

# **A mixed-methods approach to investigating the Circular Economy: Mapping the concept, the field, and their co-dynamics**

A thesis submitted to the University of Manchester for the degree of Doctor of Philosophy in  
the Faculty of Humanities

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## **Abbreviations<sup>1</sup>**

Circular Economy (CE)  
Industrial ecology (IE)  
Industrial symbiosis (IS)  
Cradle to Cradle (C2C)  
Actor-network theory (ANT)  
State Environment Protection Agency (SEPA)  
National Development and Research Council (NDRC)  
European Union (EU)  
Green economy (GE)  
Bioeconomy (BE)  
European Commission (EC)  
New Economics Foundation (NEF)  
Ellen MacArthur Foundation (EMF)  
Eco-industrial parks (EIPs)  
National Natural Science Foundation of China (NNSFC)  
United Kingdom Research Council (UKRI)  
European Resource Efficiency Platform (EREP)  
State Planning Commission (SPC)  
State Science and Technology Commission (SSTC)

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<sup>1</sup> This list includes abbreviations of larger relevance to a significant part of the thesis. Abbreviations that are either common knowledge or that were mentioned merely once are not included. Such abbreviations were explained in the text section where they occur.

## **A mixed-methods approach to investigating the Circular Economy: Mapping the concept, the field, and their co-dynamics**

Sampriti Mahanty, The University of Manchester, 2021

### **Abstract**

Operationalising the notion of sustainable development is a complex endeavour that has received much attention yet remained without satisfactory answers. To this end, many concepts have been proposed which undergo their trajectories, some reaching heights of popularity and some remaining within small circles. Amidst the quest to operationalise sustainable development, the Circular Economy (CE) concept is receiving immense attention across policy, practice, and academia. The prominence of CE is becoming such that whether one is sceptical or supportive about CE, it's an escapable concept in sustainability-related discussions. Motivated by the aim to deconstruct this prominence, this thesis is geared towards understanding how and why this prominence came about and what it means to CE research and practice. Is it just a buzzword or an emerging field? With CE-related discussions doing the rounds for almost two decades now and with its increasing prominence, at this juncture, this thesis takes a step back to analyse how did this prominence come about and what is the status of the CE concept and its related field now. Such perspectives about CE are essential because they offer valuable insights on how the contemporary conceptual understanding has emerged, increased awareness of the social pressures that affect certain kinds of research, investigations of the impact of science on policy and vice versa, which serve as the foundations for a more rational science policy.

This thesis is presented in two parts- A and B. The latter has three published research papers; *Research paper 1* serves as the starting point that analyses the vast literature on CE by characterising the corpus, identifying the underlying research topics in the literature, and conducting a pilot workshop to assess the validity of the research findings before scaling it up to a larger group. This paper also employs an advanced text mining technique, i.e., topic modelling. *Research paper 2* assesses the changes in the CE concept compared to its competing concepts, which has not been addressed in Research Paper 1. This paper relies heavily on computational techniques and uses CE as a case study to develop a computational pipeline through which changes in concepts used in the academic discourse can be detected. The insights from this paper are especially useful in drawing comparisons between CE and its competing concepts. *Research paper 3* harvests the opinion of experts to provide the first systematic expert-based assessment of the CE academic discourse. The results from this paper allow us to understand the pattern of change in the CE concept, the reasons for the pattern observed and the positioning of CE in the broader sustainability discussions through the opinion of the experts. Part A is written in a monograph format drawing from the insights of the three published papers. Using actor-network theory, part A provides a detailed investigation of the CE concept and its related field, outlining the specific field characteristics and evolution of the CE concept and its related field.

The analysis indicates that the CE is showing certain instances of deep institutionalisation within academia, policy, and practice; however, the conceptual meaning is getting highly segregated as the CE concept is associated with various actants. The field also exhibits steering of research priorities in a way that an optimistic narrative about CE is being created. The evolution of the CE concept and its related field directs attention towards the combination of a lifecycle and teleological process typology. This also indicates a relative absence of any dialectic processes within the field. The relative absence of dialectic process leads to the optimistic narrative of CE fostering continued growth and the narrative that aims to align CE with a strong sustainability narrative such as degrowth or steady-state economics to exist as segregated parts of the field. Lastly, the CE concept's popularity is not due to the logical superiority of the concept per se but the extra logical superiority from the actants who engage with it. Finally, it directs attention that CE's popularity might be an outcome of it allowing business as usual in the capitalist order.



## *Dedication*

*To Papa, Mummy, and Mani  
For all that you have done and continue to do for me.*

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*A work is never completed except by some accident such as weariness, satisfaction, the need to deliver, or death: for, in relation to who or what is making it, it can only be one stage in a series of inner transformations... - Paul Valéry*

# PART A

## Chapter 1 Introduction

*‘All knowledge ..., should be treated through and through, as material for investigation’ - David Bloor, Knowledge and Social Imagery (1976)*

This chapter provides an overview of the thesis document by introducing the phenomenon, the empirical context, and the research problem that serves as the PhD thesis's starting point. In the next section, the theoretical framing is briefly introduced. Further, the specific research questions are situated in the relevant literature. The philosophy, methods and data used to address the research questions are briefly introduced, followed by the results and discussion. Lastly, I sketch out the structure of the thesis.

### 1.1. The phenomenon

With mounting environmental pressures and rising challenges of the Anthropocene, the idea of ‘welfare states’ expanded to what has been called ‘*environmental states*’<sup>2</sup>. Environmental states possess a significant set of institutions and practices dedicated to managing the environment and societal-environmental interactions’ (Duit et al., 2016; Gough, 2016; Meadowcroft, 2005). Within this backdrop, there have been two stages. The first one started around the 1960s and 70s, which witnessed an independent realm of law, policies, administration, and regulations to clean up the environment. This period is often marked as increasing awareness regarding the environmental crisis and an emerging understanding of the earth’s limits (Barles, 2014). The second stage emerged in the late 1980s, aiming to strengthen the linkages between the environment and broader state concerns with the economy, security, and welfare, often under the banner of promoting ‘*sustainable development*’ (Meadowcroft, 2012). The seminal Brundtland report proposed sustainable development as the way forward, urging stakeholders to find sustainable development paths through multilateral solutions and a restructured economic system of cooperation that reconciles the economy, environment, and society (WCED, 1987b). The Rio Summit in 1992 was a significant milestone that set a new global agenda for sustainable development and led to the emergence of a global discourse around it (Jabareen, 2008).

Sustainable development can be understood as a broad society objective (Sauvé et al., 2016) which is abstract by nature, thereby opening numerous different ways to operationalise it (Boons & Roome,

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<sup>2</sup> There have been other comparable expressions to the environmental state such as the ‘Green state’ (Eckersley, 2004), ‘eco-state’ (Jablonowski, 2011), ecological state (Signoretta et al., 2019), ecostate (Meadowcroft, 2005).

