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Review

How do scholars approach the circular economy? A systematic literature review

Roberto Merli*, Michele Preziosi, Alessia Acampora

Roma Tre University, Department of Business Studies, Via Silvio D'Amico, 77, 00145, Roma, Italy

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ABSTRACT

Circular Economy (CE) aims to overcome the take-make-dispose linear pattern of production and consumption, proposing a circular system in which the value of products, materials and resources is maintained in the economy as long as possible. In recent years there has been a proliferation of scholars' publications on the topic. This study presents the results of a systematic literature review exploring the state-of-the-art of academic research on CE. The paper examines the CE body of literature with a systematic approach, to provide an exhaustive analysis of the phenomenon with rigorous and reproducible research criteria. The revisited material consists of 565 articles collected through the Web of Science and Scopus databases, and has been evaluated using specific structural dimensions to group literature into analytical categories. Starting from being a concept studied in connection with industrial ecology, CE has slowly acquired its independent role in academic research, framed mainly into environmental sustainability related studies. As a result of policies implementation, academic production is mainly concentrated in China and Europe, employing tools and methods for modelling processes and supporting decision-making for CE implementation (e.g. Life Cycle Assessment and Material Flow Analysis). CE studies follow three main lines of action: the first aims to change the social and economic dynamics at macro and administrative level; the second to support firms in circular processes implementation at micro level to spread new forms of consumption and product design; the third, developed at meso level, discusses industrial symbiosis experiences. CE is associated with a variety of concepts, and waste management emerges as the most relevant sub-sector. CE is also strongly connected with the concept of sustainability, proposing ways to operationalize its implementation at the environmental and economic level, while scholars only marginally consider social and institutional implications. The most explored practices are those related to cleaner production, aiming at reducing environmental impact and waste production along the life cycle of a product, and optimizing the performance and efficiency of processes. Conversely, studies on CE may devote greater attention to strategies for social and institutional changes, able to transform the upstream process of production and consumption. Considering business model strategies, scholars mainly focus on studying closing material loops strategy, while slowing the loops, which requires a radical change of consumption and production patterns, is only marginally included with respect to CE implementation. This study's findings highlight CE as an evolving concept that still requires development to consolidate its definition, boundaries, principles and associated practices.

Contents

* Corresponding author.
E-mail addresses: Roberto.merli@uniroma3.it (R. Merli), Michele.preziosi@uniroma3.it (M. Preziosi), Alessia.acampora@uniroma3.it (A. Acampora).

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1. Introduction

In recent years the concept of Circular Economy (CE) has gained the attention of institutions, scholars and firms (Ghisellini et al., 2016). The term CE appeared for the first time in a Pearce and Turner (1990) study that addressed the interlinkages between the environment and economic activities (Andersen, 2007). The authors identified a closed-loop material flow in which the economic system takes place according to the principle "*everything is an input to everything else*" (Su et al., 2013). Nevertheless, the CE principles date back to the work of Boulding (1966), who introduced the idea of a closed system to point out the limited natural resources available for human activities (Nebbia, 2000). The definition of CE is not static, and contains a broad spectrum of principles and proposals that have been formulated in the last decades, such as those of "regenerative design" (Lyle, 1994), "performance economy" (Stahel, 2008), "Cradle-to-Cradle" (Braungart et al., 2007) and "industrial ecology" (Erkman, 1997). CE was conceptualized considering that economic growth leads to environmental degradation and to an over-exploitation of natural resources, reducing the biosphere reproductive capacity (Lieder and Rashid, 2016). Therefore, starting from these assumptions, CE underlines the necessity to re-design the traditional "take-make-dispose" linear path of production and consumption (Geng and Doberstein, 2008). The transition to a more circular society aims to decouple economic growth from natural resource depletion and environmental degradation (Murray et al., 2017). Today, CE has been adopted as a guiding principle in many countries' policies, which have approached its implementation in different ways (George et al., 2015). While China has adopted a top-down approach, other countries have supported CE development with bottom-up policies (Ghisellini et al., 2016). China incorporated CE as a central objective of the 11th and 12th five-year plans for National Economic and Social Development, and in 2009 issued the "Circular Economy Promotion Law" (Su et al., 2013), in which CE is defined as "*a general term for the activity of reducing, reusing and recycling in production, circulation and consumption*" (Chinese National People's Congress, 2008). The European Union issued in 2014 the Communication "Towards a circular economy: A zero waste programme for Europe" and in 2015 the Communication "Closing the loop – An EU action plan for the circular economy", which is part of the CE Package (European Commission, 2015a, 2014). CE is defined by European Institutions 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*".

Not only governments, but also academia and non-governmental organizations, such as the Ellen MacArthur Foundation, are committed to spreading CE principles. This think-tank defined CE as*: "an industrial system that is restorative or regenerative by intention and design. It replaces the "end-of-life" concept with restoration, shifts towards 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."* (Ellen MacArthur Foundation, 2013). Several CE definitions exist, evidence that this concept has undefined boundaries, while changing the actors and point of view. Therefore, there is no commonly accepted definition of CE (Yuan et al., 2006). Over the last years, CE has received great attention from scholars, both for its theoretical conceptualization and for its practical implementation strategies (Geissdoerfer et al., 2016). Also in academia there is no common agreement over its definition (Rizos et al., 2017), and this may generate confusion as well as reducing opportunities for international cooperation (Preston, 2012). The reason is that CE is a relatively young field of research, with roots in different disciplines and schools of thought (Blomsma and Brennan, 2017; Bocken et al., 2017a). However, if on one hand this lack of common and shared definition could lead CE to a conceptual deadlock (Kirchherr et al., 2017), on the other hand it might be argued that a narrow definition is not suited for a concept which aims at establishing a new socio-economic paradigm (Masi et al., 2017).

Considering the evolutionary path that CE is undergoing, this study has as its main goal to clarify how scholars approach and study it. More detailed explanation is given in Section 2, which presents the aim of the review, formulates research questions and defines its contributions to CE studies. Next, Section 3 describes the research methodology employed; Section 4 explains how the materials for this review were collected; Section 5 presents the bibliometric evaluation and the descriptive analysis of results; Section 6 first describes how structural dimensions and the analytical categories were identified, then presents the evaluation of results; Section 7 provides discussion, implications and limitations of this study, proposing future lines of research.

2. Aim of the review and the formulation of research questions

Several studies reviewed scholars' publications on CE (Su et al., 2013). Some of these aim at identifying definitions, concepts and principles pertaining to CE (Rizos et al., 2017; Winans et al., 2017).

Table 1
Literature reviews on CE with a systematic approach.

Focus	Authors	Databases	Years	Keywords	Number of revisited papers	Source
Definitions, concepts, and principles	(Winans et al., 2017)	Scopus; ScienceDirect; Google Scholar	n.a.	Industrial symbiosis, eco-industrial park, material flow analysis and circular economy	150	Renewable and Sustainable Energy Reviews
China	(Ghisellini et al., 2016)	WOS; ScienceDirect	2004–2014	Circular economy; circular economy and cleaner production; circular economy and eco-industrial parks; circular economy and zero waste; circular economy and decoupling; circular economy and rebound effect; circular economy and sustainability	155	Journal of Cleaner Production
Sustainability	(Geissdoerfer et al., 2016)	WOS	1950–2016	circular economy, sustainability and circular economy AND sustainability	67	Journal of Cleaner Production
Business models	(Lewandowski, 2016)	EBSCO Host, Google Scholar, Scopus, and ProQuest	n.a.	Circular economy, business model, circular business model, sustainable business model	n.a	Sustainability
Manufacturing	(Lieder and Rashid, 2016)	WOS; Scopus	1950–2015	Circular economy	158	Journal of Cleaner Production
Product-service	(Tukker, 2015)	Scopus	2000–2012	Product and service and system, Sustainability	278	Journal of Cleaner Production
Big data and IOT	(Cattelan Nobre et al., 2017)	Scopus	2006–2015	Various keywords	70	Scientometrics
Supply chain	(Masi et al., 2017)	WOS; Scopus; ProQuest	2005–2017	Various keywords (mainly circular economy + supply chain)	77	Sustainability
Circular-Green-Bio-economy relationship	(D'Amato et al., 2017)	WOS	1990–2017	Circular Economy; Green Economy; Bioeconomy	1943	Journal of Cleaner Production

Kirchherr et al. (2017), for instance, try to define conceptual boundaries for the circular economy by analyzing 114 definitions of this concept, identifying 17 dimensions. Academics have also investigated the Chinese approach toward a more circular production system (Geng and Doberstein, 2008; Ghisellini et al., 2016; Su et al., 2013) and the European transition to CE (Lazarevic and Valve, 2016). Moreover, Blomsma and Brennan (2017) analyzed the emergence of the CE topic among scholars and practitioners. Circular economy seems to act as an umbrella concept, so several studies have tried to examine its relation with other concepts. For example, D'Amato et al. (2017) performed a comparative analysis of Circular Economy, Green Economy and Bioeconomy. Other reviews have focused on aspects strictly related to CE, as Product-service systems (Annarelli et al., 2016; Tukker, 2015; Vasantha et al., 2015), Industrial Symbiosis (Boons et al., 2011; Jiao and Boons, 2014), Eco-industrial parks (Li, 2011; Valenzuela-Venegas et al., 2016) and Bio-economy (Székács, 2017; Venkata Mohan et al., 2016). Furthermore, some articles study the relationship between sustainability and CE (Geissdoerfer et al., 2016; Murray et al., 2017; Sauvé et al., 2016), while others explore the development of more circular business models (Antikainen and Valkokari, 2016; Bocken et al., 2016; Lewandowski, 2016). Moreno et al. (2016) examined existing literature for Circular design. Cattelan Nobre et al. (2017) investigated the relationship between CE, Big data and Internet of Things (IOT). Lieder and Rashid (2016) explored the application of CE in the manufacturing industry. Another study deepens the application of circular principles in process engineering (Reh, 2013). Additionally, Masi et al. (2017) investigated the implementation of CE in the meso-level of supply chains. Other scholars focused their attention on the creation and evaluation of circular indicators for macro, meso and micro levels (Banait, 2016; Elia et al., 2016; Geng et al., 2012; Griffiths and Cayzer, 2016; Saidani et al., 2017). The problem of establishing metrics and methodologies for measuring the progress toward circularity has also been addressed in studies about Material Flow Analysis (MFA) (Moriguchi, 2007) and Life Cycle Assessment (LCA) methods (Daddi et al., 2017; Haupt and Zschokke, 2017). However, only some of these reviews can be framed as "systematic literature reviews", providing a scientific and transparent process and exhaustive collection of works published in the literature (Annarelli et al., 2016).

