alternative to the traditional take-make-dispose linear economy, aiming to keep products, components and materials at their highest utility and value at all times (Bocken et al., 2017, p. 476). The CE has received increased attention in recent years by policy makers, industry and science. In the last decade or so, countries such as China, Japan, Germany and more recently, the European Union, have explored options to transition from linear- to circular economies, with varying degrees of success (Gregson et al., 2015; Mathews and Tan, 2016, 2011; McDowall et al., 2017; Ohnishi et al., 2016). Some proponents of the CE have stressed the economic benefits from increased reuse and recycling and were instrumental in establishing basic concepts with regard to circularity strategies (Bocken et al., 2017; Ellen MacArthur Foundation, 2014; Preston, 2012)
55	Bag, S., Gupta, S., Kumar, S. (2021, 107,844, p. 2)	This is possible through the development of advanced manufacturing capabilities using 10 R-based manufacturing approaches such as refuse, rethink, reduce, reuse, repair, refurbish,

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#	Source	Definition
		remanufacture, repurpose, recycle and recover options that can provide opportunities for cleaner production in the circular economy based business model and help firms to achieve a competitive edge over their competitors (Kirchherr et al., 2017)
56	Araujo Galvão, G.D., De Nadae, J., Clemente, D.H., Chinen, G., De Carvalho, M.M. (2018, p. 79)	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]
57	Julianelli, V., Caiado, R.G.G., Scavarda, L.F., Cruz, S.P.D.M.F. (2020, p. 1)	The production and consumption practices that follow the "take-make-dispose" flow have negatively impacted the environment over time. This has propelled the society to evaluate and seek sustainable development options, where Circular Economy (CE) emerged as a relevant concept. This embraced the accountability for reverse logistics of the end-of-life products, which is seen as a costly and complex effort to be managed.
58	Olabi, A.G. (2019, p. 450)	"Circular Economy where nothing is wasted and where natural resources are managed sustainably, and biodiversity is protected" [1]. Ref [2] discussed different points such as: energy efficiency in buildings, industrial process and transport, bio based economy focused on bio based chemicals
59	Sönnichsen, S.D., Clement, J. (2020, p. 2)	Circular economy minimizes incineration and landfill; is regenerative and restorative by design; operates by default on renewable energy; maintains resources at their highest value at all times; inherently has a higher complexity than linear transactional value chains; and thus embeds a potential to decouple growth in the extraction of virgin resource from monetary growth (Ellen MacArthur Foundation, 2013; Webster, 2017). Accordingly, the circular economy addresses the United Nations Sustainable Development Goals, specifically goals 6e9 and 11e17 (UN, 2017; Sachs et al., 2017), indicating that a circular economy helps to meet the needs of the present without compromising the needs of the future (WCED, 1987).
60	Garmulewicz, A., Holweg, M., Veldhuis, H., Yang, A. (2018, p. 112)	The circular economy is conceptualized as an economic model for closed-loop production and consumption systems, where waste is designated a valuable resource, and economic growth and resource use are decoupled. The concept of a circular economy has its roots in ecological economics and industrial ecology scholarship [1], and it has been recently articulated as a set of principles for economic development and business model design involving product maintenance, reuse, remanufacture, and recycling and the broad cycling of material flows [2].
61	Ünal, E., Urbinati, A., Chiaroni, D., Manzini, R. (2019, p. 291)	As such, the business domain has mainly adopted the concept of circular economy as a lever for new ways of creating value, which is a core dimension of their business model (Bocken et al., 2018; Manninen et al., 2018). The antecedents of the circular economy approach are found in the fields of industrial ecology and cradle-to-cradle (C2C), mainly focusing on closed-loop flows of materials and a novel design for products (McDonough and Braungart, 2002; Stahel, 1994). The core idea of circular economy is the decoupling of economic growth from natural resources and negative social impact (Murray et al., 2015). Similarly, it has been studied as a sustainable development initiative (Korhonen et al., 2018) that represents "new concepts of system, economy, value, production, and consumption" (Murray et al., 2015, p. 373).
62	Paletta, A., Leal Filho, W., Balogun, A.-L., Foschi, E., Bonoli, A. (2019, 118149p. 2)	Geissdoerfer et al. (2017) claim that the most prominent circular economy definition has been provided by the Ellen MacArthur Foundation (2013), which reads: "(CE) is an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with re-storing, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impede reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models". This definition makes it clear that the operating model of circular economic systems must not be confused with a new waste management system. The circular approach implies a much more forward-looking business model and economic behaviour (investment, production and consumption), where recycling is only one of the possibilities (Raworth, 2017). We need to rethink the whole life cycle of products and materials, from their design to technologies and production systems up to distribution, consumption, collection, recycling, and final disposal methods. Also, health issues should be taken into account (Leal Filho et al., 2019b).
63	Ngan, S.L., How, B.S., Teng, S.Y., Promentilla, M.A.B., Yatim, P., Er, A.C., Lam, H.L. (2019, p. 316)	CE which overcomes the constraints of the linear economy of production, consumption and disposal is deemed to be one of the best remedies for sustainable development. In general, CE promotes cyclical resources flows in the production-consumption system. The system is designed to be restorative and regenerative on its own like the cycle and can be applied on a different scale, from micro-level to meso-level as well as macro-system [21]. CE is not a minor change or modification to be added at a certain stage of the industry life-cycle. Rather, it is a fundamental systemic change, regardless of industry, location, scale, nature of business etc. [7]. It proposes a new type of economic growth that involve new business model creation and job opportunities that focus on reducing dependence on the supplier for the supply of material, saving materials' cost, dampening price volatility [22].
64	Garcés-Ayerbe, C., Rivera-Torres, P., Suárez-Perales, I., Hiz, D.I. (2019, 851, p. 1)	The Circular Economy is a paradigm shift attempting to replace the end-of-life concept with reducing, reusing, recycling and recovering materials and to slow down, close and narrow material and power loops.
65	Blank, L.M., Narancic, T., Mampel, J., Tiso, T., O'Connor, K. (2020, p. 212)	The envisaged circular economy requires absolute carbon efficiency and in the long run abstinence from fossil feedstocks, and integration of industrial production with end-of-life waste management.
66	Desing, H., Brunner, D., Takacs, F., Nahrath, S., Frankenberger, K., Hischier, R. (2020, 104,673, p. 1)	As its name suggests, CE refers to a model of production and consumption that introduces a fundamentally different perspective from the dominant "linear economy" model (Sauvé et al., 2016); it is often presented as an alternative to the current "take-make-dispose" or "extract-produce-consume-trash" industrial model (amongst many others: Ellen MacArthur Foundation (2015); Ghisellini et al. (2016)). By conceiving end-of-life materials and products as resources rather than waste, it aims at closing the loops of materials, reducing the need for raw materials and waste disposal, following the example of ecosystems (Elia et al., 2017).
67	Kirchherr, J., Piscicelli, L. (2019, 104,406, p. 1)	The circular economy (CE) can be defined as a concept whose implementation entails reducing the consumption of raw materials, designing products in such a manner that they can easily be taken apart and reused after use (eco-design), prolonging the lifespan of products through

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Table 5 (*continued*)

#	Source	Definition
		maintenance and repair, using recyclables in products, and recovering raw materials from waste flow (van Buren et al., 2016).
68	Teigiserova, D.A., Hamelin, L., Thomsen, M. (2019, p. 423)	Circular economy principles aim at reducing externalities by directly substituting primary with secondary resources. As the circular economy is one of the strategies pinpointed for sustainable economic growth, these circular systems should support job creation and overall business creation, and maintain competitiveness on the market through diversification as mentioned in the Global SDG Indicators (UN, 2017)
69	Paes, L.A.B., Bezerra, B.S., Deus, R.M., Jugend, D., Battistelle, R.A.G. (2019, 118,086, p. 2)	From the perspective of CE supporting sustainable economic development, Stahel (2006) argues that China's CE adoption establishes great strategies for the 21st century. The CE perspective supports eco-industrial initiatives creating a closed loop for industrial wastes (Mathews and Tan, 2011). Zhu et al. (2011) point out that this perspective allows for economic development similar to the natural system regarding materials and energy flows, with less environmental burdens and resource consumption. CE plays a vital role in waste management by emphasizing recycling of materials and energy and turning them into valuable resources for another actor (Zhu et al., 2011).
70	Alobwede, E., Leake, J.R., Pandhal, J. (2019, p. 114)	The European Commission disclosed a legislative proposal in March 2016 on organic and waste-based fertilisers as part of their Circular Economy Action Plan (European Commission, 2016). The aim is to promote resource efficiency with regards to the fertiliser sector in order to create new business opportunities for farmers, as well as help them become more competitive in recycling organic nutrients compared to purchasing inorganic fertilisers (European Economic and Social Committee, 2016). It seeks to reduce waste, energy consumption and environmental damage (Messenger, 2016).
71	D'Amato, D., Droste, N., Winkler, K.J., Toppinen, A. (2019, p. 460)	CE draws on the ideas of industrial ecology and industrial metabolism, promotes reduction and efficiency in resource use, reuse and recycling of industrial outputs, and prolonging product lifetime. Engineering-driven innovation forms the foundation of such industrial changes, as identified in comprehensive literature reviews by Kirchherr et al., (2017); Prieto-Sandoval et al. (2018)
72	Daú, G., Scavarda, A., Scavarda, L.F., Portugal, V.J.T. (2019, 3259, p. 1)	The circular economy concept, discussed in many studies [1–3], allows the identification of the opportunities from the fourth industrial revolution and sustainable practices [4,5]. Industry 4.0 inserted disruptive technologies and it can be present in the circular economy. The Internet of Things (IoT) and the Internet of Services (IoS) are some of the examples of these disruptive technologies. The triple bottom line (environment, society, and economy) leads to the 3R concept of the recreate, the recycle, and the reuse [6]. The aim to transform the linear concept in a circular one is reinforced, allowing a wider sense of motion to the process by changing it into a cycle. Ranta et al. [7] affirm that sustainable practices are alternatives for the transition between the two economy concepts. This cycle enables the possibility to have the reverse process, delivering a product that is transformed either to the supplier as to the consumer. Therefore, it means to affirm that this cycle absorbs and enables reverse logistics.
73	Demirel, P., Danisman, G.O. (2019, p. 1608)	Circular economy (CE) emphasizes a shift away from the linear economic production and consumption models of "take-make-use-dispose" towards circular systems and business models where the objective is to eliminate waste of all kinds.
74	Mishra, S., Singh, S.P., Johansen, J., Cheng, Y., Farooq, S. (2019, 813)	In view of the growing environmental problems and consumption of non-renewable resources, there is a need for the transition from linear to circular economy which focuses on waste reduction and closely monitors the consumption of resources by encouraging practices such as reuse, recycle, remanufacturing and refurbishment
75	de la Caba, K., Guerrero, P., Trung, T.S., Cruz-Romero, M., Kerry, J.P., Fluhr, J., Maurer, M., Kruijssen, F., Albalat, A., Bunting, S., Burt, S., Little, D., Newton, R. (2018, p. 87)	This has more recently been adopted into the "circular economy" philosophy (Genovese et al., 2017). The essential principles of the circular economy are to reduce resource use and environmental emissions by "closing the loop" of production (Jurgilevich et al., 2016).
76	Meys, R., Frick, F., Westhues, S., Sternberg, A., Klankermayer, J., Bardow, A. (2020, 105,010, p. 1)	The challenges are addressed by governmental institutions and scientists through shifting towards a circular economy. The circular economy redesigns man-made systems to align economic and environmental well-being by recycling and thus, circulating material flows (Reichel et al., 2016).
77	Sharma, A., Foropon, C. (2019, p. 1019)	Over the years, more and more entities are transitioning toward a resource-efficient circular economy (Domenech and Bahn-Walkowiak, 2019), where the main idea consists of creating a regenerative system where products, components and materials are maintained at their highest value for as long as possible and resources can be productively recovered and reintegrated in the economy (Webster, 2015). This concept of circular economy involves a systemic change that encompasses innovation and technology systems but also policies, society, business models and finance (European Commission, 2015)
78	Magnier, L., Mugge, R., Schoormans, J. (2019, p. 84)	Following the principles of circular economy, plastic debris collected in the oceans can re-enter the production loop. Circular economy covers all activities that reduce, reuse and recycle materials in production, distribution and consumption processes (Blomsma and Brennan, 2017). Companies and manufacturers are encouraged to follow these principles and to use more recycled plastic materials (MacArthur Foundation, 2016; Mestre and Cooper, 2017).
79	Jaeger, B., Upadhyay, A. (2019, p. 730)	The CE model is based on the concept of changing the take-make-use-dispose pattern into closed loops of material flows. Closed loops of materials are possible through different functions i.e. maintenance, repair, reusing, refurbishing, remanufacturing and recycling. This creates the synergy effect between economic development and the environment (Masi et al., 2017
80	Mendoza, J.M.F., D'Aponte, F., Gualtieri, D., Azapagic, A. (2018, p. 463)	Although this is by 192,000 t lower than for the standard diapers, disposable diapers follow a linear economy based on take, make, use and dispose as opposed to a circular economy where products are reused and recycled in closed-loop systems (EMF, 2015). Thus, product light-weighting and cleaner production should be complemented with circular economy strategies to maximise the overall resource efficiency and sustainability of the diaper industry
81	Woern, A.L., McCaslin, J.R., Pringle, A.M., Pearce, J.M. (2018, 26, p. 2)	Rather than follow a linear model of materials use, a circular economy model can be used to provide sustainability by separating economic growth from resource consumption [6,7]. Thus, recycling, is now established in the circular economy as the optimum treatment of postconsumer

