

Review Protocol

The narrative of sustainability and circular economy – a longitudinal review of two decades of research

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This document summarizes the decisions made during the extraction, cleaning and analysis of the data used in this paper. Where applicable, it refers to the corresponding R scripts.

1. Data extraction

1.1. Circular Economy

For extracting the data for the analysis of the full body of circular economy literature (in sections 4.1-4.3) the search term “circular econom*” was used in Scopus and Web of Science. Authors such as Saavedra et al. (2018) or Nobre and Tavares (2017) used a wider range of search terms related to CE. However, as each keyword that is used in a search string will have, in most cases, also a relatively high frequency of occurrence and a high degree of connections to other keywords in the dataset, the sustainability connotation of circular economy-related research might have been obscured by also considering ancillary terms. Furthermore, this focus is considered justified by the exponential increase in the number of publications on the concept of CE and the growing number of studies that define and delimitate the field. Below the full search queries are provided.

2000-2018:

Scopus

Results: 1946

TITLE-ABS-KEY ("circular econom*") AND DOCTYPE (ar OR re) AND PUBYEAR < 2019

Web of Knowledge

Results: 1660

(from Web of Science Core Collection)

You searched for: TOPIC: ("circular econom*")

Refined by: [excluding] PUBLICATION YEARS: (2019) AND DOCUMENT TYPES: (ARTICLE OR REVIEW)

Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.

2019:

Scopus

Results: 1403

TITLE-ABS-KEY ("circular econom*") AND DOCTYPE (ar OR re) AND PUBYEAR = 2019

Web of Knowledge

Results: 1369

(from Web of Science Core Collection)

You searched for: TOPIC: ("circular econom*")

Refined by: PUBLICATION YEARS: (2019) AND DOCUMENT TYPES: (ARTICLE OR REVIEW)

Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, ESCI.

1.2. Circular Economy and Sustainability

For the analysis of the scientific literature on the intersection of Circular Economy and Sustainability the searchstring “circular econom*” AND “sustainab*” was used.

Sustainability can be understood as a long-term goal, while sustainable development refers to the many processes and pathways to achieve it (Jeronen, 2013). This conditional relation justified, to combine the two terms to “sustainab*”. Below the full search queries are provided.

2002-2019:

Scopus

Results: 1651

TITLE-ABS-KEY ("circular econom*" AND "sustainab*") AND DOCTYPE (ar OR re) AND PUBYEAR < 2020

Web of Knowledge

Results: 1799

(from Web of Science Core Collection)

You searched for: TOPIC: (circular econom*) AND TOPIC: (sustainab*) NOT YEAR PUBLISHED: (2020)

AND DOCUMENT TYPES: (Article OR Review)

2. Data cleaning

The R script “**0_load_and_clean_data.R**” comprises all steps undertaken to delete duplicates, and clean the Keywords used in sections 4.1 and 4.2 and the Abstracts used in 4.3. The R script “**4_historiographic_analysis.R**” furthermore provides the steps undertaken to clean the references used in the historiographic analysis in section 4.4. The studies identified in this analysis were furthermore used in full in the qualitative content analysis in section 4.5.

3. Data analysis

3.1. Thematic mapping (section 4.1 of the paper)

The full circular economy dataset of 3822 publications spanning from 2000 to 2019 was used for the thematic mapping. This dataset was split into four time slices. Due to the low number of circular economy-related peer-reviewed publications in the early and the exponential growth in recent years, the data had to be cut into uneven slices. One slice comprises of 13 years (2000-2012, n = 230 papers), two slices of 3 years each (2013-2015, n = 236; 2016-2018, n = 1794) and one slice of one year (2019, n = 1648). Thus, the first two and the second two slices comprised a comparable amount of papers. The split between the first and the second slice furthermore marks the publication of the first major CE-related report by the Ellen McArthur Foundation in 2012 (Ellen MacArthur Foundation, 2012). The split between the second and the third slice marks the introduction of the CE package by the EU in 2015 (European Commission, 2015). 2019 was included separately, as in this period almost the same amount of papers was published as in the previous three years.

The network plots (in the form of four scalable vector-graphs in “.pdf” format), as well as the four corresponding network files in “.net” format, can be found in the folder “networks”. The files can be opened directly in network analysis software such as Gephi.

Corresponding R script: “**1_thematic_maps.R**”

3.2. Conceptual structure (section 4.2)

The conceptual structure of CE-related research is based on an MCA and k-means clustering approach. The analysis was conducted on the full set of CE-related 3822 journal papers using keywords plus. The analysis of the conceptual structure comprises the entire period of research. Using a minimum degree of 60 (i.e., keywords that appeared at least 60 or more times) as a filter criterion in the MCA function of the “bibliometrix” package (Aria and Cuccurullo, 2017), provided a matrix of 2507 publications and 73

keywords. The data was pre-processed for the k-means clustering using an MCA, in which the first two dimensions explained 63.43 % (Dim. 1 = 47.61 %, Dim. 2 = 15.82 %) of the total variance. The percentages represent adjusted eigenvalues following the approach of Benzécri and Greenacre (Greenacre, 2007). Given their comprehensibility, two-dimensional plots are usually the representations of choice (Greenacre, 2007) Dimensions 3 and 4 only explain 10.21 % and 6.52 % of the total variance and they did not add a significant explanatory value.

Corresponding R script: **"2_conceptual_structure.R"**

3.3. Correlated topic modelling (section 4.3)

Using Correlated Topic Modelling (CTM), the abstracts of the 3822 CE-related papers were analyzed subsequently. Abstracts serve as an additional data source, since they include more text and convey more differentiation than the keywords. The CTM in the study at hand was conducted with the R-package "topicmodels" (Grün and Hornik, 2011) and followed the approach described by Silge and Robinson (2017). The optimal number of topics was estimated with the R-package "LDA tuning" (Nikita, 2019) (see Appendix C). After this optimization-based topic determination, a range of models with the following different variations of k (k = 15, 20, 50) were fitted and evaluated by the group of authors, in order to select an interpretable solution to be included in the paper.

Corresponding R script: **"3_correlated_topic_model.R"**

3.4. Historiographic analysis (section 4.4)

For the historiographic analysis, the literature subset on CE and SD (n = 2149) was chosen. By doing so, papers that define and decisively contribute to the debate on sustainability in the CE context were exposed. Based on the local citation score (LCS), a historical direct citation network was created. To keep the graph lucid, and to keep an acceptable workload for a subsequent content analysis, it was chosen to depict the top 30 papers.

Corresponding R script: **"4_historiographic_analysis.R"**

3.5. Qualitative content analysis (section 4.5)

The 30 most influential papers were analyzed with a focus on the following four categories:

- The inclusion of sustainability pillars
- CE and sustainability assessment
- R-strategies
- Design and innovation

These categories were chosen due to their appearance in chapters 4.1-4.3 as part of the sequential mixed methods design (inductive category creation), as well as due to their direct relationship with the research questions (deductive category creation): (i) the inclusion of sustainability pillars (direct relation with RQ 2), (ii) CE and sustainability assessment to identify how CE is assessed in terms of sustainability, and how this was perceived (chapters 4.1-4.2, and relation to RQ3), (iii) value retention options, as defined by Reike et al. (2018) as a proxy for circular strategies, and due to their appearance across all chapters 4.1 to 4.3 and the high prominence of R-strategies in the CE debate, and (iv) design and innovation due to the increasing importance in literature, as observed in section 4.1 and due to their position at the pole of BOL in section 4.2.

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