Table 1 presents the main characteristics of literature reviews on CE published over the last years that employed a systematic approach to the analysis.

The aim of this review is to give a comprehensive overview of the academic studies on CE, to identify research gaps and to provide potential future research directions on the topic. Therefore, the study addresses the following research question: How does the academic world approach the study of CE? From this general question, more specific questions arise: Who are the protagonists, both considering the source and the authors? Which methodologies and types of research are most employed? What is the level of analysis? What other concepts are associated with CE? What is the relationship between sustainability and CE? Which industries are most investigated? What is the geographical focus of the literature?

What are the business models more closely investigated in academic literature? What are the current and future research streams?

The review presented in the next sections of the paper aims at answering these questions by analyzing a significant portion of academic works dealing with CE. With respect to past reviews produced by other scholars, it contains various novelties that provide added value to better understand the topic under investigation. First, it explores CE with a systematic approach to provide an exhaustive and comprehensive analysis of the phenomenon with rigorous and reproducible research criteria. Second, it does not reduce the scope of the study to a specific focus, but tries to capture all related research topics and approaches linked to CE articles. As the CE topic has been analyzed without a specific viewpoint, it has been possible to include a wide spectrum of scholars' publications (roughly 600 papers). Therefore, the structural dimensions and associated analytical categories have been drawn to capture the greatest number of issues related to CE. Finally, in respect to other studies, the main goal is to better understand how scholars approach CE, highlighting trends and gaps, and serving as a baseline for the identification of research trends on the topic.

3. Research methodology

In order to avoid the limitations of narrative reviews (Tranfield et al., 2003), the paper proposes a systematic review of literature on the topic of Circular Economy (CE). Systematic literature review is a form of secondary study defined by Kitcharoen (2004) as a "*means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest*". This type of analysis allows us to provide a transparent and reproducible process of selection, analysis and reporting of previously conducted research on a specific subject (Denyer and Tranfield, 2009). Methodologically, a literature review integrates qualitative and quantitative evaluation to investigate a specific topic (Brewerton and Millward, 2001) and can be framed as a content analysis.

Several authors have proposed frameworks to produce a reliable systematic review. The first step of the review consists of proposing research questions (see Section 2) as suggested by Denyer and Tranfield (2009). Then, material collection and descriptive analysis are developed following the guidelines provided by Mayring (2002) and Tranfield et al. (2003). Next, structural dimensions and material evaluation are developed following Mayring's approach; this for two main reasons. First, in the context of cleaner production and sustainability studies, this approach has been widely employed by scholars performing reviews on supply chain management (Agrawal et al., 2015; Seuring and Gold, 2012; Shukla and Jharkharia, 2013), sustainable supply chain management (Brandenburg et al., 2014; Gold et al., 2010; Seuring et al., 2005; Seuring and Müller, 2008), education for sustainability (Karatzoglou, 2013), and sustainable innovation (Klewitz and Hansen, 2011). Secondly, with respect to other approaches to systematic literature review in the context of sustainability studies (Tranfield et al., 2003), Mayring (2002) proposed to evaluate the collected materials through topic-specific structural dimensions and analytical categories. This approach allows us to categorize a large number of records and to identify a framework to establish the main trends in circular economy studies.

The review process followed five main steps, which are summarized in Fig. 1 and listed below:

- Research questions formulation (Section 2).
- Material Collection: definition and delimitation of materials and unit of analysis (Section 4).
- Descriptive Analysis: formal aspects of collected material are assessed and analyzed using quantitative methods (Section 5).
- Category Selection: to organize the collected material, structural dimensions and related analytic categories are identified (Section 6).
- Material Evaluation: the material is evaluated according to dimensions and categories previously established. Results are interpreted to define relevant issues (Section 6).

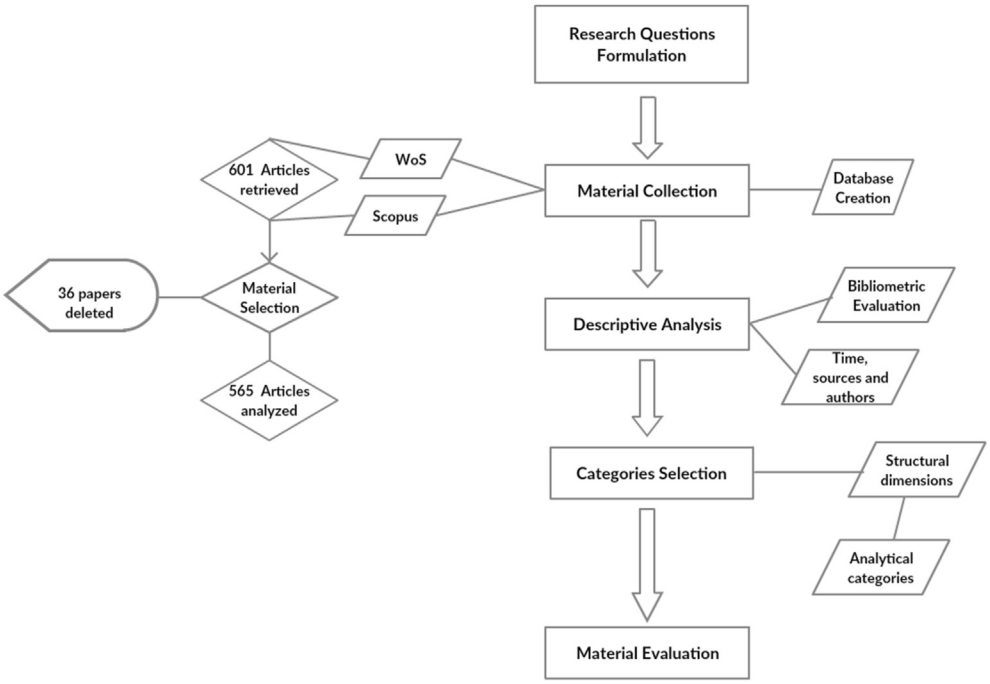

Fig. 1. Summary of the review process.

Each of the next Sections presents the methods and the results of the review process, following the steps listed above.

4. Material collection

Material collection was carried out through Web of Science (WoS) and Scopus, which are the most comprehensive scientific databases (Aghaei Chadegani et al., 2013; Guz and Rushchitsky, 2009), facilitating the implementation of reliable bibliometric studies (Sánchez et al., 2016). In order to photograph CE studies across the scientific community, the generic keyword "Circular Economy" was employed as a research criterion in both databases. In WoS the research criterion was "Topic" (Title, Author Keywords, Abstract, Keyword Plus®".), while in Scopus was "Title, Author Keywords, Abstract".

The first step in the review process is the definition of the unit of analysis. In this review, the unit is the single research article. Thus, on both databases the results were limited to "Article". Finally, only articles written in English were selected. English was selected as the exclusive language for the research as in both databases it is by far the most employed and also because it is generally considered as the international academic language (Genç and Bada, 2010). No chronological restriction was employed. The queries on the two databases were performed on April 28, 2017. The research on Scopus returned 474 results (from the original 477, 3 papers were a duplicate in Scopus and were thus deleted), while WoS returned 396 records. Next, duplicates of the two databases were deleted. Out of the total 870 documents, 269 (total 538) were overlapped between Scopus and WoS. Scopus has 205 unique records, while WoS has 127. Thus, the total of papers revisited was 601 (Fig. 2).

5. Descriptive analysis

5.1. Databases' comprehensiveness for CE

The aim of the sub-section is not to evaluate the quality of papers included in the two databases, but rather to perform a descriptive-quantitative analysis of databases comprehensiveness.

First the Meyer Index (Relative Index of Uniqueness), which evaluates databases monitoring on a given topic, was calculated. The score represents the database capacity to cover a specific theme. Primary sources that are contained in a single database are weighted 1, while secondary sources (contained in both databases) are weighted 0.5, as they are duplicates. The higher the index value, the greater the singularity of the database (Meyer et al., 1983; Sánchez et al., 2016).

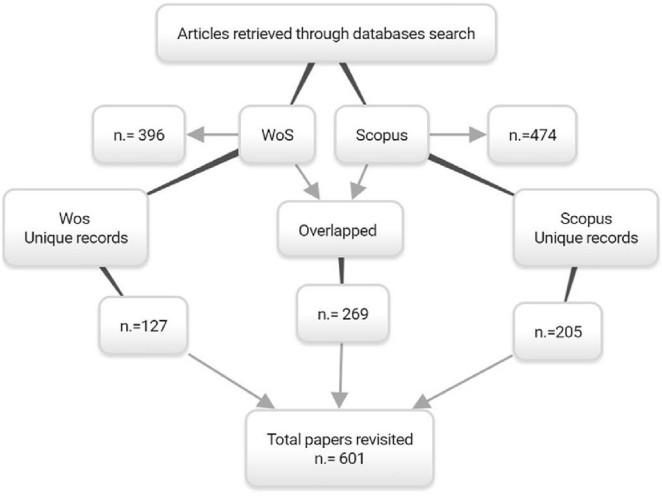

Fig. 2. Material collection process.

$$\text{Meyer Index} = \frac{\sum \text{Articles} * \text{weight}}{\text{Total articles}} \quad (1)$$

$$\text{Scopus Meyer Index} = \frac{205 + (269*0.5)}{601} = 0.56 \quad (2)$$

$$\text{WoS Meyer Index} = \frac{127 + (269*0.5)}{539} = 0.48 \quad (3)$$

Formula (2) shows the results of the Meyer Index for Scopus, while formula (3) refers to WoS. Results show a higher singularity of Scopus, with 56% of unique articles, while 48% of WoS records are unique.

Then, the Traditional Overlap between the two databases was calculated (Gluck, 1999). The value of the Traditional Overlap represents the level of similarity between two databases. The higher the value, the higher the similarity.

$$\%\ \text{Traditional overlap} = 100*\left(\frac{|\text{Scopus} \cap \text{WoS}|}{|\text{Scopus} \cup \text{WoS}|}\right) \quad (4)$$

$$\%\ \text{Traditional overlap} = 100*\left(\frac{269}{601}\right) = 44.76\% \quad (5)$$

Formula (5) indicates that 44.76% of articles are identified in both databases. At the same time, the formula suggests that searching with just one database will lead to identify 55.24% of unique sources.