2000). To this end, a diverse concept space<sup>3</sup> with various concepts that denote particular ideas and practices such as industrial ecology (IE) (Frosch & Gallopoulos, 1989), industrial symbiosis (IS) (Chertow, 2007), cradle to cradle (Braungart et al., 2007), blue economy (Pauli & Corbis, 2010), performance economy (Stahel, 2016), bio-economy (McCormick & Kautto, 2013), green economy (Loiseau et al., 2016), sharing economy (SE) (Frenken & Schor, 2017), biomimicry (Benyus, 1997), natural capital (Costanza & Daly, 1992), green growth (Hallegatte et al., 2012), has been proposed by researchers (and practitioners) to operationalise sustainable development. Such concepts have provided a language to scholars, practitioners, and policymakers to address complex environmental issues and operationalise sustainable development.

## 1.2. The empirical context of ‘circular economy’ and the research problem

Amidst the different concepts aimed at operationalising sustainable development, the *circular economy* (CE) concept has gained immense attention from various stakeholders, including policy, practice, and academia. The traction is evident through the wide range of actants participating in the CE debate, ranging from policy to practice to academia, making it a multi-actor concept (de Jesus & Mendonça, 2018). Several definitions for the CE concept have been proposed. To this end, Kirchherr et al., (2017) after analysing 114 definitions of CE, define it as an economic system that replaces the ‘end-of-life’ concept with reducing, alternatively reusing, recycling, and recovering materials in production/distribution and consumption processes to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity, and social equity, to the benefit of current and future generations.

Despite the argument that scholars have put forward that there is nothing really new about CE, and it draws from a rich history of socio-economic practices that overlap with the tenets of CE (Blomsma & Brennan, 2017; Corvellec et al., 2020; Fitch-Roy et al., 2020; Geisendorf & Pietrulla, 2018; Reike et al., 2018) the prominence of CE cannot be ignored. Studies have referred to CE as a new sustainability paradigm (Geissdoerfer et al., 2017), an umbrella concept (Blomsma & Brennan, 2017), an essentially contested concept (Korhonen et al., 2018), a development strategy in China (Yuan et al., 2006), the next political economy of Europe (Lazarevic & Valve, 2017), a policy instrument (Lakatos et al., 2021), a narrative device for greenwashing (Calisto Friant et al., 2020), a way to replace the negative connotation of sustainable development with a positive view of relationships between the environment and the economy (Valenzuela & Böhm, 2017), the emergence of new marketing languages and imaginaries (Den Hollander et al., 2017), a new way of framing ecological modernisation (Gregson et al., 2015), a

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<sup>3</sup> A concept space (Gärdenfors, 2004) is a representation of concepts, which fall under similar categorization because they are addressing similar issues or aim to achieve similar goals.

vague narrative (Niskanen et al., 2020), a patch adaptable to changing circumstances (Fitch-Roy et al., 2020) and the quite commonly used designation for CE - ‘buzzword’<sup>4</sup> (Desing et al., 2020; Henry et al., 2021; Heurkens & Dąbrowski, 2020; Moraga et al., 2019; Primc et al., 2020). It has often been cited as the only way forward urging to accelerate the transition (Maddox, 2020; OECD, 2020; World Economic Forum, 2014, 2021). The central argument being in whatever the perception about CE, its prominence is becoming such that whether one is supportive or sceptical about it, it’s become an inescapable concept in the present-day discussions on sustainability issues. As Dryzek (2013), p. 9 argues, such prominence in environmental discourses comes with no surprise as clear answers to complex problems remain absent. The motivation to make sense of this prominence in the case of CE is the starting point for this thesis:

*How and why did the concept of Circular Economy come to receive so much attention? Is it just a buzzword or an emerging field in its own right?*

Addressing this research problem is important for three reasons. Firstly, given that concepts like CE frame our understanding and our options for transitioning towards more sustainable societies, it is essential to understanding how these concepts evolve and what dynamics drive them. According to Corvellec et al., (2020) incorporating social and historical analyses enables us to appreciate CE's broader politico-economic and cultural contexts, which is an urgent task given many claims are being on its name today. Rather than taking the prominence of CE at face value, this thesis aims to deconstruct the concept and its related field (for parsimonious use of words, the concept and its related field will be called *concept-field*), bringing forward its characteristics, and the circumstances and context in which it is developing. Secondly, a better understanding of these concepts is expected to improve the decisions of various stakeholders such as researchers, companies, funding agencies, publishers who are constantly faced with new and popular research topics (Klincewicz, 2016). Thirdly, while this research problem concerning CE, as one would expect, is of interest to stakeholders using the CE concept, it raises more fundamental questions related to knowledge production, which concepts end up having more traction, the role of academic and non-academic influences in this process. Although many concepts are proposed to solve a complex issue, not all get equal attention. Whilst some concepts receive immense attention among stakeholders, some survive in minor ways within smaller groups, and some never manage to catch the attention of the scientists (Hambrick & Chen, 2008). As argued by Bonaccorsi & Vargas, (2010) very few concepts even survive the second year. Thus, it directs attention towards the intricacies of knowledge production. This thesis accounts for the developments in the scientific inquiry on CE and the social dimensions underlying the scientific inquiry, in line with the ‘plea for science studies’ (Kitcher, 1998). Moreover, it enables to address questions such as "on whose back science was riding

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<sup>4</sup> According to Merriam webster a buzzword is an important sounding usually technical word or phrase often of little meaning used chiefly to impress laymen.

on?" which, according to philosopher Stephen Toulmin is a fruitful direction of questioning (Toulmin, 1967).

Underpinned by the research problem presented above, in this thesis, the analysis starts with following the CE concept tracing the evolving language through academic discourse analysis. It then follows the CE field actors who generate and respond to the CE discussion through their interactions. The main thrust of the argument is that the interplays between the concept and the field actors demonstrate specific characteristics and circumstances which explains the nature of the concept and the field.