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#	Source	Definition
		plastics [8]. Unfortunately, there can be significant environmental impacts from the collection and transportation of relatively low-density waste plastics to collection centers and reclamation facilities for separation and reconstruction in traditional recycling [9,10].
82	Saeli, M., Tobaldi, D.M., Seabra, M.P., Labrincha, J.A. (2018, p. 1188)	Therefore, product and waste management including the reuse, recycling, and valorisation of wastes and by-products has recently become a cost-effective solution to transform high volume, low quality, zero- or low-cost materials into high-value products, with a view to improving the Circular Economy (European Parliament C, 2008; Kumar, 2008).
83	Muñoz-Torres, M.J., Fernández-Izquierdo, M., Rivera-Lirio, J.M., Ferrero-Ferrero, I., Escrig-Olmedo, E., Gisbert-Navarro, J.V., Marullo, M.C. (2017, 535, p. 4)	There is no generally accepted definition of circular economy; however, there is a general understanding of the basic characteristics that the circular economy model includes [28]: (i) it is based on closing loops by feeding waste back into production processes and aspires to become a replacement for the linear economic model "take, make and dispose"; (ii) it aims to decouple economic growth from environmental degradation; (iii) it is less dependant on external inputs and outputs and is more resilient; and (iv) it aims to maximize ecosystem function and human well-being, although its relationship with the social dimension is under discussion. In addition, the circular economy regards the supply chain as a critical unit of action for its implementation [28], given the necessity of clear acceptance and support of the model by and for all members of the supply chain.
84	Charles, R.G., Davies, M.L., Douglas, P., Hallin, I.L., Mabbett, I. (2018, p. 1208)	Fig. 3 shows the essential features of the circular economy, an alternative to current 'take-make-use-dispose' linear economic models. Retention of materials within the economy through recovery and regeneration of products at the end of each service life maximises their economic productivity, offsetting demand for primary resources and decoupling growth from resource consumption. Circular economy is regenerative by design and replaces the concepts of 'end-of-life' and 'waste' with 'restoration' and 'resources'. Key features include elimination of waste through industrial symbiosis, superior product design, appropriate business models and reverse logistics systems [14]. The economic benefits of a circular economy are expected to become increasingly important into the future as the costs of primary raw materials, and safe disposal, rise [16].
85	Chiappetta Jabbour, C.J., De Camargo Fiorini, P., Wong, C.W.Y., Jugend, D., Lopes De Sousa Jabbour, A.B., Roman Pais Seles, B.M., Paula Pinheiro, M.A., Ribeiro da Silva, H.M. (2020, 101,596, p. 1)	The circular economy (CE), according to Korhonen et al. (2018, p.39), is "an economy constructed from societal production-consumption systems that maximizes the service produced from the linear nature-society-nature material and energy throughput flow". Therefore, the CE can pose a solution to the aforementioned dilemma. The CE is implemented through the use of cyclical material flows, renewable energy sources and cascading energy flows (Korhonen et al., 2018). The CE concept provides new opportunities and business models for firms, such as the sharing economy (SE), which is one of the most important business models developed from the CE concept, and which is already starting to be used on a large scale in a number of sectors
86	Smol, M., Adam, C., Preisner, M. (2020, p. 682)	The CE concept is a global strategy which was introduced first into China in 2002 [2, 3] as the key strategy for the national development plan [4, 5]. In the European economy [6], the CE concept was adopted in 2014 in the first communication concerning the CE 'Towards a circular economy: a zero waste programme for Europe' [7]. The European Commission (EC) defined the CE as a 'system which keeps the added value in products for as long as possible and eliminates waste'. In 2015, in the second communication 'Closing the loop—An EU action plan for the Circular Economy' [8] an extended definition was provided: 'CE is a system where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste is minimised'. In the given definitions, two important aspects play a key role— more rationale use of resources and waste management. It should be noted that the improvement actions should be targeted at all groups of resources and waste, in every branch of industry.
87	Jaca, C., Prieto-Sandoval, V., Psomas, E.L., Ormazabal, M. (2018, p. 201)	The circular economy (CE) paradigm has become the most promoted way to achieve sustainable development by policy makers around the world and included in the European Union agenda (EU Commission, 2014). Moreover, the CE does not go against economic growth but instead proposes closing the cycles of energy and materials to make an intensive use of the available resources, instead of continuing to exploit them and increasing the damage to the environment. Additionally, the CE offers new business opportunities related to the design of eco-innovative products and services in the market (Prieto-Sandoval et al., 2017; Ülkü and Hsuan, 2017).
88	Buyle, M., Galle, W., Debacker, W., Audenaert, A. (2019, p. 142)	The CE aims to overcome the divergent interests of economic and environmental prosperity by closing material loops through technological innovation, including recycling and reuse, as well as by introducing new business models, relying on sale-and-take-back or lease contracts (Ellen MacArthur Foundation, 2015).
89	Chamberlin, L., Boks, C. (2018, 2070, p. 1)	An exact definition of circular economy still lacks consensus, but it is generally agreed that current business models, products and services must be redesigned so that 'linear' models ending in waste are replaced by those incorporating durability, re-use, repair, refurbishment, and recycling [2]. In the case of business models, one-off sales would be replaced by access or rental, often referred to as product service systems or PSS [3].
90	Lindgreen, E.R., Salomone, R., Reyes, T. (2020, 4973, p. 1)	Many definitions of CE are available [4]. One of the primary goals of establishing a CE has been described as decoupling global economic development from finite resource consumption by introducing closed resource loops, leading to reduced environmental degradation and positive social impacts while stimulating economic growth [5,6]. While the various roles of actors in moving towards a CE have not been formalized in literature, companies are expected to drive this transition [7], since firms are the entities that transform resources such as raw materials (natural capital) into goods and services (man-made capital) [8,9]. A new field of research focuses on understanding how to assess CE at micro (products, firms), meso (industrial symbiosis networks), and macro (city, country, and beyond) level [10].
91	Nandi, S., Sarkis, J., Hervani, A.A., Helms, M.M. (2021, p. 11)	The circular economy is focused on eliminating waste and overuse of resources. CE economic systems stress reuse, repair, and recycling in a closed-loop system to reduce inputs, pollution, and other wastes while minimizing carbon footprints. Morseletto (2020) defines the circular economy as "an economic model aimed at the efficient use of resources through waste