Finally, Formula (7) and (8) show the results for the Relative Overlap, measuring the percentage of one database's coverage compare to the other (Formula 6).

$$\%\ \text{Overlap Scopus} = 100*\left(\frac{|\text{Scopus} \cap \text{WoS}|}{|\text{Scopus}|}\right) \quad (6)$$

$$\%\ \text{Overlap Scopus} = 100*\left(\frac{269}{205 + 269}\right) = 56.75\% \quad (7)$$

$$\%\ \text{Overlap WoS} = 100*\left(\frac{269}{127 + 269}\right) = 67.92\% \quad (8)$$

The results of Formula (7) and (8) indicates that Scopus has a higher extension, covering 67.92% of WoS sources. On the other hand, 56.75% of Scopus records are covered by WoS (Formula 7).

5.2. Distribution and evolution of papers across time, sources, and authors

After collecting the records and deleting those which overlapped between the two databases, a first scanning was performed. 36 of the initial 601 records were deleted. Of these, 8 were duplicated within one database. The other 28 did not meet the research criteria, as 12 lacked an abstract and 16 did not contain the words "circular economy" within the title, abstract and keywords. Thus, the successive analysis considers 565 records.

The databases analysis shows that CE is a rapidly growing research topic. Over three-quarters (82.12%) of the records were published in the last 5 considered years (2013–April 2017). Moreover, during 2016 and the first four months of 2017, 56.11% of the works were issued, showing a sharp increase of publications. Fig. 3 illustrates the trend of CE literature, showing the increasing interest

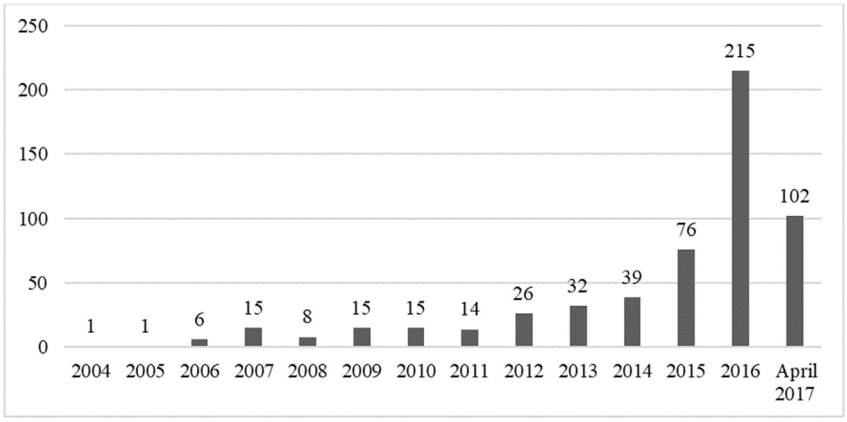

Fig. 3. Evolution of publications about CE per year (2004–April 2017).

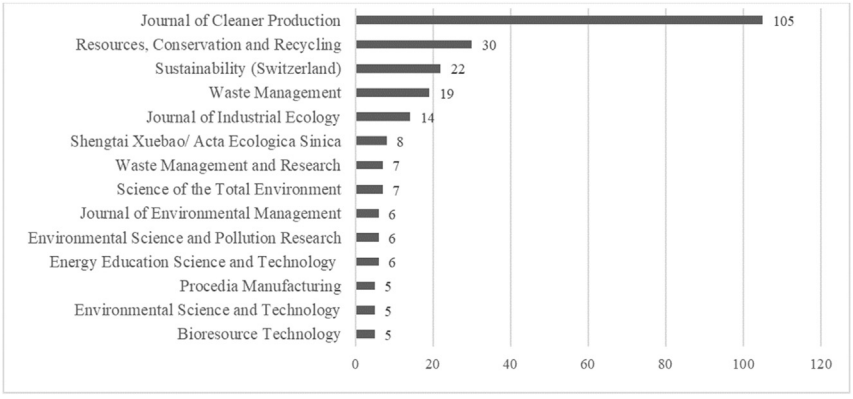

Fig. 4. Number of CE articles per Journal (Journals with at least 5 published articles).

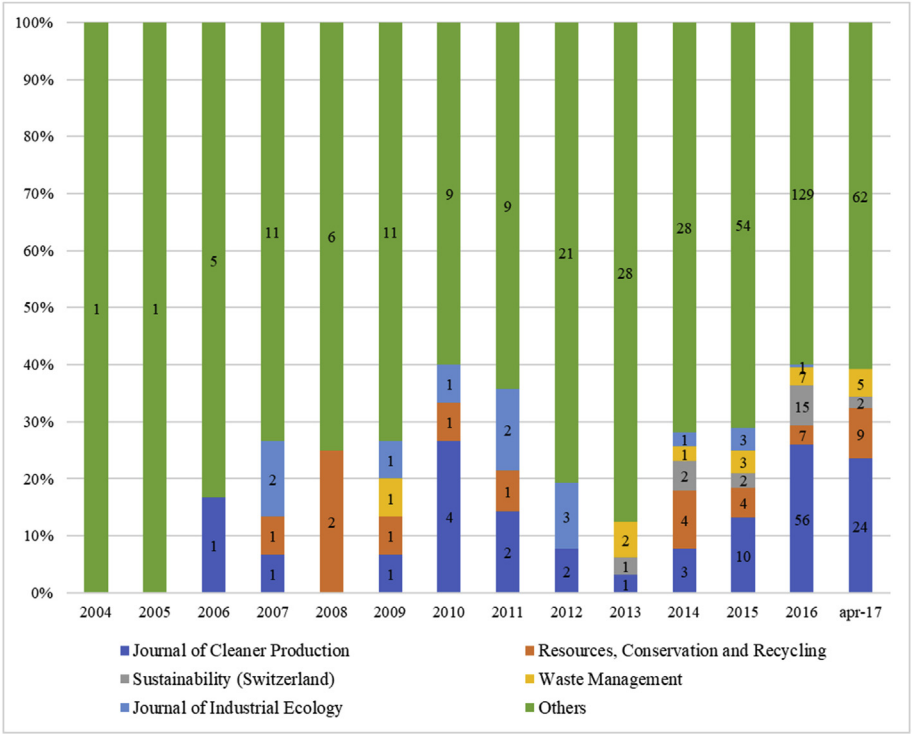

Fig. 5. The five journals with the highest share of publications.

Table 2
Authors with at least 5 publications in databases and country of affiliation.

	Authors	N. Papers	Affiliation
1	Geng, Y	28	China
2	Zhu, QH	11	China
3	Fujita, T	10	Japan
4	Liu, Zhe	7	China; Canada
5	Sarkis, j	9	USA
6	Dong, L	8	Japan; Netherlands
7	Garcia-Navarro, J	7	Spain
8	Jimenez-Rivero, A	7	Spain
9	Thomsen, M	6	Denmark
10	Fujii, M	6	Japan
11	Xue, B	5	China
12	Lai, KH	5	China (Hong Kong)

for the topic.

Most of the journal considered have environmental issues as their main topic. The Journal of Cleaner Production has pride of place, with 18.58% of the published articles. It is followed by Resources, Conservation and Recycling (5.31%), and Sustainability (3.89%). The 5 most prolific journals account for 33.63% of records (Fig. 4).

Fig. 5 shows that the Journal of Cleaner Production has maintained its leadership over the years. From 2008 this journal has constantly published articles on CE and in 2016 represented nearly 30% of the total. Resources, Conservation and Recycling has also constantly contributed to the topic. Since 2013, Sustainability has emerged as one of the most prolific journals covering CE issues. Findings show that even though CE has the final goal of redefining the entire socio-economic system, academia, both in the past and at the present time, has mainly considered the circular approach as a way of managing critical environmental aspects of the traditional linear path of production and consumption, with a clear focus on waste and recycling practices.

Table 2 presents the most prolific authors, who contributed to the topic with at least five articles. The most representative author is Geng, Y. from China with 28 publications, followed by Zhu, QH. (11) and Fujita, T. (10). Table 2 shows a substantial predominance of authors affiliated with Chinese Universities. Moreover, the analysis revealed that, apart from authors from Spain and Denmark, the other non-Chinese affiliated authors have constantly published in cooperation with Chinese colleagues. These results highlight that academic production on the topic is highly connect with the Chinese (and only later European) policies for CE. Therefore, scholars' efforts aim at providing policy makers with strategies and tools to develop CE implementation based on solid scientific foundations.

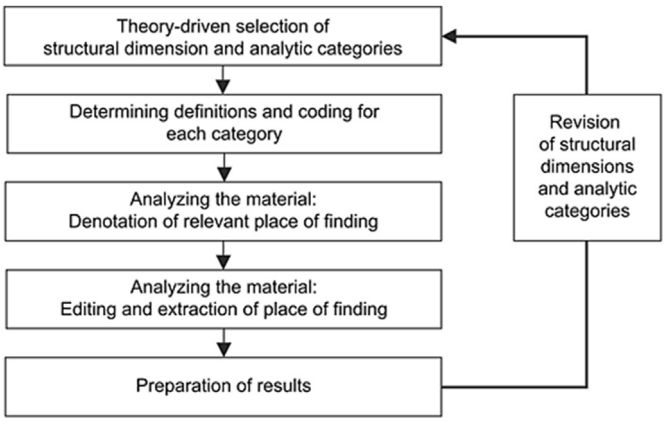

Fig. 6. Research process of a structured review analysis (Mayring, 2003; Seuring and Müller, 2008).

6. Category selection and material evaluation

The next part of the review is organized following a concept-centric approach to literature review (Webster and Watson, 2002). In relation to the research questions presented in Section 2, Fig. 6 describes the process of categories' selection and material evaluation. The feedback loop indicates the recursive process of structural dimension and analytic categories revision throughout the literature review. This framework allows the adoption of an iterative process, starting with a deductive approach, using analytical categories identified in previous literature. Once the analytical categories have been selected, a preliminary scan of collected material is carried out. Then, through an inductive process, the analytical categories that are not suitable for the analysis are discarded and new ones are chosen (Mayring, 2003; Shukla and Jharkharia, 2013).