### 1.3. Theoretical framing- The CE concept and the CE field

In this section the overview of the theoretical framing is presented. This will be discussed in detail in Chapter 2 of the thesis. Since the term *concept* is used throughout this thesis to refer to CE, it is helpful to define the term concept itself. The interpretation of the term concept is often complicated because there are different interpretations of what the term itself means, and it should also be appreciated that any definition of a concept has a sense of arbitrariness. Thus, it is desirable to articulate the term concepts with as much flexibility as possible (Fokkens et al., 2016). The understanding of concepts adopted in this thesis is that of semantic labels (Margolis & Laurence, 2005). A concept is loosely defined as a prescriptive, more-or-less coherent view on a particular issue under a specific label (Benders & Verlaar, 2003). The operative word here being a *label*. The premise of understanding a concept adopted in the discussion going forward is that during its travel through the social world, it is shaped, reshaped, reinvented, and modified every time individuals and organisational members select it or reject it (Latour, 2005). Thus, individuals and organisational members *translate* the concept for it to fit into a particular context. In this translation, new practices, ideas, human actors, organisations get associated with the concept. According to Jiao & Boons, (2017) a translation pattern has been observed in the case of CE, where the practices in Germany and Japan influenced the Chinese articulation of the CE concept, but CE was 'translated' into the Chinese context. This is different from diffusion, where the initial idea is transmitted through the social world, which becomes successful in some cases and becomes a part of larger organisations. The main characteristic of diffusion is that the idea remains the same during the process. On the other hand, translation starts from the premise that "the initial idea barely counts", and the idea is shaped during the course of its travel (Latour, 1996, p. 119).

The core argument is that a concept is translated as different actors engage with the concept in the course of time. It is these actors who engage with the concept creating specific characteristics and circumstances in which the concept develops. The organisation of the different actors around the concept is like an 'organisation field' whose components partake of a common meaning system, thereby interacting more frequently and fatefully with one another than with components outside of the field



(Scott, 1994, pp. 207–208). Thus, there are two parts to the articulation here- the CE concept and its related field.

Further, to understand the structure of the field and the concept, the framing is drawn from the pursuits of the sociology of scientific knowledge: actor-network theory (ANT) or the sociology of translation (Callon, 1984; Latour, 2005; Law, 2009). ANT understands the construction of reality through the relations between heterogeneous (human and nonhuman) actors who are called ‘actants’ (Latour, 2005; Law, 2009). Relations can arise between any kind of actants, including objects, subjects, human beings, machines, animals, “nature,” ideas, organizations, inequalities, scale and sizes, and geographical arrangements’ (Law, 2009, p. 141). Under ANT, the different actants all jostle against each other, and it is through these interactions, society takes shape, and our understandings of this society find form. In a similar vein, academic theories, concepts, methods, frameworks, fields are also an ‘unstable’ outcome of such activities (Hitchings, 2003). The heterogeneous actants interact to form a network that emerges, strengthen and dissolve over time by the interplay between the actants and events that unfold (Cordella & Shaikh, 2006). The formation of a network is not a static process; new forms of debate emerge in the wake of triggering events that cause a reconfiguration of field membership and/or interaction pattern. The process through which the network is created is called ‘translation’ (Callon, 1984; Cressman, 2009).

In short, a concept is a semantic label which loosely represents specific ideas and practices. A field is like an actor-network centred around concepts. Analysing the concept alone allows to assess the intellectual dimension whilst analysing the field overall allows assessing the underlying social dimensions in which the concept developed. The interaction of a concept with the other field actants enables us to understand the specific circumstances in which the concept evolves and its characteristics. The actor here can be both human and non-human. Thus, the CE field is conceptualised as a network of both human and non-human actants assembled around the CE concept, which is the source actant (Silvis & Alexander, 2014) that is being translated.

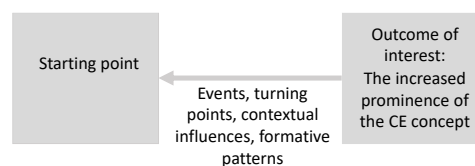
### 1.3.1. A process-based approach

There are different ways to address social science research, such as variance-based or process-based approaches (Van de Ven & Engleman, 2004). Process-based approaches are considered ideal for understanding actor-networks. The theorisation based on actor-networks encourages tracing how heterogeneous entities gradually assemble and how the relations strengthen or dissolve over time (Jiao & Boons, 2017). Process-based explanations tell a narrative story about how a sequence of events unfolds to produce a particular outcome (Van de Ven & Engleman, 2004). A process-based approach is ideal for the research problem posed as it enables to understand the process through which the CE

concept evolved and became prominent. This thesis draws from the two defining features of the process-oriented approach outlined by Boons et al., (2014).

- *First*, to begin with, a central subject must be defined in a process study. The central subject can be any kind of entity, such as an individual actor, a group of actors, a lineage, a social movement, a machine (Hull, 1975) or a concept. The unit of analysis in the process-based approach is an evolving central subject that makes events happen and which events occur (Van de Ven & Engleman, 2004). This is synonymous with the ‘source actant’ in the actor-network that is being translated by the target actants.
- *Second* is the heuristic approach, i.e., forward, backward or counterfactual. The forward approach entails starting from an event of interest and then outlining what events follow from that. The backward approach entails locating an outcome of interest and uncover the events that led to the outcome. In the counterfactual approach, the researcher seeks to understand the role of specific events by asking the question, what if a particular set of events had not occurred?

For this thesis, the central subject is the source actant, i.e., the CE concept that is being translated by the field actants and the heuristic approach followed is the backward approach. The outcome of interest is the increased prominence of the CE concept. The research problem is investigated from a backward approach which explores the current view of the social formation of the CE concept backwards, questioning how and why the prominence came about.



*Figure 1-1: Backward process perspective to address the research problem (Source: author)*

## 1.4. Operationalising the research problem

To operationalise the research problem posed earlier, three research questions are drawn that enable us to understand the CE concept, its related field and how it interacts, thereby creating specific circumstances in which the concept develops and the specific characteristics of the concept-field.

### 1.4.1. Investigating the CE concept

The first research question represents a concept level understanding, i.e., to assess the changes in the CE concept itself. The idea here is that the amount of discourse on any concept over time reflects the interest in the concept (Nijholt & Benders, 2007). Academic discourse, a vast array of codified knowledge (Hauser & Katz, 1998), represents the ways of thinking and using language within researchers (and practitioners). Its significance, in large part, lies in the fact that complex social activities like educating students, demonstrating learning, disseminating ideas, and constructing

knowledge (Hyland, 2009). Changes in the academic discourse related to the concept are used as a proxy to assess the concept's changes systematically.