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#	Source	Definition
		minimization, long-term value retention, reduction of primary resources, and closed loops of products, product parts, and materials within the boundaries of environmental protection and socio-economic benefits." The circular economy can lead to sustainable development while reducing or eliminative the negative consequences of environmental degradation and resource depletion (Murray et al., 201; Babbit et al., 2018; Hofman, 2019)
92	Helander, H., Petit-Boix, A., Leipold, S., Bringezu, S. (2019, p. 1278)	For instance, the European Union (EU) adopted an action plan for CE in 2015 (European Commission [EC], 2015), followed by the "Circular Economy package" in January 2018 (EC, 2018a). This EU policy aims for long-term economic growth, prevention of resource scarcity, and environmental protection. In terms of environmental sustainability, the action plan states that CE will "help avoid the irreversible damages caused by using up resources at a rate that exceeds the Earth's capacity to renew them […]" (EC, 2015, p. 2).
93	Selvefors, A., Rexfelt, O., Renström, S., Strömberg, H. (2019, p. 1014)	A move away from today's linear take-make-waste logic to a circular economy is one approach argued to not only have the potential to reduce the associated negative environmental impacts but also to be beneficial for businesses and people (Ellen MacArthur Foundation, 2013; European Commission, 2014; United Nations, 2016).
94	Rodriguez-Anton, J.M., Rubio-Andrada, L., Celemín-Pedroche, M.S., Alonso-Almeida, M.D.M. (2019, p. 708)	In line with this global approach, on 2 December 2015, the European Commission prepared a report entitled 'Close the Circle: An Action Plan of the European Union for the Circular Economy', whereby it sought a transition towards a more circular economy (CE), in which products, materials, and resources are kept in the system for as long as possible and in which the generation of waste was minimized.
95	Liang, W.-Z., Zhao, G.-Y., Hong, C.-S. (2018, p. 1365)	As mineral resources are non-renewable, most mine enterprises prefer to detect a novel circular economy (CE) pattern to replace the old one (Hatayama et al., 2015). Different from the traditional linear economic model with one way flow, the CE model is a feedback process of "resources - products - waste - renewable resources" (Kirchherr et al., 2017; Korhonen et al., 2018). The idea of CE was first proposed by Boulding (1966). After that, Commoner (1971) emphasized the abandon of linear production process, and advocated recycling production in modern society
96	Simon, B. (2019, p. 299)	CE is a procedure using, old materials or products" as (secondary) raw material or shared product and in this way an excellent instrument supporting sustainability goals by improving raw material availability, decreasing environmental impacts and also increase economic advances (Kalmykova et al., 2018).
97	Molina-Moreno, V., Utrilla, P.N.-C., Cortés-García, F.J., Peña-García, A. (2018, p. 1783)	As an alternative, the circular economy refers to an industrial economy that is restorative and regenerative by intent and design [7,11]. It is intended to rely on renewable energy, minimize the use of energy, and remove the use of toxic chemicals and waste eradicated through careful design.
98	Brambilla, G., Lavagna, M., Vasdravellis, G., Castiglioni, C.A. (2019, p. 133)	In contrast with this conventional model, the circular economy, denominated as "make-use-return", is aimed to maintain as long as possible the value of the materials/products and minimize the generation of waste (Ellen MacArthur Foundation, 2015).
99	Bianchini, A., Rossi, J., Pellegrini, M. (2019, 6614, p. 1)	Since the early 2000s, several efforts have concentrated on the transition from the traditional linear production ('take–make–use–dispose') to a Circular Economy (CE), proposed as a promising strategy for both dealing with the current environmental issues and providing socio-economic benefits [1]. According to the Circular Economy action plan [2], adopted by the European Commission in 2015, in a CE the 'value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised…to develop a sustainable, low carbon, resource efficient and competitive economy'.
100	lapko, y., trianni, a., nuur, c., masi, d. (2018, p. 183)	amongst different strategies proposed for mitigation of material criticality, recycling and closed-loop supply chains (clscs) are particularly highlighted. a clsc is broadly defined as a system for managing integrated operations of forward and reverse supply chains (guide et al. 2003). being an important aspect of the circular economy and resource efficiency, the clsc is considered as a promising strategy for securing long-term availability of materials by creating additional sources of their supply via recycling (bell et al. 2013; morley and eatherley 2008).
101	Smol, M. (2018, p. 227)	Currently, the implementation of SD principles in the European Union (EU) is realised by transition to the model of a circular economy (CE), where the added value of products is retained as long as possible and waste is eliminated [2, 3]. In the CE model, special attention is paid to critical raw materials (CRMs) which are economically and strategically important for the European economy, but have a high-risk associated with their supply [4].
102	Islam, M.T., Huda, N. (2019, 117,787, p. 15)	According to Lieder and Rashid (2016) "CE is [a] closed loop material flow in the whole economic system […] in association with the so-called 3R principles […] Taking into account economic aspects CE […] minimizes matter […] without restricting economic growth".
103	Donati, F., Aguilar-Hernandez, G.A., Sigüenza-Sánchez, C.P., de Koning, A., Rodrigues, J.F.D., Tukker, A. (2019, 104,508, p. 1)	CE an economy that is "… restorative and regenerative by design, and aims to keep products, components, and materials at their highest utility and value at all times." (MacArthur, 2013).
104	Eberhardt, L.C.M., Birgisdottir, H., Birkved, M. (2019, p. 2)	Circular economy (CE) has attracted both political and industrial interest as a more relatable and easier operationalized way to practice sustainability by potentially representing a way to overcome the contradiction between economic growth and environmental sustainability by moving away from the current linear business model (take, make, use and dispose) to a circular business model (reduce, reuse, recycle and recover) [8, 9]. CE can thus provide an economic incentive to work towards sustainable goals. By intent and design, CE can potentially manage resources in a way that is regenerative and restorative and does not deplete these by keeping materials at their highest utility and value at all times, distinguishing between technical and biological cycles, providing greater economic stability through resource security [10]
105	Ali, A.K., Wang, Y., Alvarado, J.L. (2019, p. 1035)	Under the framework of circular economy, which is an alternative to a traditional linear economy (fabrication, use, disposal) resources are kept in use for as long as possible by extracting their maximum value while in use. Then, materials are recovered and used to generate products and materials at the end of each service life.
106	Werning, J.P., Spinler, S. (2020, 118,609, p. 2)	For our purposes, the definition provided by Kirchherr et al. (2017, pp. 224e225) is sufficiently comprehensive. "A circular economy describes an economic system that is based on business

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#	Source	Definition
		models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations."
107	Millette, S., Williams, E., Hull, C.E. (2018, 104,436 p. 1)	CE is the antithesis of the traditional linear economy (Ness, 2008), drawing heavily on industrial ecology (Frosch and Gallopoulos, 1989). Through the development of closed loop systems and improving resource efficiency, CE seeks to reduce the anthropogenic impact on the environment from production and consumption without compromising economic growth (Pratt et al., 2016), decoupling economic growth from environmental impacts. CE aims to establish balance between economy, environment, and society (Ghisellini et al., 2016), and by redesigning products with the goal of minimizing inputs and the resulting waste (D'Amato et al., 2017, Ghisellini et al., 2016, Ellen Macarthur Foundation, 2013, McKinsey, 2012)
108	Blomsma, F. (2018, p. 969)	The concept's core proposition is to move away from 'take-make-use-dispose' practices and replace these with material, part and product cycling and cascading, thus enabling resource preservation, efficiency and productivity. CE functions as an umbrella concept. This means that it groups a wide range of waste and resource management strategies and focusses the attention on their capacity to extend resource life, whilst generating value and preventing value loss and destruction (Blomsma and Brennan, 2017). As such, the CE concept constructs and legitimises a space for the interrogation of the appropriate and effective use of such strategies.
109	Rocca, R., Rosa, P., Sassanelli, C., Fumagalli, L., Terzi, S. (2019, 2286, p. 2)	Referring to a manufacturing system, the linear model is based on a static view of the flows that characterize the logistics-production chain, which starts from raw materials supplying and processing, up to the finished product disposal. On the other hand, the Circular Economy (CE) systems provide for a more efficient and more effective use of resources, where the flows are not static and bound by one-directionality, but they fall circularly in the upstream phases of the production system [10].
110	Schöggl, J.-P., Stumpf, L., Baumgartner, R.J. (2020, 105,073, p. 1)	For the EU, it (CE) presents the possibility of promoting environmental benefits, sustained economic growth, and added value, all in addition to job creation, and hence acts to support all three sustainability pillars at once.
111	Astolfi, V., Astolfi, A.L., Mazutti, M.A., Rigo, E., Di Luccio, M., Camargo, A. F., Dalastra, C., Kubeneck, S., Fongaro, G., Treichel, H. (2019, p. 677)	Circular economics emerged as an alternative to the linear economy—based on the use of fossil resources, it becomes ineffective to meet the needs of the population—and has as one of its purposes sustainable consumption and production, its central element being recycling, that is, instead of becoming a waste and not reusing it, are studied ways to reuse it to profit and also not generate as much wastage of matter, thus replacing the resources of linear economy [2, 3]
112	Duque-Acevedo, M., Belmonte-Ureña, L.J., Plaza-Úbeda, J.A., Camacho-Ferre, F. (2020, p. 490)	Thus, the circular economy proposes a model of efficient resource management which prioritises "closing the loop" [29], thereby avoiding losses in value of materials and products and prolonging their life by incorporating waste into production processes [19,30–32].
113	Coelho, P.M., Corona, B., ten Klooster, R., Worrell, E. (2020, 100,037, p. 2)	The challenge of the circular economy is to close material loops. In practice, this means that the circle has to be as small as possible to retain the material qualities needed to serve its original function, which is also expressed in various approaches as closing material cycles, e.g. the 9 "R's" (see e.g. Potting et al., 2017) to retain the highest economic value. Reusing products and materials for as long as possible reduces the need for virgin (or primary) materials and reduces the environmental footprint of materials use, if the loops are closed in sustainable ways (e.g. with minimal energy use to close the loops).
114	Bassi, F., Dias, J.G. (2019, p.1)	A popular definition of the circular economy takes advantage of the easy-to-remember 27 3Rs: reduction, reusing, and recycling, and it describes the practical approach to the concept (see, 28 for example, Liu et al., 2017). The Ellen MacArthur Foundation (2015) proposes a more 29 comprehensive definition that includes environmental and economic advantages, according to which 30 the circular economy is "an industrial economy that is restorative or regenerative by intention and 31 design". This recent definition incorporates the idea of ensuring the safe entry of bio-nutrients in the 32 biological sphere. Another important notion in this context is the difference between the circular 33 economy and the linear production system: whereas the linear system perceives end-of-life products 34 as waste, the circular economy sees them as resources, and this also has an impact on the 35 environment, on resource scarcity, and on economic benefits.
115	Xavier, L.H., Giese, E.C., Ribeiro-Duthie, A.C., Lins, F.A.F. (2021, 101,467, p. 2)	According to the Ellen MacArthur Foundation (2013), the Circular Economy (CE) is defined as an industrial system that aims to avoid waste through design of optimized cycles of products, components and materials by keeping them at their highest utility and value. In other words, it is desirable to maintain products in use as long as possible, to incentivize repair, refurbishing and reuse techniques, and promote the use of secondary raw material, creating new growth and job opportunities.
116	Faraca, G., Tonini, D., Astrup, T.F. (2019, p. 2690)	The circular economy adopted by the EU favours a "resource cascading" approach (Sirkin and Houten, 1994), aiming for a society in which resource utilisation is optimized through sequential uses. This approach involves two dimensions, namely quality and time: to extend the entire lifetime of the material, its properties are subsequently used in different applications according to its quality grade (Fraanje, 1997).
117	Osman, A.I., O'Connor, E., McSpadden, G., Abu-Dahrieh, J.K., Farrell, C., Al-Muhtaseb, A.H., Harrison, J., Rooney, D.W. (2019, p. 183)	Upcycling and providing end-use applications to wastes acts upon and facilitates the concept of the circular economy, which is deemed 'regenerative by design'.5 This circular economy will help reduce waste, raise resource productivity and create a more competitive economy.5,6 This provides benefits to the environment and society through economic and social opportunities.
118	Gallego-Schmid, A., Chen, H.-M., Sharmina, M., Mendoza, J.M.F. (2020, 12,115, p. 1)	The CE model can be defined as "a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops" (Geissdoerfer et al., 2017). Slowing resource loops entail prolonging and intensifying the use of products to retain their value over time, whereas closing resource loops facilitate upcycling to restore or create new value from used materials (Bocken et al., 2016).