To analyze the topic, nine structural dimensions were selected. Subsequently, for each structural dimension, analytical categories were employed to systematize the material. Each record may simultaneously be part of more than one category. For this reason, in each structural dimension analyzed, the total count of articles may differ. Categories have been gathered from studies specifically dealing with CE (Level of analysis, Type of research, ReSOLVE and Bocken's Business models). Starting with a deductive approach, other categories were extrapolated through a preliminary analysis of literature reviews dealing with other topics, but which were, however, consistent with the concepts of CE (Sustainability, Methodology, Keywords). After a first scan of the materials through an inductive procedure, new categories of analysis were introduced (Industry, Waste focus, Survey focus). In each following sub-section, first the structural dimensions and related analytical categories are listed, then the results are presented. Table 3 summarizes the structural dimensions and the associated analytical categories employed for material evaluation.

6.1. Methodologies and types of research

First, papers were examined considering the structural dimension "Research methodology" that was retrieved from supply chain management studies dealing with sustainability issues (Hassini et al., 2012; Seuring and Müller, 2008). The dimension differentiates five approaches to research: Review, Case Study, Theoretical and Conceptual, Modelling and Survey.

Fig. 7 shows the distribution of articles according to research methodologies. The most employed are Modelling (32.12%) and Case Study (28.32%). In the case study category, a significant number of papers dealing with the application of CE can be found (e.g., Morlok et al., 2017; Weissbrod and Bocken, 2017), but there are also research papers with a specific focus on geographical implementation in different countries. Particularly, Chinese principles of CE are the most explored (e.g., Li and Ma, 2015; Ma et al., 2014), often with a focus on Industrial Symbiosis (IS) or eco-industrial parks (e.g., Shi et al., 2010; Yu et al., 2015). However, case studies in European countries were conducted as well (e.g., Nasir et al., 2017; Riisgaard et al., 2016). Considering studies falling in the Modelling category (e.g., George et al., 2015; Xu et al., 2009), a significant share adopted an LCA-based approach (42 papers) to carry out the analysis (e.g., Castellani et al., 2015; Niero and Olsen, 2016). The theoretical and conceptual category includes 97 papers (e.g., Murray et al., 2017; Pomponi and Moncaster, 2017), followed by Review (83) and Survey studies (49). Review studies on CE were presented in Section 2 of this paper. There are 33 survey studies with a focus on consumer's behavior (e.g., Borrello et al., 2017;

Table 3
Structural dimensions and analytical categories.

Structural dimensions	Analytical categories
Research methodologies	• Modelling • Case study • Theoretical and conceptual • Review • Survey
Type of research	• Economic model • Policy • Process engineering • Business models and management • Tools, models, framework, methods for decision making
Level of analysis	• Micro • Meso • Macro • Supply chain
Keywords	• Keywords families
Sustainability	• Economic • Environmental • Social
Industries	• Sector of activities
Geographical focus	• Specific geographical areas object of the studies
ReSOLVE Framework	• Regenerate • Share • Optimize • Loops • Virtualize • Exchange
Business models	• Industrial symbiosis • Extending resource value • Access and performance model • Encourage sufficiency • Classic long-life model • Extending product value

Lakatos et al., 2016), while there are 24 that focus on firm's behavior (e.g., Dalhammar, 2016; Sihvonen and Partanen, 2016). Among these studies, some have a specific focus on the firms' perception of Chinese implementation of CE (e.g., Liu and Bai, 2014), others on consumers' perception (e.g., Liu et al., 2009).

The structural dimension "Type of research" was adapted from Lieder and Rashid (2016) who performed a review on CE in the context of manufacturing industry. Types of research are divided into:

Tools, Models, Framework and Methods for decision making: studies developing theoretical or empirical instruments and approaches to evaluate and develop CE.

- Review: studies that summarize previously published literature.
- Process engineering: studies dealing with chemical, physical and biological processes.
- Economic Model: studies approaching CE considering its macro-economic implications.
- Policy: studies analyzing the impact of existing or potential policies for CE development.
- Business model and management: studies dealing with the development of CE business models and managerial implications.

Fig. 8 presents the results for the structural dimension "Type of Research". Most results (43.50%) are included in the "Tools, Models, Framework, Methods for decision making" category (e.g., Ruggieri et al., 2016; Xu et al., 2009). Some of these studies deal with the application or the modelling of different tools like MFA (e.g., Chen, 2009; Moriguchi, 2007), LCA (e.g., Iraldo et al., 2017; Sommerhuber et al., 2017), CE indicators (e.g., Elia et al., 2016; Geng et al., 2012; Huysman et al., 2017; Maio and Rem, 2015) and Emergy Analysis (e.g., Pan and Li, 2016; Zhe et al., 2016). The second more explored type of research is the identification of CE business models and the analysis of managerial implications for CE implementation (24.37%) (e.g., Bocken et al., 2016; Lewandowski, 2016; Rizos et al., 2016). The third is occupied by papers dealing with innovative chemical, physical and biological processes (18.05%) (e.g., Hu et al., 2011; Ma et al., 2015; Schetters et al., 2015). Then, 11.55% of articles investigate CE national and international policies effectiveness (e.g., Bigano et al., 2016; Kama, 2015; Mathews et al., 2011). Finally, 2.53% develop the analysis with a macro-economic approach (e.g., Cucchiella et al., 2016; Xia and Yang, 2007). The prevalence of Modelling associated with tools for decision making indicates that CE is considered as a way to practically deal with critical issues in the production and consumption system. These instruments are used in order to apply CE principles to solve practical situations and create new references to measure circularity. Additionally, circular process engineering is mainly used with case studies methodologies. Finally, results show that academia also recognizes that CE necessitates a managerial approach, one which is able to capture the business implications of this transition (Figs. 6 and 7).

6.2. Level of analysis

The CE implementation may be categorized at three systemic levels (Ghisellini et al., 2016). Firstly, the macro level includes activities developed at a city, province, region or national level and

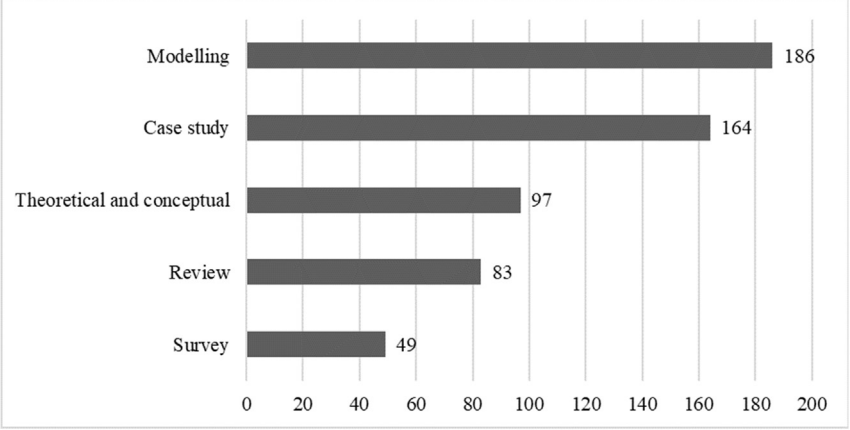

Fig. 7. Research methodologies employed.

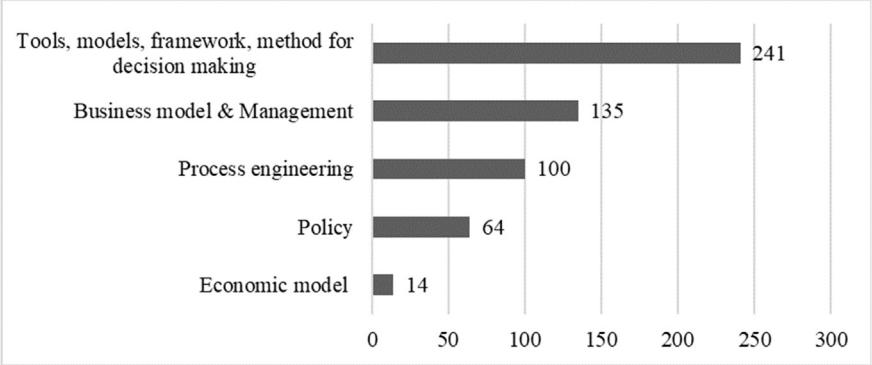

Fig. 8. Types of research employed.

Table 4
Analytical categories adopted from other CE studies.

Analytical Categories	Authors
Micro	corporate-level (micro-level) initiatives (Franklin-Johnson et al., 2016; Geng et al., 2012; Geng and Doberstein, 2008; Ghisellini et al., 2016; Park et al., 2010; Shao-ping et al., 2010; Su et al., 2013); consumers level (Ghisellini et al., 2016; Su et al., 2013)
Meso	Inter-firm level within geographic proximity. Industrial Symbiosis and Eco-industrial parks (Chertow, 2000; Geng et al., 2012; Geng and Doberstein, 2008; Ghisellini et al., 2016; Park et al., 2010; Su et al., 2013; Yuan et al., 2006)
Supply chain	More firms involved within a supply chain (Ghisellini et al., 2016; Park et al., 2010)
Macro	Redefine production and consumption activities as whole: create a recycling oriented society (Geng et al., 2012; Shao-ping et al., 2010). Activities developed at city, province, region, national level (Franklin-Johnson et al., 2016; Geng et al., 2012; Geng and Doberstein, 2008; Ghisellini and Thurston, 2005; Su et al., 2013; Yuan et al., 2006)

activities to promote a recycling oriented society. Secondly, the meso level that describes an inter-firm level within geographic proximity. It includes Industrial Symbiosis and Eco-industrial parks. Finally, the micro level, which focuses on single firm activities or consumers. The analysis integrates these three categories with the supply chain level, where the focus is on the interactions among firms involved within a supply chain. Table 4 lists the studies that have previously defined the four levels of CE analysis.

Fig. 9 shows that over a half of the articles study CE implementation with a macro level of analysis (51.33%), conducting studies oriented at society level (e.g., Hobson and Lynch, 2016; Scheel, 2016) or investigating CE at city (e.g., Schneider et al., 2017), region (e.g., Geng et al., 2009), province (e.g., Du et al., 2009) or country level (e.g., Li et al., 2010; Ormazabal et al., 2016; van Buren et al., 2016; Yaduvanshi et al., 2016). The micro level of analysis represents 33.98% of articles (e.g., Jiménez-Rivero et al., 2017; Wang and Hazen, 2016), followed by Meso (11.15%) (e.g., Boons et al., 2011; Yu et al., 2015) and Supply Chain level (3.54%) (e.g., O'Connor et al., 2016; Zhu et al., 2011). In order to become effective, CE needs to change the traditional patterns at all levels of society, and this is reflected in the four levels of analysis proposed by scholars. The macro level satisfies the public decision-makers' necessity to address circularity at territorial level. On the other hand, the micro and meso levels consider specific needs of single or clustered firms to apply CE principles. However, figures show that further attention should be devoted to studying potential circular exchanges into supply chains (Fig. 9).