Given the academic interest in the CE concept, there are several systematic, bibliometric, and narrative reviews analysing the existing academic discourse. Notwithstanding the value of the scholarly works done so far, several gaps are identified. Qualitative reviews are subject to potential author bias when the review authors intentionally or unintentionally select or emphasise research according to their own opinions, prejudices, or commercial interests (Bilotta et al., 2014). Qualitative reviews are also characterised by manual inspection of the literature, limiting literature coverage in the analysis (Delen & Crossland, 2008). While quantitative assessments solve issues about selection bias and coverage of the literature, the interpretation of the results is made by the authors conducting the analysis itself and hence could be limited in scope. The opinion and assessment of an expert group from the scientific community are seldom considered in analysing the evolution of the scientific discourse on a concept even though many processes of scientific knowledge production occurs within the scientific community (D'Amato et al., 2019). Previous studies have assessed the changes in the CE concept either qualitatively or quantitatively. Blomsma and Brennan, (2017) use a qualitative narrative approach based on a limited set of references uncovering antecedents to CE. Reike, Vermeulen and Witjes (2018) use similar data to identify phases in the CE evolution, establishing that the CE in its dominant framing is not as new as often claimed. However, both these studies do not take into consideration the recent developments in the academic discourse on the CE concept. A recent study by Schöggel, Stumpf and Baumgartner, (2020) uses a suite of methods on a comprehensive set of articles to provide a longitudinal review. Such quantitative analysis is crucial, yet the interpretation is provided by the researchers conducting the quantitative study itself. To this end, the first research question is:

*RQ 1: How has the CE concept changed over the years?*

#### **1.4.2. Investigating the CE field**

The second research question represents an interest in understanding the CE field, focussing on the different actants who engage with the CE concept. Scholarly works on the CE concept introduces some actants who have been key in popularising the CE concept. For instance, Jiao et al., (2018); Jiao & Boons, (2017) argue that governmental organizations in China such as State Environment Protection Agency (SEPA), National Development and Research Council (NDRC) have been key in steering the CE concept in the Chinese context. The role of SEPA, NDRC in steering CE in China has also been briefly discussed in some other studies (see Yong, 2007; Yuan et al., 2006; Zhang et al., 2010; Zhou et al., 2014). A popular topic of scholarly research is CE implementation in the European Union (EU) context. Scholars have investigated various aspects of the EU implementation ranging from the barriers of implementing CE in the EU to the requirement of institutional entrepreneurship to promote CE in

the EU (Alonso-Almeida et al., 2021; Busu, 2019; Calisto Friant et al., 2021; Hartley et al., 2020; Völker et al., 2020). Within the EU, localised actants' roles in specific contexts have also been outlined, for instance, SITRA in Finland (Morganti et al., 2019), Circle Economy in the Netherlands (ten Wolde, 2016). However, most studies focus on the role of actants in a specific context of CE. They do not engage with it from an overall field perspective, including both academic and non-academic actants. To this end, the second research question is:

*RQ 2: What specific characteristics does the CE field exhibit as different actors assemble around the (evolving) CE concept?*

#### 1.4.3. Interaction between the concept and the field

Explaining change and the process or sequences of events that unfold as a part of this change has been a central quest for scholars (Graetz & Smith, 2010; Kezar, 2011; van de Ven & Poole, 1995). In the last research question, the interest is to investigate the changes in the CE concept-field through the interactions between the concept and the field of actants. The idea here is that the interplays between the concept and the field actants demonstrate specific characteristics and circumstances that explain the concept-field's nature and status. To this end, the research question is:

*RQ 3: How do the CE concept and its related field evolve? What mechanisms and processes underpin their interaction and evolution?*

### 1.5. Methodology

In this section, the philosophy, data sources and methods used in this research are briefly introduced. A detailed discussion of these aspects is presented in [Chapter 3](#).

#### 1.5.1. Pragmatism

Social science research has been approached from a broad range of philosophical angles such as positivism, post-positivism, critical theory, constructivism (Guba & Lincoln, 1994) and more recently, pragmatism (Morgan, 2014). The choice of the philosophical position determines the basic set of beliefs that guide the actions, define the researcher's worldview, and the methods that the researcher uses (Denzin & Lincoln, 2011). This thesis is grounded in pragmatism. A pragmatist philosophy has been applied in broad areas of social science research ranging from social work to communication (Kaushik & Walsh, 2019; Perry, 2001). Pragmatism, when regarded as an alternative philosophy to other competing philosophies, sidesteps issues of truth and reality and accepts philosophically that there exists singular and multiple realities that are open to empirical inquiry, thereby providing freedom to the researcher from the constraints imposed by the dichotomy of post-positivism and constructivism

(Yvonne Feilzer, 2010). It does not expect to find unvarying causal links or truths but aims to interrogate a particular question, theory, or phenomenon with the most appropriate research method (ibid). Thus, pragmatist researchers are not bound by any particular method or techniques and choose the procedure that best meets their research objectives (Creswell & Creswell, 2007).

### 1.5.2. Data and Methods

Taking a pragmatic approach, this thesis demonstrates the use of a variety of data sources and research methods that have been briefly listed in Table 1.1 and 1.2 respectively.

Table 1.1: Data sources used to address the research questions

Data Sources	RQ 1	RQ 2	RQ 3
<i>Academic discourse</i> 61,444 research articles, books, conference proceedings on CE and its competing concepts (Out of this, 3300 are CE-related)	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
<i>Data from a workshop</i> A pilot workshop was conducted with 7 experts from the Sustainable Consumption Institute, the University of Manchester, to assess if experts in the field could engage with the text mining results before scaling it up.	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
<i>Data from the two rounds of the Delphi study</i> Two rounds of data were collected from 68 academic experts working on the CE globally through a Delphi study which included both closed and open-ended questions through an online survey.	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<i>Interviews</i> Data was collected through 16 semi-structured interviews with academic experts and policymakers engaged in the CE discussion. The interviews lasted from 45 to 75 minutes.		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<i>Other secondary sources</i> Extensive desk-based research involved the collection of secondary data from policy documents, CE-related conferences, research centres, university-level courses, 552 news items from July 2010 to April 2021 archived by the Ellen MacArthur Foundation.	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Table 1.2: Methods used to address the research questions

Methods	RQ 1	RQ 2	RQ 3
<i>Text Mining</i> Text mining refers to the process of extracting interesting and non-trivial patterns or knowledge from text data (Gaikwad et al., 2014). Text-mining methods are extensively used in the thesis to assess the research questions posed earlier systematically. I use topic modelling, word embedding, co-occurrence networks to extract information from the academic discourse produced on CE and its competing concepts, which would not be possible by manual inspection.	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
<i>The Delphi study</i> The Delphi study is a group process used to survey and collect expert opinions on a particular subject (Yousuf, 2007). A Delphi study with 68 international CE experts is conducted	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