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#	Source	Definition
		Finally, narrowing resource loops imply eco-efficient solutions that reduce resource intensity and environmental impacts per unit of product or service (Mendoza et al., 2019).
119	Campbell-Johnston, K., Cate, J.T., Elfering-Petrovic, M., Gupta, J. (2019, p. 1233)	CE seeks a paradigm shift from linear to circular practices which reduces the demand for virgin materials (currently 90 B tonnes annually) in production/consumption cycles (Genovese et al., 2017; Lieder and Rashid, 2016), to decouple economic activity from environmental pressures (Cullen, 2017; Elia et al., 2017) and promotes a restorative and regenerative economy by intention and design (Ellen MacArthur Foundation, 2013). A CE uses the R-principles (Ghisellini et al., 2016; Reike et al., 2018), ranging from a 3R (Reduce-Reuse-Recycle) in China through 5Rs (Reduce-Reuse-Remanufacture-Recycle-Recover) to 10Rs (Kirchherr et al., 2017).
120	Inigo, E.A., Blok, V. (2019, p. 280)	In principle, the CE aims to achieve welfare-increasing, sustainable economic growth, hence addressing inter and intragenerational equity concerns through the preservation of natural capital, resource productivity and the removal of negative externalities (Ellen MacArthur Foundation, 2017.
121	Sehnem, S., Vazquez-Brust, D., Pereira, S.C.F., Campos, L.M.S. (2019, p. 785)	CE proposes to replace wasteful and inefficient linear and open-ended cycles of production (input-output-waste) for a closed-loop where waste is minimized or transformed into inputs and value is created in the process (Blomsma and Brennan, 2017; Homrich et al., 2018). The CE contributes to raising productivity, optimizing the use of natural and human resources (Missemer, 2018) and increasing efficiency in resource management (Linder and Williander, 2017; EEA, 2016).
122	Smol, M., Marcinek, P., Duda, J., Szołdrowska, D. (2020, 55, p. 2)	The CE assumes a transition from a linear model based on "take–make–dispose" to a circular model, in which waste, if it arises, becomes a valuable resource [8]. At the same time, it is recommended to make use of mineral resources (raw materials (RMs)) in more efficient way and to recycle and recover RMs from any waste streams
123	Casiano Flores, C., Bressers, H., Gutierrez, C., de Boer, C. (2018, p. 555)	The principle of circular economy is a zero-waste imperative and it is based on three rules: (1) All durables, which are products with a long or infinite life span, must retain their value and be reused but never discarded or down cycled (broken down into parts and repurposed into new products of lesser value). (2) All consumables, which are products with a short life span, should be used as often as possible before safely returning to the biosphere. (3) Natural resources may only be used to the extent that they can be regenerated (Stuchtey, 2015).
124	Taušová, M., Mihaliková, E., Čulková, K., Stehlíková, B., Tauš, P., Kudelas, D., Štrba, L. (2019, 2904, p. 2)	The goal of a circular economy is to observe the value of products and materials in the long-term, which means after the termination of their life cycle not to reject resources from the economy, but to use them repeatedly for creation of new value. In this way, waste creation can be minimized.
125	Heisel, F., Rau-Oberhuber, S. (2020, 118,482, p.1)	A circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles" (Ellen MacArthur Foundation, 2015).
126	Chen, L.-H., Hung, P., Ma, H.-W. (2020, p. 1887)	In recent years, a circular economy (CE) has been regarded as a key to sustainable development, capable of offering a systematic solution to waste of resources and environmental pollution, a chronic problem caused by a linear economy and existing consumption pattern. It can transform linear economic problems into new circular business opportunities, detaching the consumption of energy and resources from economic growth and thereby attaining sustainable development (EMF, 2015a).
127	Rahito, Wahab, D.A., Azman, A.H. (2019, p. 802)	This [CE] aims to contrive a loop system of raw material flow to minimize the use of new raw materials sourced from nature, and to replace it with processed or used materials from an existing product [10]. CE implementation requires the manufacturers to comply with the requirements of sustainable design during product development. In doing so, the product will be deemed suitable to go through the loop system within CE implementation [10].
128	Moktadir, M.A., Kumar, A., Ali, S.M., Paul, S.K., Sultana, R., Rezaei, J. (2020, p. 3612)	CE practices may drive industries to develop strategies for sustainable manufacturing practices (van Loon et al., 2018; Kwon & Lee, 2019; Centobelli, Cer-chione, Chiaroni, Del Vecchio, & Urbinati, 2020). They can help minimize waste and build a resilient supply chain (SC) framework. To overcome the issue of scarce natural resources, CE practices such as the 4R policy (reduce, reuse, recycle, remanufacture) may prompt industries to reuse items, recycle waste, and reduce consumption of resources (Govindan & Hasanagic, 2018; van Loon and Van Wassenhove, 2018; Hazen, Mollenkopf, & Wang, 2017). The closed-loop supply chain (CLSC) concept may also contribute to the prevention of environmental pollution (Perey, Benn, Agarwal, & Edwards,2018)
129	Jedelhauser, M., Binder, C.R. (2018, p. 857)	CE "focuses on recycling, limiting and re-using the physical inputs to the economy, and using waste as a resource leading to reduced primary resource consumption" (European Environment Agency, 2014:
130	Patwa, N., Sivarajah, U., Seetharaman, A., Sarkar, S., Maiti, K., Hingorani, K. (2021, p. 725)	CE principles promote minimizing or eliminating waste and pollution, maximizing products and materials use, and regeneration of natural systems (EMF, 2020). Organizations and businesses are looking towards technological innovations such as 3D printing (Despeisse et al., 2017) and numerous entrepreneurial initiatives, where the cost of pollution are also factored in, and gaps between environmental costs and economic growth are bridged (Ries, 2017). The practice of reduce, reuse and recycle (3R) are growing in significance amongst businesses and consumers alike (Confente, Scarpi, & Russo, 2019; EMF, 2013; Ghisellini et al., 2018).
131	Yazan, D.M., Cafagna, D., Fraccascia, L., Mes, M., Pontrandolfo, P., Zijm, H. (2018, p. 606)	In particular, the increasing awareness that natural resources are limited pushes toward the development and the implementation of new circular economy models, able to manage existing resources in a continuous cycle, hence providing an effective use of these resources (Bocken et al., 2016; Fraccascia et al., 2016). In this regard, the European Commission claims that circular economy may be able to provide economic benefits for firms, in addition to environmental benefits, and widely recommends their adoption (European Commission, 2015).
132	Fitch-Roy, O., Benson, D., Monciardini, D. (2018, p. 983)	In response, the normative concept of the circular economy (CE), which integrates environmental and economic objectives into a distinctive model of 'sustainable growth', has rapidly come to dominate the discussion about how best to disrupt unsustainable development patterns. A defining CE characteristic 'is the valuation of materials within a closed-looped

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#	Source	Definition
		system with the aim to allow for natural resource use while reducing pollution or avoiding resource constraints and sustaining economic growth' (Winans et al. 2017, p. 825, see also Ghisellini et al. 2016).
133	Shao, J. (2019, p. 1508)	The general term "circular economy" means to reduce, reuse, and recycle resources in the process of production, transportation, and consumption. It defines the "3R's principle" of reduction, reuse, and recycle and brings fundamental change to the traditional growing pattern of business.
134	Marrucci, L., Marchi, M., Daddi, T. (2020, p. 595)	The interest of both scholars and practitioners has grown accordingly (Marrucci et al., 2019), and as a broad concept the circular economy has been studied from various points of view (PrietoSandoval et al., 2018). Geissdoerfer et al. (2017) compared the circular economy with sustainability and identify the main similarities and differences. . However, the understanding of the concept remains controversial and Kirchherr et al. (2017) identified and analysed over 100 definitions before providing a "final" one. Ghisellini et al. (2016) reviewed the main circular economy features and perspectives at micro (products, companies and consumers), meso (industrial clusters) and macro (city, region, nation, and global) levels. The micro and meso levels are those most commonly investigated, but the three levels are typically analysed separately.
135	Ginga, C.P., Ongpeng, J.M.C., Daly, M.K.M. (2020, p. 2970)	Circular economy or CE is an economic system that is based on business models which replace the "end-of-life" concept—a stage of any product that does not receive continuing support, either because existing processes are terminated or it is at the end of its useful life —with reducing or alternatively reusing, recycling, and recovering materials in the production/ distribution and consumption processes [7
136	Johansson, N., Henriksson, M. (2020, p. 148)	A circular economy is the transition from linear to circular material flows, where resources once taken from nature stay in the economy as long as possible. In a circular economy, technical, legal and semantic processes transform waste into resources to increase the lifetime of raw material. Hence, waste does not exist in a circular economy. A circular economy can thus, just like landfilling, be understood as an ideological strategy (Hird et al., 2014) that takes focus away from waste and its underlying causes, including ever growing consumption (Corvellec, 2019).
137	Romero-Hernández, O., Romero, S. (2018, p. 758)	The circular economy concept aims to extend the useful life of materials and promotes recycling in order to maximize material service per resource input while lowering the environmental impacts and resource use (Tisserant et al., 2017).
138	Horvath, B., Khazami, N., Ymeri, P., Fogarassy, C. (2019, p. 65)	The CE concept refuses the traditional features of economic growth (e.g. mass production, utilization of scarce and non-renewable resources, producing non-durable goods etc.) and offers innovative solutions to preserve natural capital and to enhance social welfare. Its top priority is to achieve the lowest possible material and energy flow through economic processes and to avoid resource leakages (Ellen MacArthur Foundation, 2015a).
139	Gong, Y., Putnam, E., You, W., Zhao, C. (2020, 118,941, p. 2)	The CE concept shifts away from the linear model, offering a 'closed loop' model that enables resource utilisation, with the main purpose to reduce waste, natural resource use, and greenhouse gas emissions (Bastein et al., 2013).
140	Abad-Segura, E., de la Fuente, A.B., González-Zamar, M.-D., Belmonte-Ureña, L.J. (2020, 5792, p. 1)	This circumstance has motivated the emergence of an alternative model, known as the circular economy (CE) model, which places an emphasis on the sustainability of the use of natural resources [6]. This economic development system is based on the reduction, reuse, recovery, and recycling of materials and energy, transforming the linear flow into circular flows [7,8]. In this way, waste becomes a resource and is reintroduced into the production process. CE is key to breaking the link between economic growth and the increased consumption of natural resources [9–11]. Moreover, implementation of the CE principles entails a large number of benefits for the environment and society, such as a reduction in the use of resources, a reduction in waste production, and limitations of energy consumption, and directly enables the prospect of sustainable growth [12–14].
141	Bonsu, N.O. (2020, 120,659, p. 2)	Unlike the linear economy model where products "single-use" means a "take-make-dispose" pattern, CE ensures products circularity in a value chain, whilst capturing more of the value normally lost in a traditional linear system.
142	Charnley, F., Tiwari, D., Hutabarat, W., Moreno, M., Okorie, O., Tiwari, A. (2019, p. 3379, p. 1)	The circular economy model offers an alternative to the traditional linear economy (take, make, use and dispose), decoupling economic value creation from resource consumption by keeping resources in use for as long as possible, extracting the maximum value from them whilst in use and then recovering and regenerating products at the end of each service life [1].
143	Ingemarsdotter, E., Jamsin, E., Balkenende, R. (2020, 105,047, p. 1)	The term Circular Economy (CE) envisions an economy that simultaneously considers environmental impact, resource scarcity and economic benefits (Lieder and Rashid, 2016). A commonly cited view describes the CE as "an industrial system that is restorative or regenerative by intention and design" (Ellen MacArthur Foundation, 2013). Design and business model strategies in the CE include long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling (Bakker et al., 2014; Geissdoerfer et al., 2018)
144	Caruso, G., Gattone, S.A. (2019, p. 186)	In recent years, the term circular economy has gained much attention. It refers to a system of production and consumption providing minimal losses of materials and energy through extensive reuse, recycling, and recovery Haupt et al. (2017). In other words, it is an economic system for which is essential to recycle materials from waste in order "to close the cycle"
145	Paço, A., Jacinto, J., da Costa, J.P., Santos, P.S.M., Vitorino, R., Duarte, A. C., Rocha-Santos, T. (2019, p. 430)	This is, as defined by Geissdoerfer and colleagues, "a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. (These goals) can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" (Geissdoerfer, Savaget, Bocken, & Hultink, 2017).
146	Pedersen, E.R.G., Earley, R., Andersen, K.R. (2019, p. 310)	Recently, the literature on business models for sustainability has been mixed with the visions of a circular economy, which has become a popular antonym to the linear economy and the predominant take-make-dispose industrial system (Bocken et al., 2016; Ghiselliniet al., 2015; Murray et al., 2017). Within this literature, the circular economy is seen as a new business model expected to lead to more sustainable development (Ghisellini et al., 2015). Examples of business