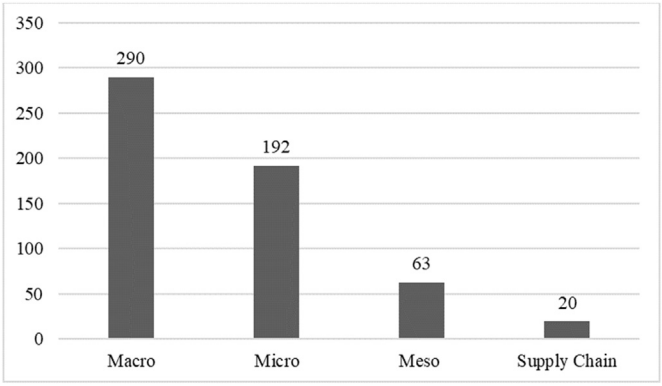

Fig. 9. CE level of analysis.

6.3. Keywords families

In the next step of the analysis all authors' keywords were extracted. Many keywords differ only in formal aspects (as in the use of a line or acronyms), while others have strong conceptual similarities. To summarize and clarify the analysis, keyword families were created to explain how other concepts are related to CE (Fig. 10). After "Circular Economy", three categories stand out over the others: Waste (144), Industrial Ecology (134) and Sustainability (128). Industrial Ecology is inclusive of other concepts closely linked to it, like industrial symbiosis and eco-industrial parks. Other important concepts related to CE are Recycling/Reuse (83) and Environment (61), which is mainly used to characterize other terms. China is the only keyword family identifying a specific territory (59). Efficiency (59) and Energy (45) keywords are often used jointly. The Bio-economy (55) family is comprehensive of bio-based products such as bio-energy and bio-refinery. Among the most employed keywords families, there are two methods of analysis mainly related to industrial ecology, namely the LCA (48) and MFA (20). Finally, Closed-loop was identified in 15 articles, especially in relation to recycling and supply chain management. Results indicate that CE is employed as a Keyword in less than a half of the records. However, scholars refer to CE in the papers' abstract as they recognize its implications in defining other concepts or practices into a model which is able to lead toward a radical societal shift. This connection is marked in those papers focusing on activities aiming at closing material loops (e.g., Waste, Industrial Ecology, etc.). Another significant aspect to consider is the frequent connection of CE with sustainability and environmental issues (Fig. 10).

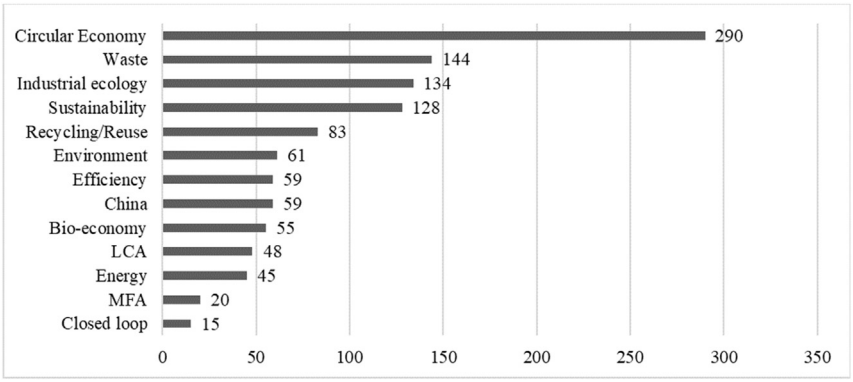

Fig. 10. Keyword families.

6.4. Sustainability

From the keyword analysis, it emerged that CE is often linked with sustainability. Therefore, articles were analyzed considering the triple bottom line of sustainable development. The structural dimension and analytical categories were adapted from Corporate Social Responsibility (CSR) and sustainable supply chain review studies (Chen et al., 2014; Goyal et al., 2013; Seuring and Müller, 2008). These studies employ the triple bottom line of sustainability to categorize literature into Economic, Environmental or Social focus.

Fig. 11 shows that almost all the articles investigate the environmental dimension of sustainability, which is often the starting point of the analysis. In most cases, this environmental focus is associated with economic considerations (303), while in 150 articles it is considered exclusively. The triple bottom line is adopted in 80 cases. The analysis highlights that social and economic aspects, jointly or exclusively, are only marginally considered (18).

Fig. 12 presents the chronological evolution of the three sustainability dimensions studies. Over the years, most of the literature has dealt jointly with the environmental and economic pillars, followed by the environmental-related studies. However, during recent years, a more comprehensive approach to CE has been emerging, as a growing number of articles integrate the three dimensions of sustainability. The strong linkage with sustainability, and especially with environmental sustainability, shows that CE, through the application of its principles, offers practical solutions to reduce the anthropic pressure on natural ecosystems.

6.5. Industries

The next step of the analysis consisted in categorizing papers in relation to the industry investigated. In over 70% of the reviewed articles it was possible to distinguish a specific sector of activity. The most numerous sectors are waste (21.63%) (e.g., Wilts et al., 2016; Zorpas, 2016), metallurgic (14.90%) and agri-food (13.46%) (e.g., Monlau et al., 2016; Zabaniotou et al., 2015). Considering the metallurgic sector, the most investigated is steel (e.g., Broadbent, 2016), followed by aluminum (e.g., Niero and Olsen, 2016) and iron (e.g., Ma et al., 2014). As one of the main goals of CE is to minimize and valorize what in a traditional linear model is considered waste, most of the experiences deal with the implementation of circular models into the waste industry. This is reinforced by the fact that, regardless of the industry under investigation, 135 articles consider how to treat waste produced in the light of CE principles within a specific industry. As far as the other industries are concerned, the metallurgic is the most studied concerning the technological sphere, while the agri-food industry is the most investigated in the biological sphere (Fig. 13).

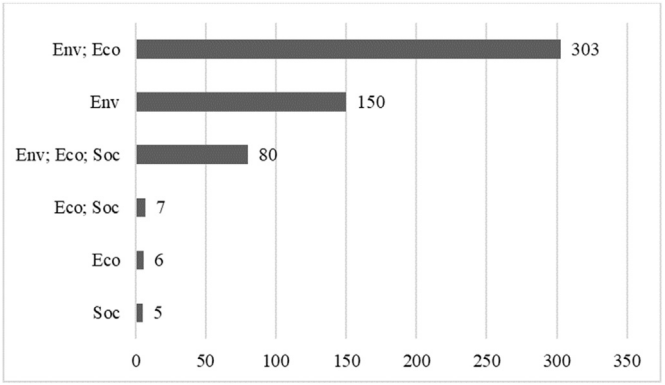

Fig. 11. Dimensions of sustainable development explored.

6.6. Geographical focus

In order to evaluate the areas where CE studies are more applied, when possible the articles were classified according to the geographic focus. 59.11% of records investigate a specific geographic area. Of these, 56.29% concentrate their analysis in Asia and 40.12% in Europe (Table 5).

For Asia, 92.55% of the articles focus on China, while in Europe the most represented countries are UK (14.17%), Italy and the Netherlands (12.60% respectively). Fig. 14 shows the 10 most represented European countries.

Fig. 15 illustrates that CE studies in China started in the early 2000s, maintaining a constant growth since the publication of the 11th "5-Years Action Plan for CE" in 2005. Also, the European interest in this topic arose as a result of the European Action Plan for CE, issued in 2014. It is also interesting to note that, in Europe, the predominance of UK is due both to the national government commitment and to the Ellen McArthur Foundation that has strongly contributed to increasing CE awareness.

6.7. CE practices in the ReSOLVE framework

The Ellen McArthur Foundation proposed the ReSOLVE framework, with the objective of defining operational actions to put into practice CE principles. This framework was employed as a structural dimension, and the six different operational actions were utilized as analytical categories (Table 6) (Ellen Macarthur Foundation, 2015a; Lewandowski, 2016).

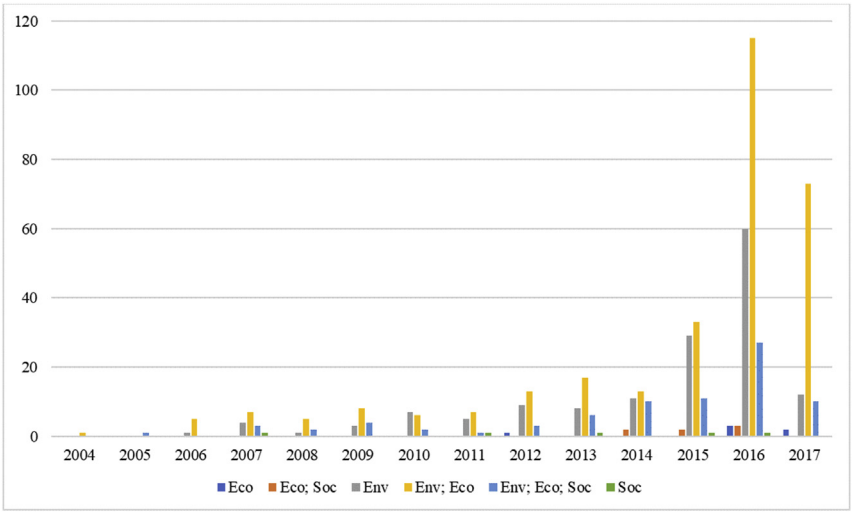

Fig. 12. Chronological evolution of sustainable development dimensions explored.