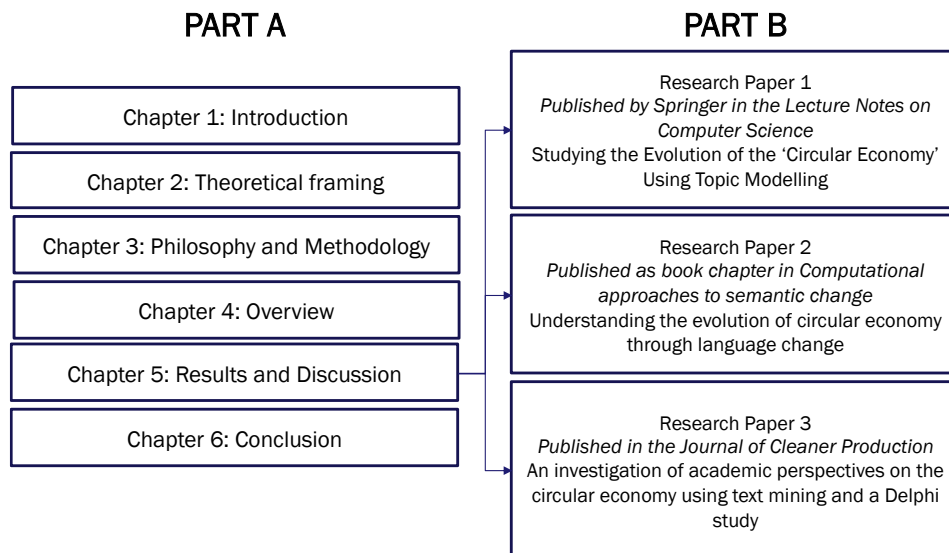
<p><i>Inductive content analysis</i></p> <p>To enable a careful analysis of the data collected in the Delphi study, interviews, and secondary data sources, inductive data analysis approaches are used.</p>		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
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## 1.6. Results and discussion

This thesis is presented in two parts- A and B, wherein part B comprises three published papers. The results and discussion presented in [Chapter 5](#) of this thesis build on the insights presented in the three papers in Part B. The research papers presented in Part B of the thesis were co-authored with the doctoral supervisors Frank Boons, Julia Handl and Riza Batista Navarro. I led all the stages of producing the final manuscript under the supervision of my PhD supervisors and was solely responsible for the data collection, analysis, manuscript drafting and editing. The three published papers are: [Research paper 1](#) entitled: *Analysing the CE literature using Topic modelling* published by Springer in the *Lecture Notes on Computer Science* serves as the starting point to analyse the academic discourse and its evolution. This paper analyses the vast literature on CE by characterizing the corpus, identifying the underlying research topics in the CE literature, and conducting a pilot workshop to assess the validity of the research findings before scaling it up to a larger group. Additionally, this paper also employs an advanced text mining technique, i.e., topic modelling, to assess the evolution of the academic discourse on the CE concept. [Research paper 2](#), entitled '*Computational of semantic change in scientific concepts: A case study of circular economy*' is a chapter in a book titled *Computational Approaches to semantic change*. This book chapter was specifically geared towards a text mining related discussion. This chapter builds a case to analyse the semantic change in concepts used in the academic discourse and how it is different from other studies on semantic change, which focus on core vocabulary and slang. This paper relies heavily on computational techniques and uses CE as a case study to develop a computational pipeline through which changes in concepts used in the academic discourse can be detected. The empirical evidence from this paper is especially useful in drawing comparisons between CE and its competing concepts. This book chapter utilises the results from the topic modelling ([research paper 1](#)) as one of the elements in the computational pipeline. [Research paper 3](#), titled: *An investigation of academic perspectives on CE using text mining and a Delphi* published in the *Journal of Cleaner Production*, uses the text mining results from [Research paper 1](#) as an input. This paper harvests the opinion of experts to provide the first systematic expert-based assessment of the CE academic discourse. The results from this paper allow to understand the pattern of evolution of the CE concept, the reasons for the pattern observed, the positioning of CE in the broader sustainability discussions and an informed future research agenda through the opinion of the experts. In [Chapter 5](#) an integrated results and discussion are provided for the research problem and questions posed earlier in this chapter drawing insights from the three papers and combing them with further analysis.

## 1.7. Summary and structure of the thesis

This introduction provides a basic structure of the thesis which will be substantiated in the following chapters. This chapter contributes to the thesis by creating a context of the phenomenon and the research problem. The research problem has been translated into research questions that guide the remainder of the thesis. The philosophy, data, methods, brief sketch of the papers used to create an integrated result and discussion of the thesis have been introduced. The overall thesis is divided into two parts- Part A, which constitutes six chapters presented in a monograph format deepening the insights gained from the three papers, and Part B, which consists of three published papers. The structure of the thesis has been outlined in figure 1.2 below.



*Figure 1-2: Structure of the thesis (Source: author)*

## Chapter 2 Theoretical framing

*“How does social science change? In its complex history, some see immanent trajectories; others see local practices. Some see political determination; others see internal competition.”- Andrew Abbott in *Chaos of Disciplines**

In this chapter, I present the overarching framing for the thesis by focussing on the relevant literature. To do so, first, I provide a sketch of the relevant literature situating the research. The synthesis provides background and positioning for the theoretical framing. The different elements of the theoretical framework are then discussed.

### 2.1. Introduction

To analyse the research problem posed in this thesis, a theoretical framework is required. The theoretical framework is a coherent structure that summarises and synthesises the theories that have been previously tested, thereby providing the researcher with a basis for analysis and interpretation of the research data (Kivunja, 2018). According to Swanson & Chermack, (2013) the theoretical framework is the structure that can hold or support a theory of a research study. One of the suggested ways to develop a theoretical framework is by conducting a thorough literature review so that the theoretical framework can emerge from that literature itself (Scott & Usher, 2010). Thus, this chapter starts with scanning the relevant literature in [Section 2.2](#), synthesising it in [Section 2.3](#), and finally presenting the theoretical framework in [Section 2.4](#).

### 2.2. Review of literature

The research problem posed in this thesis about concept-field evolution can be assessed from various theoretical angles. In the discussion going forward I outline different lines of scholarly inquiry where the research problem could be situated. To this end, I start with the philosophy of science. Within the philosophy of science, I specifically focus on evolutionary epistemology, which enables understanding knowledge generation through evolutionary mechanisms. Although evolutionary epistemology is one of the oldest framings of knowledge production, it remains relevant even today. According to Gontier, (2006), p. 23 until today, evolutionary theories are the only theories that are not rejected by the scientific community because evolution is a phenomenon. Evolutionary theories continue to form a basis for contemporary theories to understand various social phenomena. They have been applied to different empirical settings ranging from language change (Bowern, 2019), to understanding environmental business strategies (Boons et al., 2009), to assessing multiplicity of standards in the global coffee industry (Manning et al., 2012), to assess the development of nuclear arms control (Adler, 1992).

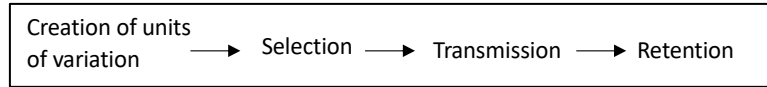


Moreover, evolutionary theories also provide inputs to other theoretical framings such as the triple helix of innovation systems (Leydesdorff & Deakin, 2011) and lifecycle of management fashions (Abrahamson & Fairchild, 1999) which will be discussed in the review going forward.