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#	Source	Definition
		models with elements of circularity include recycling, upcycling, sharing, repair and remanufacturing, which are also well-known phenomena in the fashion industry.
147	Busu, M. (2019, p. 159)	At present, the real problem is how to change the current structure of the consumption pattern, based on a production–consumption–waste model, into a circular economy (CE) which is regenerative by definition, based on a production–consumption–reuse model. According to Kirchherr et al. (2017), a CE is most frequently depicted as a combination of reduce, reuse, and recycle activities. Thus, an essential role in the circular economy is to invest in innovative equipment for environmental protection (Porter and Van der Linde 1995)
148	Wakiru, J., Pintelon, L., Muchiri, P.N., Chemweno, P. (2018, p. 899)	Circular economy (CE) is considered as an innovative approach used to increase the resource efficiency in companies by keeping equipment functioning for as long as possible. This is done while extracting maximum value from such equipment during use, recovery after failure by restoring components back to normal condition and renewing the components to as good as new state at the end of their serviceable life. Many authors concur that CE incorporates reuse, remanufacturing, recycling and maintenance [1±4].
149	de Sadeleer, I., Brattebø, H., Callewaert, P. (2020, 104,908, p. 1)	On the other hand, the Circular Economy package adopted by European Commission in 2015 advocates an economic system that leaves no waste to be landfilled and that keeps all material flows in the economy through reuse, redesign, material recovery or energy recovery (European Commission, 2015).
150	Pinheiro, M.A.P., Seles, B.M.R.P., De Camargo Fiorini, P., Jugend, D., Lopes de Sousa Jabbour, A.B., da Silva, H.M.R., Latan, H. (2019, p. 840)	To slow consumption and close the resource ties in today's market, a regenerative economic model – a circular economy (CE) – is needed. CE has become an important production and consumption system in sustainable economics, receiving more and more attention worldwide as a way to Management Decision overcome the current model of linear economy (Skene, 2018; Ghisellini et al., 2016). CE is characterized as an economy that is restorative by design, aiming to keep products, components and materials at their highest utility and value at all times (Webster, 2015).
151	Ranta, V., Aarikka-Stenroos, L., Väisänen, J.-M. (2020, 105,155, p. 3)	Regarding material flows, CE can be realized through the so-called 3R principles of reduce, reuse, and recycle, derived from the waste management hierarchy (Ghisellini et al., 2016), and the extended versions of up to 9Rs, highlighting diverse reusing potentials (Kirchherr et al., 2017). Another conceptualization offered by Bocken et al. (2016) suggests that CE business models should aim to narrow, slow, or close resource flows.
152	Tolstykh, T., Shmeleva, N., Gamidullaeva, L. (2020, 4574, p. 1)	Circular economy is widely considered as a strategy to reconcile industrial systems with the natural environment through the careful design of new products and implementing the "closed-loop system" processes [1]. Russian Federation is just starting to develop a circular and green economy [2]. Implementing the circular economy (CE) concept encourages environmental protection and social prosperity [3], eliminate the environmental problems faced by society, while enabling value-added growth of industries in line with country's sustainable development.
153	Ghisetti, C., Montresor, S. (2019, p. 560)	Production and consumption systems based on the linear model of 'Take, Make, and Dispose' are neither environmentally sustainable, nor economically convenient anymore (EMAF 2015a). A shift is required towards a new "circular" paradigm based on the 'Reduce, Reuse, and Recycle' of resources, which allows one to "close the loop" in the functioning of economic systems (EC 2015), providing environmental and economic benefits at different levels of analysis (EEA 2016; WEF 2014).
154	Xiao, K., Zhou, Y. (2020, 119,373, p. 3)	For the shift of one technology from the laboratory-scale to the full-scale, the concept of circular economy (CE) must be taken into consideration. CE is one of the most effective transition methods for "sludge-to-protein" towards a sustainable future. Incorporation of CE into protein recovery from sludge may help to prevent sludge production, reduce raw materials for protein production, and promote the reuse and recycle of the recovered protein products from full-chain processes of production, distribution, and consumption (Pradel and Aissani, 2019).
155	Sharma, H.B., Panigrahi, S., Sarmah, A.K., Dubey, B.K. (2019, 135,907, p. 2)	A circular economy is an alternative to the traditional linear economy (take, make, waste). It seeks to reduce waste, recovers resources at the end of a product's life, and channels them back into production or economy, thus significantly reducing pressure on the environment (Sawatdeenarunat et al., 2015).
156	Gall, M., Wiener, M., Chagas de Oliveira, C., Lang, R.W., Hansen, E.G. (2020, 104,685, p. 1)	It abandons the idea of products and materials ever becoming waste and instead envisions "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers" (Kirchherr et al., 2017).
157	Warrings, R., Fellner, J. (2018, p. 217)	Such an integrated pattern is the essence of the concept of the Circular Economy. While there is no uniform definition of Circular Economy, all do have the same bottom-line: "the objective of the circular economy is to preserve the value of utilized resources and materials as long as possible, to use them as frequently as possible, and to produce as little waste as possible (ideally none at all)" (Wilts, 2016). The European Environment Agency EAA (2016) adds that Circular Economy has "a positive, solutions-based perspective for achieving economic development within increasing environmental constraints".
158	Testa, F., Iovino, R., Iraldo, F. (2020, p. 3435)	The aim of this economic transition is to retain "the highest utility and value of products, components, and materials at all times" by reducing the negative externalities on the natural environment (EU Commission, 2015). The goal is "close the loop", by decoupling economic growth from the burden on the finite natural resources (Kirchherr, Reike, & Hekkert, 2017
159	Taleb, M.A., Al Farooque, O. (2021, 124,047, p. 1)	In contrast, the concept of the circular economy replaces the 'dispose' aspect with 'repair, refurbish, recycle' by giving circular criteria to the life cycle of the products. It emerged as a paradigm shift with core principles 'take, make, reuse' that respond to environmental and societal needs while using natural resources. A circular economy values resources by keeping materials and products in use for as long as possible.

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160	Zaman, A.U., Arnott, J., Mclntyre, K., Hannon, J. (2018, 3430, p. 6)	A circular economy represents an alternative to the existing, predominantly linear, 'take-make-consume-dispose' economic model. The Ellen MacArthur Foundation defines a circular economy as one that is restorative, and one which aims to maintain the utility of products, components, and materials and retain their value [46]. The fundamental principles of a circular economy as outlined by the Ellen MacArthur Foundation are as follows. It preserves and enhances natural capital by controlling finite stocks and balancing renewable resource flows; it optimizes resource yields by circulating products, components, and materials in use at the highest utility at all times in both biological and technical cycles (as shown in Fig. 1); and it fosters system effectiveness by revealing and designing out the negative externalities
161	Lipińska, D. (2018, p. 123)	The circular economy is defined in various ways in the available literature. Most often, it is described as a new concept of economic development; a modern vision of creating value through the rational use of resources; the principle of closing the product lifecycle; an ideological alternative to a linear economy based on the "take, use, and throw away" principle; the idea of minimizing the negative impact on the environment; the model in which the preferred rule is to reduce, repair, re- use, and recycle; a new opportunity for development and business opportunities; a solution that is able to reconcile sustainable development and economic growth, or popularly, cyclically giving a second, more interesting life to used products.
162	Konietzko, J., Baldassarre, B., Brown, P., Bocken, N., Hultink, E.J. (2020, 122,596, p. 1)	In a circular economy, firms maximize the value of the material resources and minimize the overall resource use, waste, pollution and emissions that are associated with their business activities (Geissdoerfer et al., 2017).
163	Loizia, P., Voukkali, I., Zorpas, A.A., Navarro Pedreño, J., Chatziparaskeva, G., Inglezakis, V.J., Vardopoulos, I., Doula, M. (2021, 141,974, p. 3)	The European Commission has adopted an ambitious new Circular Economy Package (CEP) to help European businesses and consumers to make the transition, to a stronger and more circular economy where resources are used, in a more sustainable way.
164	Grippo, V., Romano, S., Vastola, A. (2029, p. 126)	The circular economy (CE) is receiving increasing attention, as a way of overcoming the current production and consumption model based on continuous growth, to provide a better alternative to the dominant economic development model—so-called take, make and dispose (Ness 2008) for increasing the efficiency of the use of resources.
165	Campalani, C., Amadio, E., Zanini, S., Dall'Acqua, S., Panozzo, M., Ferrari, S., De Nadai, G., Francescato, S., Selva, M., Perosa, A. (2020, 101,259, p. 5)	In a circular economy context, it is mandatory to recover, reprocess, reuse and recycle as much as possible of all materials.
166	Bianco, M. (2018, p. 238)	The Circular Economy is considered the most important deliverable of the EU's Roadmap to a Resource Efficient Europe, which sets out a vision for the structural and technological changes needed in order to transform Europe's economy into a sustainable one by 2050. In this framework, there is the need to move away from a 'linear' economic model that is resource intensive and unsustainable, towards a more 'circular' approach, in which the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized. Getting maximum value from resources requires action at all stages of the life-cycle of products, from the extraction of raw materials to the product design, production and distribution of goods, and through increasing use of secondary raw materials. Economic actors, such as businesses and consumers, are key to driving this process.
167	Gracida-Alvarez, U.R., Winjobi, O., Sacramento-Rivero, J.C., Shonnard, D. R. (2019, p. 18,267)	From a sustainability perspective, circular economy aims to minimize the use of virgin materials and energy by using cyclic material flows and renewable resources to provide economic, societal, and environmental benefits without compromising natural cycles.
168	Hahladakis, John N.; Iacovidou, Eleni; Gerassimidou, Spyridoula (2020, p. 490)	Here, we define CE as "a system that has the ability to restore, retain and redistribute materials, components and products back into the system in an optimised manner and for as long as it is environmentally, technically, socially and economically feasible."
169	Jain, N.K., Panda, A., Choudhary, P. (2020, p. 3509)	CE aims at reducing solid waste, landfill and emissions, which are environmental challenges through activities such as reuse, remanufacturing and/or recycling (Murray et al., 2017). Organizations, while addressing environmental demands by making their operations CE compliant, strive to reap economic benefits simultaneously (Ghisellini, Cialani, & Ulgiati, 2016).
170	Cole, C., Gnanapragasam, A., Cooper, T., Singh, J. (2019, 100,004, p. 1)	Initiatives towards a circular economy (Stahel, 2016) are intended to address current and future resource concerns, and in the EU Circular Economy Action Plan (EC, 2015a,b) the inclusion of strategies to extend product lifetimes highlights the importance of reuse, particularly when value remains in working products and their components (Ellen MacArthur Foundation, 2013; Green Alliance, 2015) and many discarded items remain in a functional condition (WRAP, 2011b).
171	Narayan, R., Tidström, A. (2019, p. 394)	The CE-concept has its roots in historical, economic, and ecological fields, which highlights its relevance to sustainable business (Murray et al. 2017). Geissdoerfer et al. (2017: 759) have defined CE as: "as a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops".
172	Van Boerdonk, P.J.M., Krikke, H.R., Lambrechts, W. (2021, 125,375, p. 1)	Circular Economy (CE) can be defined as "an economic system that makes use of the reuse of products and materials and the conservation of natural resources as a starting point "where economic, social and environmental values are important in every part of the system (Reike et al., 2018).
173	Salvioni, D.M., Almici, A. (2020, 8641, 2)	The circular economy model is internationally recognized [17–23] as a virtuous model in that it complies with a set of key principles, the first being the reuse of resources according to a continuous circular process (involving design, production/remanufacturing, distribution, use, reuse, repair, collection, and recycling) as opposed to the traditional linear "extract-produce-use-dump" approach [24]. The model also ensures the preservation of the value of the materials a product is made of, either by lengthening its life or changing the belief that obsolescence (in functional, economic, regulatory, technological, and aesthetic terms) necessitates discarding the product [25]. The circular economy model also advocates increasing convergence toward a zero-waste situation, the promotion of "low-impact" growth to reduce greenhouse gas (GHG) emissions, and the use of sustainable and non-toxic materials.
174	Lin, R. (2020, 514, p. 1)	Low-carbon economy is a production method with low energy consumption, low pollution, and improved energy and resource utilization efficiency. Circular economy is a production method of low-carbon economy. Circular economy refers to the process of comprehensive utilization of