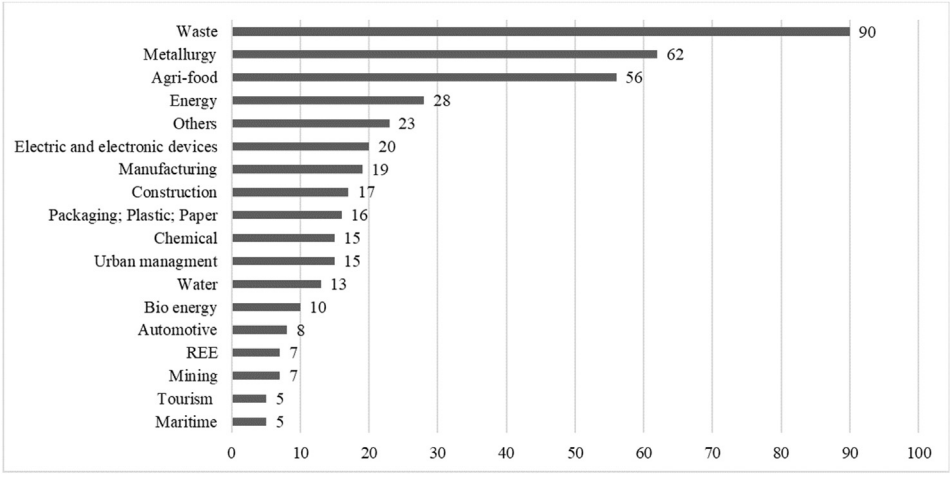

Fig. 13. Industries covered and investigated by the articles.

Table 5
Geographical focus of the papers.

Area	N. Papers
Asia	188
Europe	134
Oceania	5
South America	3
North America	2
Africa	2

The ReSOLVE framework aims at defining a comprehensive categorization of CE practices. Nevertheless, it was possible to enclose only 43.01% (243) of the articles within this framework. Of these, 27.25% of the papers investigate jointly more than one ReSOLVE category. Closing material and resource loops is one of the pillars to achieve a circular system and represents the most employed practice. Fig. 16 shows that most studies deal with actions aimed at closing resource loops (44.61%) (e.g., Stoknes et al., 2016; Wang and Hazen, 2016; Zhang et al., 2011), of which the majority explore recycling practices (e.g., Longana et al., 2016; Machacek et al., 2015). "Optimize" mostly covers energy efficiency and waste reduction practices and represents 22.46% of the cases (e.g., Cattelan Nobre et al., 2017; Schulte, 2013; Singh and Ordonez, 2016), followed by "Regenerate" (17.07%) (e.g., Diez et al., 2016; Seghetta et al., 2016).

"Share" (11.98%) (e.g., Bakker et al., 2014; Bonciu and Balgar, 2016; Viani et al., 2016), "Exchange" (2.69%) (e.g., Delgado-Aguilar et al., 2015; Despeisse et al., 2017) and "Virtualize" (1.20%) (e.g., Bigano et al., 2016; Fox, 2016) are the least explored categories. Results highlight that practices aimed at reducing environmental impact and at promoting a more efficient use of natural resources have been widely investigated by scholars. Conversely, those aiming at reformulating value proposition of product and services (e.g. sharing economy), and proposing the introduction of new technological solutions (e.g. dematerialization) still remain marginal in the academic debate.

6.8. Business models for CE

Following the work of Bocken et al. (2016), the last structural dimension investigated is "Business models for CE". The authors distinguish two categories of CE business strategies: "Slowing resource loops" and "Closing loops". The first concerns the creation of products with longer life and the development of product reuse practices. The second consists in creating value from what in a

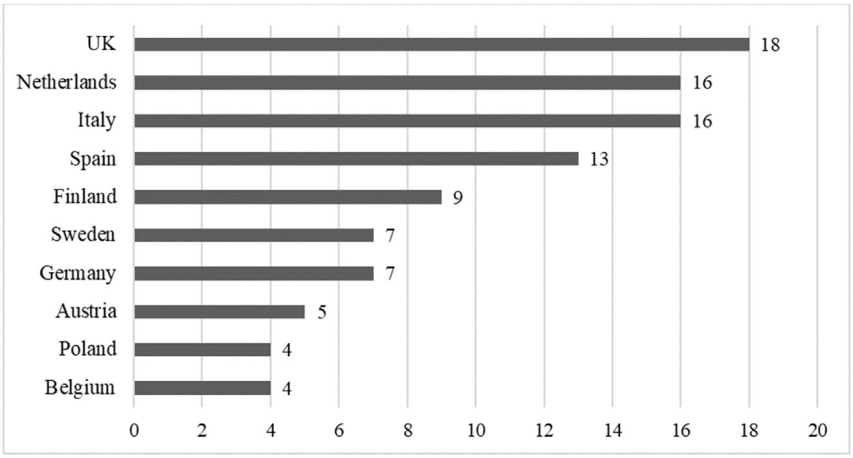

Fig. 14. Top 10 European countries according to the geographical focus of the articles.

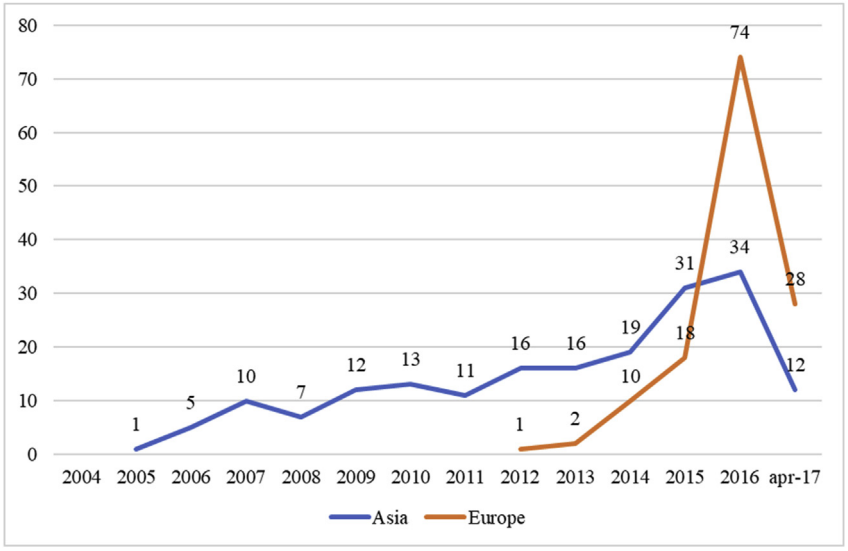

Fig. 15. Evolution of geographical focus over the years.

Table 6
The ReSOLVE framework, adapted from (Ellen Macarthur Foundation, 2015a).

Analytical category	Description
Regenerate	Shift to renewable energy and material; reclaim, retain, and regenerate the health of ecosystems; return recovered biological resources to the biosphere
Share	Share products among users; reuse/second hand; prolong product life (durability, upgradability, maintenance)
Optimize	Increase product performance/efficiency; remove waste from production and supply chain; leverage big data, automation, remote sensing and steering
Loops	Remanufacture product and components; recycle material; extract biochemical from organic waste
Virtualize	Dematerialize
Exchange	Replace old materials with advanced non-renewable materials; apply new technologies; chose new products and services

traditional linear model is considered as waste (Bocken et al., 2016). Table 7 describes the analytical categories of these two macro-groups.

From the analysis performed, 39.82% can be categorized according to the CE business models proposed. Of these, the majority (75.11%) fall in the "Closing the loops" category, while the remaining 24.89% in the "Slowing loops" category. Only in 16% of the articles, were two or more business models explored at the same time.

In "Closing the loops", the "Extending resource value" analytical category consists of 118 articles (e.g., Lee et al., 2014; Molina-Moreno et al., 2016), while "Industrial symbiosis" is represented by 51 articles (e.g., Walls and Paquin, 2015; Zhao et al., 2017). "Slowing the loops" is significantly less explored than the other macro-category and in this type of business model implementation "Extending the product value" is the most explored category with 30 articles (e.g., Han et al., 2016; Van Weelden et al., 2016). It is followed by "Classic long-life model" (13) (e.g., Bakker et al., 2014; Mont, 2008), "Encourage sufficiency" (8) (e.g., Moreno et al., 2016; Riisgaard et al., 2016) and "Access and performance model" (5) (e.g., Cohen and Muñoz, 2016) (Fig. 17).

The analysis of literature with a business model perspective confirms findings which emerged from the ReSOLVE framework (Sub-section 6.7): a stronger focus is given to studying how to

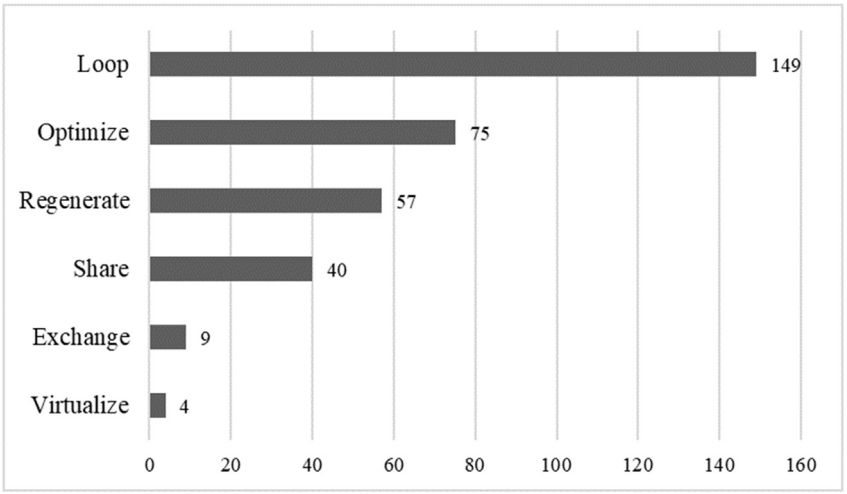

Fig. 16. Identification of CE practices investigated according to ReSOLVE framework.

Table 7
CE business models' analytical categories. Adapted from Bocken et al. (2016).

Analytical category	Description
SLOWING THE LOOPS	
Access and performance model	Satisfy needs without the physical ownership of product
Extending product value	Remanufacturing and refurbishment practices
Classic long-life model	Design of long-life products (durability and repair)
Encourage sufficiency	Prolong product life at end user level through durability, upgradability, repair and warrantees
CLOSING THE LOOPS	
Extending resource value	Transform waste into a valuable resource
Industrial symbiosis	Residual output of an industrial process becomes input for another industry

manage and valorize waste and to extend resource values as long as possible, while less attention is assigned to more innovative approaches that aim to change the way how product and services are provided to consumers.

7. Discussion

This final section of the paper discusses the most important findings of the study, identifying the relevant trends in academic studies on CE. Then, the main limitations of the study are listed, providing the baseline for possible future lines of research.

7.1. Main research findings

With respect to the research questions presented in Section 2, the most significant findings are presented in bullet points and then discussed:

- Academic publications on CE are growing rapidly and are published mainly in journals with a focus on environmental sustainability.