### *Philosophy of Science- Evolutionary Epistemology*

The earlier dominant ideas of scientific development were primarily positivist. They posited that science develops by adding new truth on top of an old truth, or the increasing approximation of theories to the truth, and in some instances, correction of past errors. One of the first authors who formulated an alternative philosophy of science deviating from the largely positivist approach was Thomas Kuhn, thereby initiating the study of the history of science (Bird, 2018). The "Kuhnian" idea of scientific development postulated that science is not uniform but has alternating phases between what is 'normal' and 'revolutionary' (or 'extraordinary'). In this conceptualisation, the revolutionary phases were not articulated merely as periods of accelerated progress but would differ qualitatively from the normal stages (Kuhn, 2021). Building on this further, philosophers of science (Campbell, 1974; Hull, 2010; Popper, 1972; Toulmin, 1967) have developed understandings of scientific development using metaphors relating to Darwin's theory of natural selection called evolutionary epistemology. Evolutionary epistemology extends evolutionary mechanisms from biology to the production of knowledge. The consequence of this is the conceptualisation of scientific development as constituting an "evolutionary process." According to this perspective, species become more adaptive to their natural environment by undergoing natural selection during evolution. Likewise, scientific progress results from selectionist mechanisms on an individual scientist level and in the scientific community. In the context of this thesis, the development of a particular field could undergo this evolutionary pattern where variations of concepts are created, selected, transmitted, and retained in the field. Variation originates in the idea taken from biology that mutations of genetic material occur in the reproduction of genes and species. In scientific knowledge production, variation means creating novel forms of knowledge, which could result from various mechanisms such as the problem-solving attitude of scientists, regrouping of old ideas, creating new versions of old theories. Variations also arise as scientists aim to balance legitimacy and originality (Hull, 2010). The notion of selection captures processes and mechanisms leading to the reduction of variety because of competitive and other selectionist pressures. Selection of a particular line of scientific pursuit instead of others can occur due to various reasons such as the idea's intuitive appeal, empirical support, predictive success, precision (Bradie, 1986). Transmission captures how scientific knowledge is transmitted within the scientific community, and retention involves the routinisation of certain forms of scientific knowledge (ibid). Transmission and retention can happen through various means such as books, articles, essays, or any other written material, which are "vehicles" in the process of knowledge production (Hull, 2010) and through contagion in master-pupil relationships, knowledge is transmitted and retained (Bradie, 1986).

In the context of the research problem posed in this thesis adopting evolutionary epistemology would mean that I can articulate concept-field development to constitute an evolutionary process where different concepts are created, selected, transmitted, and sometimes retained.



*Figure 2-1: An evolutionary account of scientific knowledge production (Source: author)*

### *Sociology of science (SSK)*

The next line of scholarly inquiry that I explored was the sociology of science (SSK) which explains the underlying social dimensions of knowledge creation. SSK is understood as a broad category covering science and technology studies, cultural studies of science, ethnomethodological studies of science, and other science studies programs (Lynch & Bogen, 1997). Studies in this line of inquiry can be categorised into two stages. The first stage until the 1970s was concerned with science as an institution and the analysis of scientists' norms, career patterns and reward structures following the Mertonian ideas. The second stage focused on the actual account of scientific ideas, theories, and experiments as the subject of analysis (Pinch & Bijker, 1984). I specifically focussed on the second stage. In the second stage, various schools emerged in Europe, such as the Edinburgh School, which was famous for the strong programme of sociology (Bloor, 1991; Shapin, 1982, 2018), French School, which focusses on the interplay of human and non-human actants within networks, i.e., the actor-network theory (ANT) (Callon, 1984; Latour, 2005), Bath School which focussed on the study of scientific controversies (Collins, 1983) and the Chicago school which concentrates on the processual ontology of social life (Abbott, 2010, 2016). A comparatively recent strand of work combining elements from Edinburgh and French schools, i.e., scientific and intellectual movements (SIMs), has emerged (Frickel & Gross, 2005). SIMs are based on the strong program of sociology from the Edinburgh school, which refuses to consider the intrinsic truth of an idea as the sole cause of its popularity (Bloor, 1991). SIMs also emphasise the central tenets of actor-network theory, i.e., translation and enrolment (Callon, 1984; Latour, 2005; Law, 2009). Another scholarly work combines the Mertonian ideas of SSK with institutional theory (DiMaggio & Powell, 1983) to understand academic fields as admittance seeking movements (Hambrick & Chen, 2008). In the following sections, I present these different lines of scholarly work. This discussion's scope is undoubtedly very narrow and does not cover the plethora of work that SSK covers. However, the intent is not to review SSK in detail but to present a constellation of theoretical framings where the research problem could be situated.

### *Actor-Network Theory (ANT)*

The beginnings of ANT can be traced to the late 1970s to early 1980s with the pioneering work of French sociologists like Bruno Latour, Michel Callon. At the heart of the unusual set of empirical studies, such as laboratory work (Latour, 1979), scallops, fisherman and scientists (Callon, 1984), were fundamental questions about how science and technology were produced. What made some claims successful whilst others failed? To address such questions, ANT recognises the construction of reality through the relations between heterogeneous (human and non-human) actants (Latour, 2005; Law, 2009). Relations in the social world can arise between any kind of heterogeneous components 'including objects, subjects, human beings, machines, animals, nature, ideas, organisations, inequalities, scale and sizes, and geographical arrangements.' (Law, 2009, p. 141). These heterogeneous components progressively mobilise, juxtapose, hold together and establish a temporally stable assemblage (Jiao et al., 2018). The network is created through a process called 'translation' (Callon, 1984; Cressman, 2009). *Translation* is defined as how the different components in the network interact and gradually build up the social world (Callon, 1984). A 'focal actant' (human or non-human) circulates through the network and interacts with different actants, thereby initiating translation. The network strengthens or dissolves over time by the interplay between the actants and events that unfold (Cordella & Shaikh, 2006; Jiao et al., 2018; Jiao & Boons, 2014). The interesting aspect about ANT is that scholars have called it not a theory per se but a methodological technique that allows for assessing how different actants assemble to form a temporary social order (Bleakley, 2012). Gad & Bruun Jensen, (2010) argue that ANT is not a theory about what the social is made of but a method that gives actants a voice and learns from them without prejudging their activities. According to the authors, ANT provides a vocabulary to understand the social.