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#	Source	Definition
		energy and waste in accordance with the method of clean production. It is a development state in order to meet the requirements of human environmental protection and health. The main characteristic of circular economy is a balanced economy that maintains the human living environment, protects resources and energy, and is beneficial to the healthy development of society and economy.
175	Cabrera-Codony, A., Ruiz, B., Gil, R.R., Popartan, L.A., Santos-Clotas, E., Martín, M.J., Fuente, E. (2020, 101,229, p. 1)	Circular Economy (CE) became synonymous with providing an alternative to the dominant linear economic model, otherwise called 'take, make and dispose' model (Andersen, 2007). Because of this, both economy and natural ecosystems are perceived as taking a negative spiral, putting in danger the survival of humanity itself (Ghisellini et al., 2016). At the core of CE stands the idea that economy and environment can function in a mutually reinforcing way, whereby environmental protection can generate and benefit from new business models while creating innovative job opportunities.
176	Bertin et al 2019 IOP Conf. Ser.: Earth Environ. Sci. **323** 012020	The ultimate objective of the CE is to break the pattern of economic growth depleting natural resources. The idea is to extend the useful life of material (reuse, recycling) and products (eco-design) over the product's entire lifespan. This model is based on creating positive feedback loops for each use or reuse of the material or product before its final destruction. The material is passed on indefinitely from stakeholder to stakeholder until a new use process is found.
177	Zheng, P., Wang, Z., Chen, C.-H. (2019, p. 240)	Furthermore, Smart PSS lifecycle perspectives in a circular economy is also discussed, where it is suggested that further studies should consider value re-generation process, including reconfiguration, remanufacturing, and recycling in a close-loop manner.
178	Hartini, S., Sari, D.P., Utami, A.A. IOP Conf. Series: Materials Science and Engineering 703 (2019) 012025	Waste cooking oil (WCO) can actually be collected and then used as a biofuel production unit, soap, detergent, paint or lubricant [12]. Not to mention, collecting and recycling this waste is a contribution to solve three problems at once, which are reducing waste, reducing dependence on fossil fuel energy, and reducing pollutant emissions [13]. This concept adopts the concept of the circular economy (CE). The CE concept is when material flow continues to circulate and does not enter the biosphere, except biological nutrition [14]. Today, industries are beginning to see this concept as a mechanism to increase competitive advantage [15]. One of the three CE principles is to keep the product or material used.
179	I. Makarova, A. Andreev, L. Gubacheva and D. Shevchenko, (2019, p. 694)	In connection with this, more and more companies in the world are starting to implement the circular economy principles in their activities which leads to significant environmental, economic and social benefits [3].
180	Ripanti, E.F., Tjahjono, B. (2018, p. 1)	Circular Economy (CE) is a concept that is restorative and regenerative by design, and which aims to keep products, components and materials at their highest utility and value, distinguishing between technical and biological cycles (EMF 2013). Boulding (1966), Kneese et al. (1970), Stahel and Reday-Mullvey (1981), and Pearce and Turner (1990) are some of the researchers that have initiated research in CE. The area of CE is extensive as the redesign of global production and consumption systems which combine the environmental, resources, technology, and consumer demand (Preston 2012).
181	Rapp, G., Garcia-Montoto, V., Bouyssiere, B., Thiebaud-Roux, S., Montoya, A., Trethowan, R., Pratt, P., Mozet, K., Portha, J.-F., Coniglio, L. (2021, 125,411, p. 9)	This section aims at highlighting a potential biorefinery system focused on Indian mustard contributing to a green circular economy that would benefit both farmers and consumers in the respect of environment. The objective is to illustrate that within such a system, farmers would gain in energy security and flexibility by on-farm production of biofuel, biolubricants and other bioproducts, while ensuring healthy food security and offering job opportunities, the whole with reduced chemical and energy inputs and minimized waste effluents.
182	Elvanidi, A., Reascos, C.M.B., Gourzoulidou, E., Kunze, A., Max, J.F.J., Katsoulas, N. (2020, 83, p. 1)	Within the agricultural realm, the circular economy approach suggests that the crop production industry can achieve greater sustainability simply by keeping more resources and materials in use for as long as possible [2,3]. A circular economy system is comprised of 4R components; that is, reducing, alternatively reusing, recycling, and recovering materials in production/distribution and consumption processes. The idea of a circular economy is a response to the foreseen depletion of raw materials and the increase in CO2 emissions, which will eventually lead to global shortages and irreversible tipping points in natural ecosystems [4]. Such a radical system entails a major transformation of current production and consumption patterns in agriculture, which in turn will have a significant impact on the economy, the environment and society.
183	Cornejo-Ortega, J.L., Dagostino, R.M.C. (2020, 4442, p. 1)	The dominant linear economic model is based on having large amounts of energy and other resources easily accessible, but the Earth's physical capacity limit is being reached. In addition to merely using resources more efficiently, the solution to this problem means an end to waste and a new type of inclusive and sustainable economic growth. The circular economy (CE) model is a reparative and regenerative method to rethink progress. The CE aims to ensure that products, components, and resources maintain their usefulness and value at all times [1].
184	Kuzmina, K., Prendeville, S., Walker, D., Charnley, F. (2019, p. 75)	The CE is a conceptual model that describes a reformed production-consumption system according to closed-loop material cycles (Blomsma & Brennan, 2017; Ghisellini, Cialani, & Ulgiati, 2016; Murray, Skene, & Haynes, 2015). It requires a systemic approach that engages with multiple stakeholders (Ghisellini et al., 2016) as well as placing emphasis on product, process and system 'redesign' (Murray et al., 2015). At the essence of this resource-centric concept is the need to innovate business models based on circular value propositions that shift from single transactions between actors in the value chain to multiple transactions through circular business models (Bakker, den Hollander, van Hinte, & Zijlstra, 2014; Nußholz, 2017; Urbinati, Chiaroni, & Chiesa, 2017).
185	Aslam, M.S., Huang, B., Cui, L. (2019, 110,445, p. 2)	Stock improvement, eco-friendly waste minimization and the 4Rs (reduce, reuse, recycle & recover) are circular economy factors, which hold their mechanism for achieving stock optimization (Ghisellini et al., 2018b; Kalmykova et al., 2018; Ranta et al., 2018; Ritz€en and Sandstrom, € 2017).
186	Ferasso, M., Beliaeva, T., Kraus, S., Clauss, T., Ribeiro-Soriano, D. (2020, p. 3006)	The circular economy is acyclic system that aims to eliminate waste by turning goods that are at the end of their life cycle into resources for new ones (Stahel, 2016). Closing material loops in industrial ecosystems can create a continual use of resources. This can be achieved through long-

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		lasting design, proactive maintenance, recycling, repairing, refurbishment, and remanufacturing (Geissdoerfer, Savaget,Bocken, & Hultink, 2017). Given its substantial impact on the environment, the circular economy has become a key topic in public debates, with the EU declaring the need for academic research on new and more sustainable economic models and strategies (Urbinati, Chiaroni, & Chiesa, 2017). The transition to the circular economy often entails holistic adaptations in firms' business models or even the creation of new ones (e.g., Bocken, de Pauw, Bakker, & van der Grinten, 2016; Manninenet al., 2018). The implementation of circular economy principles often requires new visions and strategies and a fundamental redesign of product concepts, service offerings, and channels towards long-life solutions (Lewandowski, 2016). This is in line with the reassessment of suppliers and partners as well as a value chains that focus on long-term instead of short-term efficiency (Geissdoerfer et al., 2018). Eventually, circular economy principles also affect how companies can make money, with the ownership structure perhaps shifting, boosting demand for services along the product life cycle. This means that revenue models such as renting, leasing, or subscriptions might become more frequent product-focused industries (Tunn, Bocken, van den Hende, & Schoormans, 2019)
187	Macura, B., Johannesdottir, S.L., Piniewski, M., Haddaway, N.R., Kvarnström, E. (2019, p. 2)	Since recently, however, there is a shift in thinking towards circular economy that is defined as an economy where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized [12]. This paradigm applied to the wastewater sector means a shift from the sole focus on waste treatment and nutrient removal to the recovery of energy and nutrients from waste and further reuse of these products [13, 14]
188	Sodiq, A., Baloch, A.A.B., Khan, S.A., Sezer, N., Mahmoud, S., Jama, M., Abdelaal, A. (2019, p. 984)	Circular economy (CE), as defined by Geissdoerfer et al. (2017), is a system that closes and slows down resource input, emission, waste and energy leakages by narrowing energy and material loops.
189	Calisto Friant, M., Vermeulen, W.J.V., Salomone, R. (2020, 104,917, p. 1)	Overall, the CE concept is viewed as a promising idea and ideal that has much to bring towards addressing challenges of the Anthropocene (Aurez et al., 2016; Geissdoerfer et al., 2017; Murray et al., 2017). By proposing a regenerative and restorative system of production and consumption, which closes the input and output cycles of the economy, the CE is expected to solve the problems of resource scarcity, biochemical flow disruption, and climate change, all while revitalizing local and regional economies (Batista et al., 2018; Delannoy, 2017; Stahel, 2010).
190	Parida, V., Wincent, J. (2019, p. 3)	Circular economy suggests the need for a system-level view of resources and their value generation potential (MacArthur et al. 2015). This may entail firms and partners shouldering life-cycle responsibilities, shifting from unrenewable to renewable energy, embracing recycling, reuse, refurbishing, and remanufacturing of products, and improving maintenance commitments (Tukker 2014).
191	Fidelis, M., De Moura, C., Kabbas, T., Pap, N., Mattila, P., Mäkinen, S., Putnik, P., Kovačević, D.B., Tian, Y., Yang, B., Granato, D. (2019, 3854, p. 1)	According to Homrich et al. [1], the circular economy (CE) is an umbrella concept that applies different mechanisms aiming to minimize waste generation, thus decoupling economic growth from natural resources. European Union (EU) countries are leading this concept by promoting the responsive and cyclical use of resources and contributing to sustainability [2]. From the economic standpoint, CE is a model that should replace the conventional, linear material, and energy flow models by addressing the issues of environmental deterioration, social equity, and long, sustainable economic growth [3]. In fact, a holistic assessment based on a dashboard of qualitative and quantitative indicators is necessary to encompass the environmental, economic, social, and technical dimensions of CE [2,4]
192	Prieto-Sandoval, V., Jaca, C., Santos, J., Baumgartner, R.J., Ormazabal, M. (2019, p. 1)	The CE is defined as "an economic system that represents a change of paradigm in the way that human society is interrelated with nature and aims to prevent the depletion of resources, close energy and materials loops, and facilitate sustainable development through its implementation at the micro (enterprises and consumers), meso (economic agents integrated in symbiosis) and macro (city, regions and governments) levels. Attaining this circular model requires cyclical and regenerative environmental innovations in the way society legislates, produces and consumes" (Prieto-Sandoval, Jaca, & Ormazabal, 2018).
193	Ingrao, C., Faccilongo, N., Di Gioia, L., Messineo, A. (2019, p. 871)	In practice, CE aims at minimising waste and excessive resource utilisation by turning goods at the end of their lifespan and waste generated during the manufacturing and use of goods into resources for the manufacturing of other products (Topi and Bilinska, 2017). Therefore, in agreement with Korhonen et al. (2018), CE can play multiple key roles for sustainable development and its three dimensions (i.e. environmental, economic and social). It is in the light of this that Korhonen et al. (2018) has suggested a new definition for CE, based upon a new business-related concept. The definition provides CE to be an economy constructed from societal production-consumption systems to maximise the service produced from the linear nature-society nature material and energy throughput flow. This is achieved by using cyclical materials flows, renewable energy sources and cascading-type energy flows. CE limits the throughput flow to a level that nature tolerates and utilises ecosystem cycles in economic cycles by respecting their natural reproduction rates (Korhonen et al., 2018).
194	Kiss, K., Ruszkai, C., Takács-György, K. (2019, 161, p. 3)	The concept of circular economy aims circular flows in the economy (opposed to the "linear flows" are dominant currently) [32]. It represents an economic model based on the recycling, reuse, repair, sharing, and leasing of existing materials and products [17]. The model of the circular economy can be interpreted in food chains regarding waste reduction (and minimization of surplus), food reuse, nutrient recycling, and the promotion of more varied and effective dietary patterns. It can affect the different levels of production and consumption [7].
195	Saidani, M., Yannou, B., Leroy, Y., Cluzel, F. (2018, p. 5)	First, as there are several ways to close the loop (cf. Lansink's waste hierarchy ladder developed in 1979) (Parto et al., 2007; Recycling, 2016), the different pathways that help close the loops are used as criteria for comparison. The four possible feedback loops in the circular economy butterfly diagram proposed by the Ellen MacArthur Foundation (EMF, 2013b), were scrutinised, namely: (i) maintain or prolong, (ii) reuse, (iii) remanufacture or refurbish, and (iv) recycle. Additionally, to complete this focus on EoL loops and encompass the CE paradigm more broadly, current situations and practices in the automotive and HDOR sectors were also analysed in terms