Only 14 Journals have published more than 5 articles within the research criteria employed. The Journal of Cleaner Production has pride of place among sources and significantly outperforms the others, distinguishing itself as a reference point on the topic. From its outset as a concept studied in connection with industrial ecology, CE has since acquired its independent role in academic research, becoming closer to environmental sustainability related studies (Hobson and Lynch, 2016). Additionally, studies on CE mainly focus on natural resources management and environmental protection practices, while less attention is given to CE implication in the context of social science and managerial studies. However, in recent years the number of publications that analyze CE from other viewpoints, such as strategic management and business ethics, has been constantly growing (Murray et al., 2017).

- Chinese scholars are the most prolific in CE studies.
- The geographical focus of articles is largely concentrated on China and Europe.

Authors affiliated to Chinese universities are leaders in the academic publications on the topic. The first publication dates to 2004, but only from 2008 has CE become a widely discussed research topic. The geographical focus of the articles underpins this finding. Starting from 2005 and until 2013, almost all the articles with a well-defined geographical focus were about China. Despite its past unsustainable economic development, China was one of the first countries to plan an economy based on closed loops, in order to maintain a strong economic growth while pursuing environmental sustainability (Zink and Geyer, 2017). Therefore, the Chinese predominance is probably a consequence of the early implementation of CE policies, based on industrial ecology studies (Mathews et al., 2011). Starting from the 11th Five-Year Plan (2006–10), China issued in 2008 the circular-economy promotion law that resulted in the production of several studies on CE implementation, especially for the coal, steel, electronics and chemical industries (Mathew and Tan, 2016). Then, with the 12th Five-Year Plan (2011–15), CE was advanced to a national development strategy (Su et al., 2013), whose main goal was to recycle metals and minerals, and to stimulate remanufacturing in the industrial symbiosis context (Preston, 2012). At the European Community level, CE emerged later as a result of activity by the Ellen McArthur Foundation (also with the British Government) and the enactment of the Circular Economy Package (Masi et al., 2017), which is considered as the next political economy policy for Europe (Lazarevic and Valve, 2016) and aims to reach the 2030 Sustainable Development Goals (European Commission, 2015a; Manninen et al., 2017). Therefore, starting from 2013, there has been a growing Europe-centric interest in the topic, that has started to match the output of Chinese

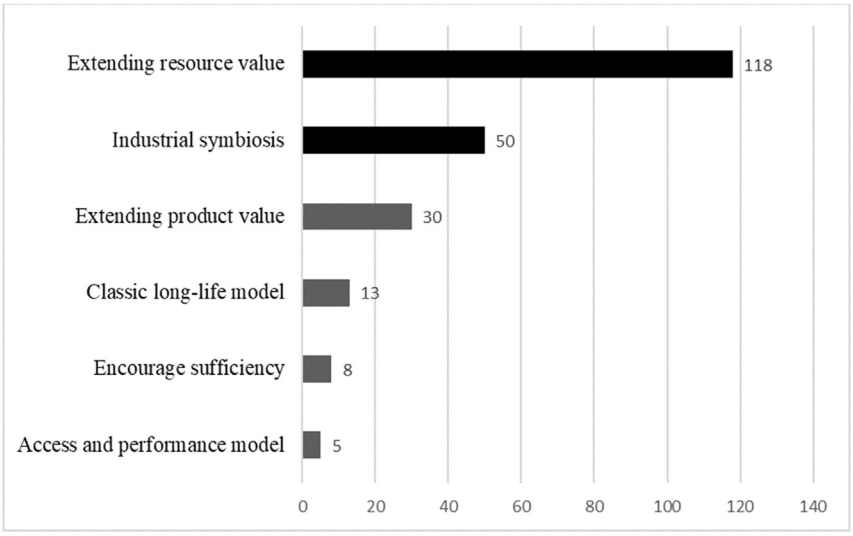

Fig. 17. Identification of CE business models investigated according to Bocken et al. (2016) framework.

academic publications. Even in this case, this is probably a reaction to public policies implementation.

- Most studies have a practical approach, employing tools and methods for modelling processes and supporting decision-making for CE implementation.

Academia is supporting firms and governments by providing models and tools which are able to guide the transition toward CE. It probably reflects the necessity to provide practical answers to the public policies launched in China and Europe. As a consequence, decision-making at policy level is highly dependent on information obtained from quantitative tools, which are based on standardized and systematic methods (Pauliuk, 2018). From the analysis, it emerges that the application of methods such as LCA and MFA is widely diffused. These approaches, including also MFCA (Material Flow Cost Analysis), allow to identify flows, stocks and balances among production processes (Sakai et al., 2017), helping scholars to model reality and to identify critical patterns to orientate the industrial system. Furthermore, these approaches may support firms and large-scale projects in decision-making process, especially when considering that secondary production is not always the optimal solution in terms of environmental impact. For example, these methods are critical in calculating the net consequences of recycling practices, which may have a negative rebound effect (Zink and Geyer, 2017). However, these approaches may fail to consider large-scale issues, like the scarcity of raw materials and the deterioration of products' value retention (Haupt and Zschokke, 2017), which are pillars of the CE system-thinking. MFA and LCA are also used for developing indicators to assess circularity, resource efficiency and sustainable production. The review shows that the development of a specific indicators' set for CE is still at an early stage, especially for the micro level of analysis (Elia et al., 2016). The development of indicators will also contribute to a deeper understanding of CE and to evaluating the related concepts that are emerging in a more mature phase (Blomsma and Brennan, 2017). Despite the interest of academia in the managerial implications of CE implementation, from the analysis there emerges the absence of a shared framework on how CE should be applied to firms' operations (Murray et al., 2017) and how firms may adapt their business models to CE paradigm (Urbinati et al., 2017).

- CE studies mainly follow two lines of action. The first oriented toward changing the social and economic dynamics at the macro level. The second toward supporting firms in circular processes implementation.

Strategies for CE are proposed on two main levels. The first mostly refers to the macro level, in which CE is fostered at an administrative level such as country, region, or city. The high number of studies on this level is due to the fact that China has launched a national policy for CE (Geng and Doberstein, 2008). Chinese strategy follows a top-down approach, which is focused on the development of eco-cities or eco-provinces (Yuan et al., 2006). On the other hand, the European strategy is more oriented toward the identification of patterns for a circular-oriented society (Pomponi and Moncaster, 2017). For this reason, the European academic approach to a macro level of analysis is mainly focused on circular cities, waste management at country level, but also on the interrelation of waste flows between member states. The micro level of analysis shifts its focus toward firms and consumers. This approach is more applied in European studies, as the European Action Plan for CE follows a bottom-up approach, with the aim of spreading sustainability practices and culture among all society stakeholders (Ghisellini et al., 2016). This reflects the need to recognize and design innovative forms of consumption and production, which calls for a general societal change from institutions to firms and consumers (Saavedra et al., 2017), in which actions must be implemented at all the value-chain stages and with the involvement of all stakeholders (Manninen et al., 2017).

Another aspect concerns the meso-level of analysis. Most works refer to China and represent planning and evaluation of Eco-industrial Parks pilot projects and networks focusing on environmental improvements (Geng et al., 2012). In Europe, the meso-level consists in industrial symbiosis experiences carried out mainly by Italian scholars. These experiences, based on the industrial ecology paradigm, may support the transition toward CE, through the identification of an alternative use of materials and waste flows (Saavedra et al., 2017).

- CE is linked with a variety of concepts. Mainly, it is associated with efficient and sustainable waste management.

CE has its roots in a variety of scientific disciplines, such as industrial ecology, environmental science and ecological economics, which determine its association with a variety of concepts (Lazarevic and Valve, 2016). Blomsma and Brennan (2017) discussed the current role of CE as an *umbrella* concept that may reduce the knowledge gap, group pre-existing concepts and operationalize them (Blomsma and Brennan, 2017). Additionally, CE has no defined boundaries with respect to other concepts such as Green Economy and Bio-Economy, with whom it shares the objective of harmonizing environmental, economic and social issues (D'Amato et al., 2017). Therefore, from the study, CE arises as an assortment of concepts from different scientific fields, without a clear and well-defined identity (Korhonen et al., 2018). Since CE is a resource-oriented model which considers both input and output of a production process (Sauvé et al., 2016), waste management emerges as a relevant sub-sector, as one of the main goals of CE is to minimize waste production (D'Amato et al., 2017). The study reveals that the focus on waste is often a consequence of international and national sectorial initiatives, linked to waste management policies, which are aimed at minimizing its production and maximize its reuse as material and energy sources (Song, 2013). Considering the European Union Action Plan for CE this nexus is evident, since legislative proposals are strongly tied to the achievement of waste generation reduction and management objectives (European Commission, 2015b). However, these proposals lack a clear line of action to develop the societal changes needed for a global transition (Haupt and Zschokke, 2017), as they are mainly targeted at increasing recycling rates. From the review, it also emerges that industrial ecology has probably the strongest practical influence in the definition of CE, as it is founded on closed loop cycles (Lazarevic and Valve, 2016). Specifically, industrial symbiosis appears as the more widely used model to implement CE principles at a meso level. Finally, another line of research links CE with bio-economy practices and bioenergy production. Thus, the pivotal role of bio-economy and its potential contribution to CE is recognized by academia (D'Amato et al., 2017), since it may be considered as the biological engine of CE, focusing on the renewability of material end energy in closed loops (European Commission, 2015c).

- CE offers a way of reaching the wider goal of economic and environmental sustainability.

Scholars' approach to CE is closely linked with sustainability, and their attention is largely focused on environmental aspects, often integrated with an economic evaluation. However, the nexus between CE and sustainable development does not have clear and defined boundaries, sparking an animated debate among academics (Pauliuk, 2018). Some scholars believe that CE supersedes sustainable development, since sustainable development has its roots and limitations in its linear thinking strategies. In this sense, the circular approach may offer a solution to sustainability failures (Sauvé et al., 2016). Others, instead, frame CE into the wider movement toward sustainability (Kopnina and Blewitt, 2014), as CE may act as a tool to operationalize sustainable development principles (Kirchherr et al., 2017). Nevertheless, whereas sustainability aims to integrate the environmental, economic and social dimensions, CE is mainly focused on environmental issues, "*giving a clear angle of attack to help solving them*" (Sauvé et al., 2016). One possible explanation of its specific focus is that CE is set in an industrial context, which generally does not address social issues (D'Amato et al., 2017). From the review it also emerged that only a few studies have focused on social questions and concurrently on the three pillars of sustainable development (Geissdoerfer et al., 2016). When linking CE with the broader notion of sustainability there is often a failure to fully recognize the social implications of a circular system. However, CE is positively correlated especially with intergenerational considerations, since the reduction of natural resources consumption implies more opportunities for future generations. Therefore, the CE construct should be increasingly integrated with its social aspects (Murray et al., 2017). Nevertheless, over the years, the triple bottom line approach has increasingly gained the attention of scholars.