### *Fractal development of disciplines*

In this section, I focus on two core arguments posited by Andrew Abbott, a Chicago school sociologist, in understanding the evolution of disciplines. First, the social world is constantly making and unmaking; thus, social phenomena can be understood in time and space (Abbott, 2016). Second, the development of disciplines can be seen through a fractal pattern of division and convergence (Abbott, 2010). That means that there is branching out pattern during the process of scientific knowledge production in disciplines. The fractal pattern in the division of discipline rejects the notion that in the spectrum of research methods, extremely qualitative constitutes one end of the spectrum and extremely quantitative as the other end of the spectrum. Instead, the fractal pattern of qualitative and quantitative distinctions is repeated throughout the fabric of the discipline. This fractal pattern also operates on a discipline level where Abbott takes the example of history and sociology. By conceptualising disciplinary developments in this way, Abbott argues that contrasting positions like social science history and historical sociology have much more in common with each other rather than the mainstream of the

parent discipline. On similar lines, he argues against the sharp distinction between positivist and interpretivist stances in sociology inquiry based on the empirical context of stress research (Abbott, 1990). The processual development of disciplines thus follows a branching out pattern. If this theory were to be followed in the context of the research problem, it would mean articulating the concept-field of CE through branching out or fractal patterns.

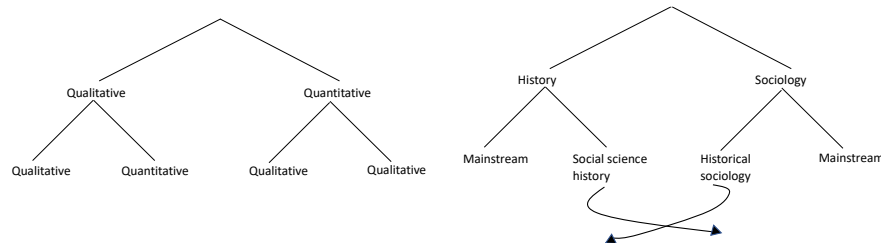


Figure 2-2: The fractal pattern in disciplinary development (Source: (Abbott, 2010, p. 11,14))

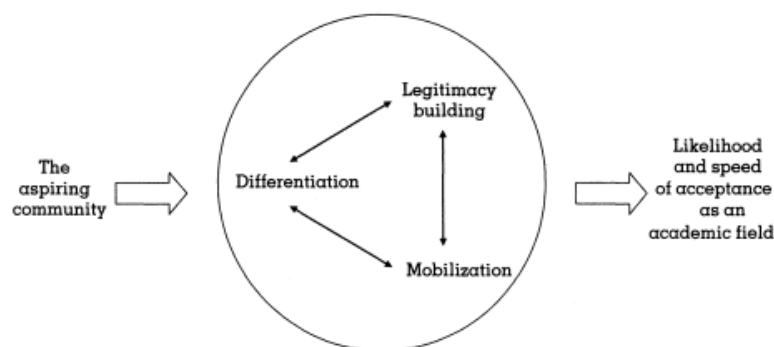
### *Scientific and intellectual movements (SIMs)*

As discussed earlier, combining some elements from the Edinburgh school and French school of SSK, a SIM may be seen as a specific type and subset of a social movement (Schneiberg & Lounsbury, 2008). Frickel & Gross, (2005) outline a general theory of how a SIM emerges and develops through four key propositions, i.e., (1) SIMs emerge when high-status intellectual actants harbour complaints against the prevalent central intellectual tendencies, (2) SIMs are more likely to be successful when structural conditions provide access to crucial resources such as employment, prestige, organisational resources, (3) The success of a SIM is contingent upon the work done by movement participants to frame movement ideas in ways that resonate with the concerns of those who inhabit the intellectual field or fields (4) The greater a SIM's access to various micro mobilisation contexts like conferences, symposia, research centres the more likely it is to be successful. Lastly, even when SIM's lose their energising potential over time, they leave legacies, elements of institutional orders and bits and pieces of paths not taken, producing diffuse but essential effects, and creating possibilities for subsequent movements, institution-building and transformation (Schneiberg & Lounsbury, 2008). The theory of SIMs has been used in various cases to understand the development of intellectual fields such as entrepreneurship (Aldrich, 2012), the rise of rational choice theory within sociology (Foy et al., 2018), and service-learning (Butin, 2011). In the context of the research problem posed theory of SIM's provide helpful propositions that, to some extent, provide a background on the emergence and success of the CE concept-field.

### *Academic fields as admittance seeking movements*

Hambrick & Chen, (2008) present a theoretical model on the development of academic fields drawing from the sociology of science (Merton, 1973) and institutional theory (DiMaggio & Powell, 1983). This

theoretical model provides a definition of an academic field drawing from institutional theory as a reputational work organisational which emerges when a substantial number of major universities designate positions for its members, grant tenure to its members, seek peer tenure evaluations from its members and allow its members to supervise graduate students. Further, the authors map the ascendance of a new academic field as a 'successful admittance-seeking social movement' that consists of three major stages, i.e., differentiation, mobilisation, and legitimacy building. First, for a new field to emerge, it must differentiate itself from the pre-existing fields by arguing how essential issues and problems cannot be solved with the status quo entities. In the second stage, resources are mobilised for collective action. Resources, in this case, could be political opportunity structure, shared interests, and social infrastructure that must support the field members. In the third and last stage, the aspiring community must build legitimacy in the eyes of academics established by intellectual persuasion and by adhering to the norms, styles, and standards of adjoining established fields. In the context of the research problem, this theory can only partially explain the development of the CE concept field because it is primarily concerned with the academic field and not the non-academic field.



*Figure 2-3: Theory of academic fields as admittance seeking movements (Source: Hambrick & Chen, 2008)*

### *Contemporary framings of knowledge production*

The discussion so far provides a constellation of frameworks that allow us to assess the social dimensions of scientific inquiry. However, in the last 30 years, scholars have provided accounts of the changing nature of science systems and knowledge production (Schäfer, 2012). The different lines of scholarly work discussed so far do not account for this changing system. This change is mainly characterised by science systems oriented towards strategic goals, production of policy and practice relevant knowledge, and the corporatisation of universities (Hessels & van Lente, 2008). Thus, the next line of work that I explore is the contemporary framings of knowledge production, which provide an account of the changing nature of science, science policy and knowledge production. Some of these framings include post-normal science (Funtowicz & Ravetz, 1993), academic capitalism (Slaughter & Leslie, 1997), the triple helix of innovation systems (Etzkowitz & Leydesdorff, 2000). One of the most popular framings, which include elements from various framings of contemporary knowledge

production (Hessels & van Lente, 2008), is Mode 2 knowledge production (Gibbons et al., 1994), enabling to build an understanding of significant trends in contemporary science systems. This discussion is crucial in the CE concept field because the contemporary framings of knowledge production are especially relevant for practice and policy-related fields like environmental research (Mohrman & Lawler, 2011). In the context of this thesis articulating the research problem using contemporary framings of knowledge production would mean taking an inductive and exploratory approach to identify which field characteristics are evidenced in the case of CE (Turnpenny et al., 2011). To this end, some of the contemporary framings are discussed.