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#	Source	Definition
		of the CE building blocks defined by the EMF (2013b). The shift toward a more circular economy involves four fundamental building blocks, namely: (i) circular product design, (ii) new business models, (iii) reverse networks, and (iv) enablers and favourable system conditions. These comparison criteria were selected not only to ensure a systemic analysis of the CE concept applied to these two industrial sectors, but also because the CE model proposed by the EMF is one of the best known and most widely shared and acknowledged visions of CE amongst academics and industrial practitioners.
196	Singh, P., Giacosa, E. (2018, p. 921)	circular economy (CE) – has been gaining momentum worldwide (Ghisellini et al., 2016), as it promises a new business model to decouple economic growth and environmental pressure (Stahel, 2016; UNEP, 2006). Current linear business models, often described as "take–make–waste" models, have led the world into a nexus of waste production and depletion of resources (Preston, 2012). Hence, there is a pressing need for the current business economy to transition towards CE, which envisages the global economy as regenerative and restorative by intention and design (Ellen MacArthur Foundation, 2012). Businesses models incorporating CE principles lead the way towards a CE (Lewandowski, 2016; Edbring et al., 2016, p. 5), ensuring the circular flow of materials in the production and consumption phase (Edbring et al., 2016, p. 5). The main activities based on this principle are: cascading, renewability, longevity, reuse, upgrade, repair, capacity sharing, dematerialisation and refurbishment (Lacy et al., 2014). Product service system (PSS), collaborative consumption and industrial symbiosis are some of the business strategies based upon these activities for the circular flow of materials. Despite the cost and environmental benefits of these strategies, they are yet to be widely adopted in consumers markets (Abbey et al., 2015; Baines et al., 2017; Tukker, 2015)
197	Flynn, A., Hacking, N. (2019, p. 1256)	"an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It [the CE] operates at [multiple levels] with the aim to accomplish sustainable development … It is enabled by novel business models and responsible consumers."
198	Sehnem, S., Campos, L.M.S., Julkovski, D.J., Cazella, C.F. (2019, p. 1043)	The objective of the circular economy (CE) is to contribute to the necessary transition from the traditional linear model (Ranta, Aarikka-Stenroos and Mäkinen, 2018). The linear model relies on a take-to-discard approach (Hopkinson et al., 2018), and this system, according to Muranko et al. (2018), can lead to an overuse of resources and the production of waste, because it is based on the naive assumption of an infinite supply of material. The linear model is understood to be restorative by design (EMF, 2013). The management of circular business models integrates technical aspects and biological aspects (Stahel and Reday, 1976) and uses resources for as long as possible. Hence, the CE can reduce emissions of some nations by up to 70 percent, increase the workforce by 4 percent and reduce waste (Stahel, 2016). Joustra et al. (2013) and Van Renswoude et al. (2015) identify the main principles of the CE: design without residue, design for reuse, building resilience through biodiversity, relying on renewable energy, the idea that waste is food, the natural system of a waterfall and understanding the value of actions (symbiosis). Circular business models are those that devise an organizational logic that creates, captures and delivers value with – and within – closed cycles of materials (Mentink, 2014). They do not necessarily aim to balance ecological, social and economic needs in contrast to traditional business models, even though they may meet sustainability goals (Lewandowski, 2016)
199	Alamerew, Y.A., Brissaud, D. (2019, 120,025, p. 1)	CE promotes circular flows to reduce environmental impacts and maximize resource efficiency as a strategy for sustainability. It aims to meet economic prosperity, while maintaining environmental quality and social equity to create sustainable world for future generations (Kirchherr et al., 2017). The implementation of circular economy principles is critical in meeting sustainable development goals (Korhonen et al., 2018; Saidani et al., 2018).
200	Salguero-Puerta, L., Leyva-Díaz, J.C., Cortés-García, F.J., Molina-Moreno, V. (2019, 2234, p. 2)	According to the European Environment Agency [5], circular economy represents a fundamental alternative to the linear take-make-consume-dispose economic model that currently predominates. Circular economy proposes a scheme in which waste is replaced by subproducts. According to Directive 2008/98/EC [1] on waste, a subproduct is a substance or object resulting from a production process that can be used again in another production process without subsequent transformation, except the usual industrial practice, and without producing adverse impacts on human health. Thus, circular economy is characterized by the removal or mitigation of wastes and subproducts in different production processes, and if that elimination or reduction were not possible, this new paradigm considers that wastes and subproducts must be integrated into the same productive processes or others of similar or different nature with the aim of avoiding negative externalities and protecting the environment. amongst these change strategies, the principle of the "3Rs" appears: reduce, reuse, and recycle. The waste hierarchy lists different options for managing waste from an environmental perspective, from best (waste prevention) to worst (disposal).
201	Domenech, T., Bleischwitz, R., Doranova, A., Panayotopoulos, D., Roman, L. (2019, p. 77)	The concept of the CE has recently attracted increasing policy and business attention. It proposes an alternative to the predominant 'take-make-consume-dispose' linear model of production and consumption, which is 'restorative and regenerative by design' and where resources are maintained at the 'highest utility and value' for longer (EMF, 2013). The concept of the CE is intuitively easy to understand, however, realising it in the practice is a complex issue. Industrial symbiosis has been identified as a practical approach to close the loop of manufacturing processes by transforming waste of different processes and industries in feedstock to other industries and, therefore, enabling the transition from wasteful to closed loop systems (Wen and Meng, 2015), where materials are kept in productive cycles for longer reducing the pressure on primary raw materials and impacts linked to waste generation and GHG emissions. IS is considered a solution to enhance environmental sustainability while achieving economic benefits simultaneously and one of the practical routes to embed CE in manufacturing activities (Lieder and Rashid, 2016). Policy developments in both China and Europe have attempted to accelerate the transition towards the CE (McDowall et al., 2017).

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202	Sun, J., Li, G., Wang, Z. (2019, p. 337)	To achieve sustainable development and increase resource utilization, Pearce and Turner (1990) first proposed the concept of a circular economy (CE). In a circular economic system (CES), resources can be used sustainably and cyclically to save resources and reduce pollution emissions, satisfying a sustainable economic growth mode (Simon, 2019). China has significant environmental, human health, and social problems due to rapid and sustained economic development (Sun et al., 2014; Song et al., 2015). Therefore, compared with other countries, China is paying more attention to CE (Su et al., 2013). In 2005, the Chinese government issued "Several Opinions on Accelerating the Development of Circular Economy1 " and began exploring the development mode associated with a circular economy (Babbitt et al., 2018).
203	Aranda-Usón, A., Portillo-Tarragona, P., Marín-Vinuesa, L.M., Scarpellini, S. (2019, 888, p. 6)	In a CE, materials that can be re-circulated are injected back into the economy as new raw materials, increasing the security of supply. These "secondary raw materials" can be traded and shipped just like primary raw materials from traditional extractive resources [101]. Materials from products at the end of their lifecycle are recovered through dismantling and recycling to reduce environmental impacts and production costs. Recycling is therefore a necessary precondition for a CE that includes eco-design for recyclability, reuse and other environmental management practices, such as resource efficiency [13].
204	Konietzko, J., Bocken, N., Hultink, E.J. (2020, 417, p. 1)	The circular economy may help firms to decarbonize and dematerialize their business activities [1,2]. Firms can pursue five integrated strategies towards a circular economy: they can narrow (use less material and energy), slow (use products and components longer), close (use material again), regenerate (use non-toxic material and renewable energy) and inform (use information technology to pursue circularity) the resource and energy flows that are associated with their business activities [2–5]. To combine these five strategies, firms need to transform the higher-order production and consumption systems that they form part of [6–13]. This requires a broad innovation perspective; one that innovates products/services, business models, and ecosystems [3,14–17]. Product/service innovation develops, produces and commercializes new products/services [18]. Business model innovation changes what a firm offers and to whom, how a firm creates and delivers the offering, and how it captures value from it [19–21]. Ecosystem innovation changes how a group of loosely coupled organizations interact with each other to achieve a collective outcome [16,22].
205	Coughlan, D., Fitzpatrick, C., McMahon, M. (2018, p. 810)	The United Nations Environment Program (UNEP) and the European Union (EU) have identified resource efficiency as a key objective to further protect our economic, environmental and societal well-being for the coming years (European Commission, 2011) (UNEP, 2016). A key aspect of Resource Efficiency is the Circular Economy which aims to promote appropriate and environmentally acceptable use of resources to enable a green economy (EMF, 2013). The Circular Economy is divided into two business models, the reuse and product lifetime extension model and the recycling for material recovery model (Stahel, 2015).
206	Barros, M.V., Salvador, R., de Francisco, A.C., Piekarski, C.M. (2020, 109,958, p. 1)	In contrast with the linear economy (take-make-use-dispose) [8], the circular economy (grow-make-use-restore) [9] is a model that aims to maintain components, materials, and products at their highest utility in order to eliminate waste from a system [10], although only 9% of the world's economy is circular [11]. The good news is that there is a possibility of improvement of 91% [12]. A successful circular economy contributes to the three dimensions of sustainable development [13]. This concept has been gaining prominence in recent years, aiming to reduce and optimize the way organizations are producing goods [14]. Thus, in a simplified way, it is based on the ability to recover resources instead of import the resources from outside of the system [15]. Therefore, circular economy aims to minimize or eliminate input materials from fossil or non-renewable sources in a production system and maximize the reuse of these materials within the same system [16]
207	Allesina, G., Pedrazzi, S., Allegretti, F., Morselli, N., Puglia, M., Santunione, G., Tartarini, P. (2018, p. 393)	By supporting the creation of circular production schemes within an economic system, CE aims to increase the efficiency of resource use, especially waste, to harmonize economy, environment and society [37]
208	Amenta, L., van Timmeren, A. (2018, 4740, p. 10)	CE implies a rethinking of society towards closed loops of resource use, creating an economy in which there is no waste in industrial process chains. CE aims to shift the focus away from products and more towards processes [73]. This could be a challenge, however, as decision makers could encounter difficulties in the implementation of Eco-Innovative Solutions (EIS) to support CE principles. It is not easy to change the ruling paradigms and growth paths [74] of current economic systems and production models. Within this context, wastescapes should be investigated at multiple and different scales:
209	Neligan, A. (2018, p. 101)	Targets 8.4, 9.4 and 12.2 place a special emphasis on retrofitting industries to improve resource-use efficiency by 2030. Target 12.4, which aims at avoiding waste through prevention, reduction, recycling and reuse, enhances the idea of a circular economy.2 The rationale behind a circular economy is to keep resources in use for as long as possible. The approach is to look at the complete life cycle of a resource – from extraction to product design, production, consumption and ultimately waste management, e.g. recycling. A circular economy aims to minimise both material input and waste generation by resource-saving product design (eco-design) and by recycling and reusing products and materials. Through recycling and reuse, waste is turned back into a resource.3
210	Coderoni, S., Perito, M.A. (2019, 119,870, p. 1)	Beyond the many different definitions of the CE, the main goal of this approach is to avoid and minimize product and resource consumption through multiple material loops (Kirchherr et al., 2017). According to the CE concept, the value of products and materials should be maintained for as long as possible, for example minimizing wastes or using them to create value-added products. The CE approach can thus change production processes in order to satisfy consumer needs in new and more sustainable ways (European Commission, 2018). As well as other economic activities, food production and consumption significantly exploit the environment, through resource use and waste production. Thus, even in the food sector, a substantial change is needed to ensure enduring sustainability (Laureti and Benedetti, 2018; Aschemann-Witzel and Peschel, 2019).