- The most investigated practices are those related to cleaner production, while those aiming to re-shape the socio-economic system are still to be explored in the CE context.

United Nations Environmental Programme (UNEP) defines cleaner production as "*the continuous application of an integrated preventative environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment*" (Luken and Navratil, 2004). The study highlights that most articles fall under this definition of cleaner production, whose main goals are to reduce negative environmental impacts and waste generation throughout the life cycle of a product and to optimize processes performance and efficiency. Thus, cleaner production is considered an essential strategy for achieving CE (Bilitewski, 2012), since it introduces new patterns into the relationship between firms and the environment (Ghisellini et al., 2016). Considering the ReSOLVE framework, scholars link CE to practices for closing and optimizing resource loops (Regenerate-Optimize-Loop) (Ellen McArthur Foundation, 2015). The attention is given to cleaner production practices aimed at reducing the biological impact of production and consumption, as well as introducing bio-energy and renewable materials. These activities are frequently connected to waste management in a recycling perspective, confirming the central role of product end-of-life operations. Even if cleaner production practices are crucial to CE development, greater efforts are needed in order to understand and spread the "profound transformative change" required to go beyond the take-make-dispose linear model (Hobson, 2015). Studies on CE should devote greater attention to strategies for social and institutional changes which are able to transform the upstream process of production and consumption (Bocken et al., 2017b). To follow this path, it is necessary to rethink and reshape the way goods and services are perceived and how they can best meet every day needs (Hobson, 2015). This gap may also be seen in the findings of this review, which shows that little consideration is assigned to the design of new products and services, sharing and performance economy and dematerialization practices.

- Scholars focus on studying closing material loops strategies, while slowing the loops is only marginally included with respect to CE.

In order to satisfy the need to reduce resource usage, CE implementation requires firms to rethink product and process design (European Comission, 2015). Thus, business models development is widely considered a cornerstone of research in CE, as they support firms in shifting their business paradigms (Lewandowski, 2016). Nevertheless, the academic debate on the topic is still insufficient, as few works investigate how firms may capture CE principles into their business practices (Lieder and Rashid, 2016; Manninen et al., 2017). CE is an evolving concept that contains several principles and their operationalization strategies. The review shows that most of scholars' interest is given to "traditional" cleaner production business practices, that are well reflected in the ReSOLVE framework developed by the Ellen McArthur Foundation (2015) and in the closing resource loops family of business models developed by Bocken et al. (2016). As far

as the last approach is concerned, CE is often contextualized as a way of extending resource values, especially through recycling and industrial symbiosis practices. On the contrary, few works have explored those strategies proposing innovative business models associated with the necessity of slowing resource loops. These strategies aim at maintaining a higher product value over time and changing the way a product is used and owned (e.g. access and performance model) and are explored only in the literature published from 2011 that investigates the European context. This research gap may be attributed to the fact that these practices were first developed and subsequently maintained their identity as an independent line of research, and only in a second phase were ascribed to the field of CE. Therefore, often works related to these models are not indexed in the CE framework. Especially when considering access and performance practices, they are relatively new and in an early stage of research, requiring a switch in customer value proposition and a radical change at a societal and institutional level, to accompany consumers toward a functional service economy, unlinked to individual ownership (Stahel, 2016).

- This study's findings highlight CE as an evolving concept whose definition, boundaries, principles and associated practices still need to be consolidated.

Before 2006, CE was not a defined field of research, rather its principles were disseminated in a variety of schools of thought reflecting a significant assortment of antecedents (Bocken et al., 2017a). As CE had not yet been conceptualized, during this phase some of its principles can be found in industrial ecology and environmental protection practices, with the main goals of minimizing and recycling waste and improving natural resources management. Scholars' viewpoint in this period had mainly an engineering perspective (Zink and Geyer, 2017). Since 2006, CE has started to gain its identity, distancing itself from the disciplines in which it took its roots. Academic research started to refer directly to CE, thanks to the Chinese policy that started to formalize and define its boundaries. In this period, CE was mainly associated with the 3R approach and to eco-industrial parks development. This approach integrated its engineering perspective into the Chinese industrial system with a marked top-down strategy. Later, the macro and meso level of implementation started to be combined with a bottom up approach, in which CE was also implemented at micro level. At this stage, academics adopted tools such as MFA, LCA and indicators to measure the potential implementation of CE principles. Since 2014, after the European decision to define a specific plan in conjunction with the growing interest of civil society (e.g. Ellen McArthur Foundation), CE has expanded its scope and formed its identity as a new socio-economic paradigm. New concepts and principles such as collaborative consumption, sharing and performance economy have begun to enrichen the CE framework. CE should not only be confined to production practices, but should also extend its concerns to the societal level, involving consumers and radical shifts in their behavior. As a result, a lively debate is in progress about the relationship between CE and sustainability, including also academic critical engagement on the topic. Therefore, CE is now facing its "*validity challenge period*" on its way to becoming a robust and consolidated concept (Blomsma and Brennan, 2017).

7.2. Limitations and future research

The main goal of this paper is to give an overview on how scholars deal with the topic of CE. The study is not free of limitations, principally due to its qualitative nature. Even though the research process was documented to produce a transparent review, the categorization of the information is necessarily affected by researcher bias. To mitigate this issue, the structural dimensions and analytical categories have been punctually described in the paper and, in most cases, have been retrieved from other studies that analyzed literature on CE. Another aspect relates to the choice to examine only articles published in journals, which does not allow the consideration of the grey literature that may offer an important contribution to the topic (Geissdoerfer et al., 2016). The large number of reviewed articles makes a deep analysis of all the records in the database rather challenging. Moreover, due to synthesis needs, not all the articles for each analytical category selected have been cited. Nevertheless, for each category some meaningful examples have been provided. Finally, it was necessary to select a specific research criterion ("Circular Economy"). Inevitably, this represents a limitation, as not all the records extracted focus on CE. Nevertheless, it gives the opportunity to explore how scholars relate CE to other concepts. Limitations of the study may serve as a baseline for improving and stimulating future research on the topic. First, the scope of the research may be expanded not only to academic literature, but also to grey literature, that in the context of an emerging research field has a critical role in providing cases of CE practices implementation among firms. In the context of CE, the Ellen MacArthur Foundation provides a clear example of how grey literature can emerge as a reference point (Ellen MacArthur Foundation, 2013). Given that survey studies were shown to be an underexplored research methodology, they may be further developed as a way of understanding the awareness levels of firms and consumers, and of identifying enabling measures to disseminate CE practices. "Closing material and resource loops" is a driver to go beyond the linear economic system. It implies that all the actors in the supply chains should cooperate to find synergies to embrace a closed loop economic system (Rizos et al., 2016). Further investigation would represent a critical factor to stimulate the transition toward circular supply chains. The CE proposal implies not only a change in the way of managing resources and business, but also a modification of social interrelations (Ellen Macarthur Foundation, 2015b). The review has shown that the social impact of CE is only marginally considered in scholarly research. Considering the goal of addressing the triple bottom line of sustainability, more efforts should be made to study how CE impacts social well-being. It also emerged from the study that scholars have mainly devoted their attention to business models for closing resource loops. On the other hand, little consideration was given to strategies aimed at slowing resource loops. Therefore, further investigation on these strategies (e.g. sharing economy, collaborative consumption, remanufacturing, reuse, design, second-hand, product-service-system) may open the way to filling this lacuna. This review has not focused on metrics to measure CE. Further research may deepen the analysis of literature in the light of CE indicators creation and evaluation, especially considering the micro level of analysis.

8. Conclusion

How do scholars deal with the topic of CE? The paper has presented the results of a literature review conducted to answer this question. The scope of the study was the identification of a framework to categorize the literature, through the analysis of over 500 articles published in journals retrieved from WoS and Scopus. This framework consisted in a list of structural dimensions and analytical categories, which allowed us to analyze the past and current direction of CE studies.

The study highlights that CE is a topic in rapid development, which has been recognized both by public decision makers and academia as the way forward to balanced development. This

paradigm shift is considered as a reference point to harmonize economic growth, environmental issues and resource scarcity. The geographical focus of CE studies is concentrated in China and Europe as a result of public policies implementation. Thus, the academic production aims at providing instruments which are able to guide the transition toward CE through quantitative tools, which are based on standardized and systematic methods (e.g. LCA and MFA). Scholars approach CE at a macro level of analysis (country, region, or city), at a micro level for its operationalization in single firms, and at a meso level for the implementation of industrial symbiosis. The review highlights that CE is often framed in the wider concept of sustainability. Considering the triple bottom line of sustainability, whilst it does give a clear angle of attack toward solving environmental issues, there is insufficient consideration given to social implications and to balancing the three pillars of sustainability. CE has blurred boundaries, as there is no clear definition and no common agreement on the guiding principles for action. For this reason, CE appears as an *umbrella* concept, associated with a variety of other disciplines that define its roots. As it is a resource-oriented model, waste management emerges as a relevant sub-sector of CE, with a predominance of studies related to cleaner production, which is considered an essential strategy for achieving CE goals. However, the academic approach to CE must take significant steps toward the definition of a clear line of action to support the societal changes required for a global transition, in order to surpass the traditional linear pattern on which the economic system is based. Scholars should devote more attention to rethinking and reshaping new approaches to production and consumption. This necessity emerged from the analysis of circular business models, which demonstrated that there has been a lack of consideration toward circular design and innovative strategies to slow material and resource loops. Value-focused innovative practices, which embody CE philosophy, such as sharing economy, product-service systems, dematerialization, remanufacturing and IOT should be further explored by academia. Findings also show that CE is an evolving concept, which embraces best practices and solutions from several schools of thought. At present, it is growing and emerging as a new socio-economic paradigm that may open the path toward innovative and sustainable ways of production and consumption.

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