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211	Gusmerotti, N.M., Testa, F., Corsini, F., Pretner, G., Iraldo, F. (2019, p. 315)	The Circular Economy recalls other connected concepts, such as those of industrial ecology (Lüdeke-Freund et al., 2018), product-life extension (Corsini et al., 2015), regenerative design (Ghisellini et al., 2016) and the cradle-to-cradle approach (Ünal and Shao, 2019). Several authors attribute the original introduction of the CE concept to Pearce and Turner (1990), who described how natural resources influence the economy by providing inputs for production and consumption and, at the same time, serve as a sink for outputs in the form of waste. This thus fostered the idea of a circular economy as opposed to the current "linear" and "open-ended" one which directly transforms natural resources into waste (Winans et al., 2017). Scholars and practitioners have documented how the CE paradigm is giving birth to entirely new and very innovative business models (Bocken et al., 2014). Sharing platforms, remanufacturing, modular design and circular supplies are radical and crucial levers that could profoundly change the current economic system and generate circular loops (Esposito et al., 2018).
212	Brown, P., Bocken, N., Balkenende, R. (2019, 635, p. 3)	As such, CE can be categorised as being pre-paradigmatic, where no single paradigm exists, with guidance and consensus still forming [18]. Recent analysis by Kirchherr et al. [20] of CE 114 definitions, with 95 uniquely given, indicates this clearly. To overcome this challenge, Masi et al. [34] deviate focus from the specific antecedents and definitions to the interconnecting goals and principles that are central to support a common CE vision. They include: (1) replacing linear systems with intentionally designed regenerative and restorative circular systems, (2) decoupling economic growth from non-renewable material throughput and environmental degradation, (3) increasing system resilience and (4) maximising value creation, capture and recovery across economic, social and ecological values. These four goals indicate the necessity for a systemic approach. Bocken et al. [35] propose to achieve this through developing a CE vision in conjunction with combinations of CE product design and business model innovation strategies to design systems that slow, narrow or close resource loops
213	Prideaux, B., Yin, P. (2019, p. 462)	Both the EU and China (McDowall et al., 2017) have adopted low level policy measures that support elements of the circular economy. In China, a small number of scholars have combined the concept of the circular economy with tourism development and created the concept of the Tourism Circular Economy. Ming and Shu (2007) for example postulated a model based on a Tourism Circular Economy that can achieve wins for the economy, society and the environment. One proposal is a Tourism Circular Economy operation model that includes the three dimensions of enterprise, region, and society (Li & Ming, 2007). In that model, tourism enterprises adopt a circular economy strategy allowing the tourism industry to strengthen integration with other industries at the regional level, and finally into the social macro cycle. Song, Zhang, Wen, and Xiao (2009) suggested a tourism circular economy evaluation index system with 28 indicators based on the "Rethink-Reduce-Reuse-Recycle-Repair" concept, and pointed out that this evaluation indicator system can be used to evaluate the circular level of a tourism destination
214	Holzer, D., Rauter, R., Fleiß, E., Stern, T. (2020, 126,696, p. 1)	Circular Economy (CE) offers a way to create "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/ distribution and consumption processes" (Kirchherr et al., 2017, p. 229). The Ellen (EMF) (2015a) has estimated that a transition to a CE could reduce global emissions by 48% by 2030 and by 83% by 2050, based on current levels; therefore, CE contributes to environmental quality and social equity (Kirchherr et al., 2017), supporting the shift towards more sustainable social and economic systems in general. C
215	Sorin, F., Sivarajah, U. (2021, p. 265)	The circular economy challenges the established linear production and consumption economic model. It proposes an economic system intentionally restorative of natural and social capital in which resources and materials circulate in regenerative production and consumption cycles (Blomsma & Brennan, 2017; Webster et al., 2013).
216	Wysokińska, Z. (2018, p. 83)	The idea of a circular economy, which can also be called a 'closed-loop economy', i.e. one that produces minimum waste, and in which waste, if it is generated, becomes a raw material. The amount of real waste is constantly shrinking. The waste on our planet can be minimized by implementation of responsible research to further the innovation principle, i.e., "reduce, reuse, and recycle." This means that each individual must reduce waste and, if he or she has generated any, reuse it or recycle it. The circular economy is thus an economy in which production and consumption are organized in such a way that the value of products, components, materials, and resources is maintained within the value chain and products' life-cycles. Resource efficiency is maximized, while the extraction of raw materials and the production of wastes are minimized.
217	Eckelman, M.J., Laboy, M.M. (2020, p. 744)	A central goal of industrial ecology is closing material and energy loops, moving away from a linear economy and toward a circular economy. Abstract and seminal representations of these closed loops, such as the typical progression of life cycle stages (Fig. 3) or the "butterfly diagram" of biological and technical materials loops for a circular economy (Fig. 4), have been some of the most effective tools in communicating industrial ecology ideals to the public and are widely used in both scientific and general public presentations.
218	Gonçalves, A., Galliano, D., Triboulet, P. (2021, p. 1)	The circular economy (CE) is the establishment of an economy that minimizes the loss of materials and energy to preserve the biosphere and the resources it provides (Geissdoerfer et al. 2017). This non-linear economy is based on the creation of loops, circular systems, in which the waste generated by one process becomes the raw material for another. To do so, actors have to shift beyond strictly sectoral concerns and consider the territorial dimension in their strategies (Geissdoerfer et al. 2017).
219	Galatti, L.G., Baruque-Ramos, J. (2019, p. 1)	The circle model is becoming popular under the concept of "circular economy" (CE), and it is one in which products and materials are recycled, repaired and reused rather than thrown away [1, 6, 7]. CE could help meet the material needs of growing populations through drastically lower rates of per capita primary resource use. More than the material issues, CE is also an accepted concept promising to support sustainable development and alleviate the social problems caused by rapid global economic growth [8]. "Cradle to Cradle" is a certification program managed by the nonprofit "Cradle to Cradle Products Innovation Institute" for firms wanting to transition to the CE. To receive this certification, products are assessed for environmental and social

(*continued on next page*)

Table 5 (*continued*)

#	Source	Definition
		performance across some sustainability categories: material health and material reuse; renewable energy and carbon management; water stewardship; and social fairness [9].
220	Hjaltadóttir, R.E., Hild, P. (2020, p. 2228)	Circular Economy is seen as an alternative economic paradigm that emphasis living within the planetary boundaries. CE includes using less raw materials, keeping current materials in use longer through designing longer living products, reuse and recycle materials and minimize waste at all states. The most cited definition (Kirchherr, Reike, and Hekkert 2017; Yuan, Bi, and Moriguichi 2006) is provided by the Ellen MacArthur foundation claiming, 'A circular economy is an industrial system that is restorative or regenerative by intention and design' (MacArthur 2013). Research on CE in the building industry mirrors the definitions focusing on technological solutions and management, mainly waste (Adams et al. 2017; Akanbi et al. 2018; Esa, Halog, and Rigamonti 2017), predominantly the 3R's, recycle, reuse and reduce (Ghisellini, Ripa, and Ulgiati 2018; Kalmykova, Sadagopan, and Rosado 2018), and life cycle analysis of buildings and materials (Soust-Verdaguer, Llatas, and García-Martínez 2017).
221	Tunn, V.S.C., Ackermann, L. (2020, p. 2167)	Researchers then realised that focusing on products alone missed many sustainable solutions and the focus shifted towards the design of sustainable product-service bundles (Roy, 2000; Mont, 2004). Currently, the circular economy integrates these approaches and aims to deliver a sustainable economic system through circular business models. However, even well-designed business models can fall short of their potential because of rebound effects; consumers might use products or services differently or more than intended (Hertwich, 2005; Zink and Geyer, 2017). Product care describes all activities initiated by consumers that prevent shortening of products' lifetimes and thus influence the length of the useful life of products. It thus influences the sustainability of consumption through circular business models and rebound effects (Tukker, 2004; Agrawal et al., 2012; Bardhi and Eckhardt, 2012; Kjaer et al., 2019). For example, access-based product-service systems (AB-PSS) are business models that allow consumers to use products' functionalities without purchasing the products.

a variety of factors including date of publication (older articles tend to have more citations), prominence of publication venue (e.g., a journal with a high impact factor), visibility and credibility of the authors, and subfield (some subfields are larger, and thus would garner more citations, than other subfields – this is relevant particularly when considering studies that focus on narrow contexts like textiles in Finland, construction in India, etc.). As such, the identification of 'influence' is not necessarily a reflection of where the entire field is headed, and citation count does not necessarily imply a threshold level of methodological rigour. Future studies, where feasible in terms of resources and technology, could survey the entire superset of 6566 articles and treat each equally (i.e., agnostic to citation count). This may yield different results and could be an opportunity for further comparison.

From a methodological perspective, future research may undertake refinement of the codebook, aiming to increase inter-coder reliability. More quantitative approaches may also be adopted; for example, the complete corpus of CE literature could be analysed using methods like latent Dirichlet allocation (Tiba et al., 2018; 2021). Graph analytics could further reveal how single articles have shaped CE understandings and could provide a more granular picture regarding the development of CE understandings over time. While such approaches may further refine the findings of this study, we would not anticipate them producing fundamentally different results at this time.

Finally, and perhaps most importantly, we note that the development of a 'final' and consensus definition of CE is elusive. This study has attempted to derive a conceptualization as it exists currently, based on a thorough review of literature. It does not necessarily promote any particular vision of CE, but instead aims to illustrate where the academic field currently sits in its own understandings of CE. As such, we recognize that a final definition may never materialize; we hope that this study, and others that seek to capture the essence of CE through literature analysis, does not imply that any single definition of CE is possible or even desirable. Given the constantly shifting state of technology, environmental conditions, and economic and socio-political contexts, definitions of CE will likely be in a state of perpetual evolution. To this end, we plan to replicate this study again five years from now and we are keen to observe how the CE concept continues to evolve over that time. Overall, we hope that this study contributes to ongoing discussions about CE, helping to avoid conceptual deadlock while creating a common ground to advance the concept.

Authors' contributions

J.K. conceptualized the research. N.N.Y. and M.J.H. collected and coded the data. J.K., N.N.Y., F.S.S., and M.J.H. wrote the article. J.K. and K.H. revised the article.

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.

Data availability

Data will be made available on request.

Appendix

Tables 3-5

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