### *Post-normal science*

The discussion around 'Post-normal science' emerged in a journal article in the early 1990s by Funtowicz & Ravetz, (1993) based on environmental policy issues. The authors argued that through post-normal science, a "new, enriched awareness of the functions and methods of science" is being developed (Funtowicz & Ravetz, 1993, p. 755). The discussion of post-normal science is especially relevant for this thesis because of its empirical setting in environmental issues. Given the complexity of the prevailing environmental policy issues, the theory of post-normal science urges to reassess the role of scientific research. Post-normal science is analysed in contrast to traditional problem-solving strategies. The two attributes used for the analysis are system uncertainties and decision stakes to distinguish between traditional problem-solving strategies, including core science, applied science, and professional consultancy. Post-normal science is appropriate when either of the two attributes (i.e., system uncertainties and decision stakes) is high; then, the traditional methodologies become ineffective. One of the main thrusts of the argument for post-normal science is the quality assurance of scientific inputs to the policy process, requiring an extended peer community consisting of all actants who have a stake in the dialogue on the issue. Post-normal science stresses the need for scientific practice to cope with uncertainty, with value plurality and including the decision stakes of various actants. As argued by Ravetz, (1999) the main thrust of post-normal science is enhancing quality rather than establishing truth is the crucial problem for science in the post-normal age. New methodologies in science, transcending the bounds of normal training and research, are required to address problems in this age. The author also highlights the mutual respect among participants in the dialogue and the recognition that no side necessarily has a monopoly of morality or truth. There have been various empirical settings where the formulations from post-normal science have been used, such as gene drives (Brossard et al., 2019), science communication (Brüggemann et al., 2020), mathematics education (Hauge & Barwell, 2017), and engineering ethics (Verrax, 2017).

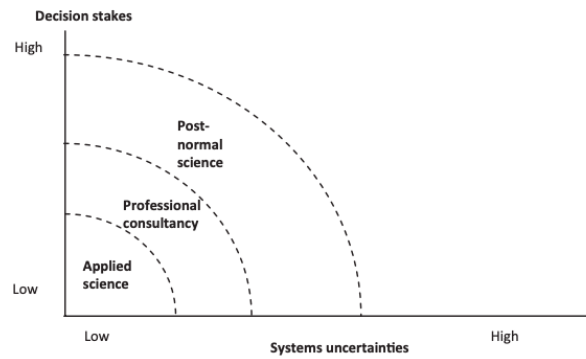


Figure 2-4: Problem-solving activities based on decision stakes and system uncertainties (Source: Funtowicz & Ravetz, 1993)

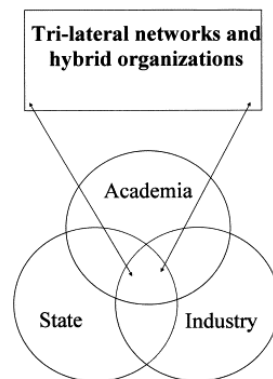
### *Academic Capitalism*

A book entitled '*Academic Capitalism*' by Slaughter & Leslie, (1997) was based on the observation of increasing market like activities in the universities based on empirical case studies in the UK, US, Australia and Canada. As argued by Slaughter & Leslie, (2001) academic capitalism refers to how public research universities respond to neo-liberal tendencies of treating higher education policy as a subset of economic policy. The authors direct attention to the increasing market like competition in academia for external funding, grants, endowment funds, university-industry partnerships, or any other revenue-generating activity. There are two main reasons for such capitalism in academia- First, the increasing globalisation, which enhances the pressure on the industry to innovate whereby they turn to universities for assistance. Second, universities no longer receive public funding; hence they are willing to engage in more capitalist activities. Interestingly, both these causes are non-academic and arise from sources outside of academia. Academic capitalism stresses the growing engagement of academics in application-oriented and commercially funded research. However, the authors also acknowledge that the extent of such engagement is based on the closeness of the discipline to the market. Through their analysis, the authors also outline the risks of such market-like activities. The risks could be a business failure due to a lack of product responsibility and the neglect of students because academics are engaging more in revenue-generating activities. The authors recommend that governments incentivise universities to spend the money in the way they deem necessary to avoid a decline in the quality of academic education. Since the term was coined, it has received much traction in scholarly works. To this end, various books have been written exploring this idea further (Münch, 2014), various forms of academic capitalism are outlined (Jessop, 2017), its impact on academics has been investigated (Park, 2011), its application in a translational context has been studied (Kauppinen, 2015). Lastly, as argued by Loroño-Leturiondo & Davies, (2018) scholars consider academic capitalism as the new order of contemporary science.



### *The Triple Helix system*

Scholars framed the process of knowledge production in the context of a double helix model, including the university and the business. Followed by the double helix was the triple helix was formulated, which included university-industry-government relations (Ivanova, 2014). The triple helix of the innovation system is based on the premise that industry, university, and government roles are increasingly interdependent. The triple helix model argues a complex interaction system underlying the knowledge-based economy (Leydesdorff & Zawdie, 2010). This general model has been typically used as an analytic tool in studying science and innovation policies or transferring ideas from different knowledge producers to policymakers (Etzkowitz, 1993; Fogelberg & Thorpenberg, 2012; Rodrigues & Melo, 2013). While the original model proposed that a hybridisation from the three different spheres is required to bring about a systemic change and innovation policy, later advanced versions also outlined the role differentiation between the different spheres (Ranga & Etzkowitz, 2013). The triple helix system has also been applied in CE to understand the different knowledge bases created and the synergies between university, industry, and government (Anttonen et al., 2018). Building further from the triple helix systems, scholars propose advanced versions, including the quadruple, quintuple and the N-tuple helices, providing detailed explanations of how different agencies interact in wealth creation and knowledge production (Leydesdorff, 2012).



*Figure 2-5: The triple helix system of innovation system (Source: (Etzkowitz & Leydesdorff, 2000))*

### *Mode 2 of knowledge production*

As discussed earlier, most of these contemporary framings come under the umbrella of what has been called Mode 2 knowledge production. Hence, Mode 2 defines attributes of the changing nature of the science systems. Mode 2 of knowledge production was proposed in 1994 in a book entitled: *The new production of knowledge: The dynamics of science and research in contemporary societies* (Gibbons et al., 1994). The core argument of Mode 2 knowledge production is that the research process is transforming, and there are new ways through which scientific knowledge production can be explained. Mode 1 knowledge production, which occurs mainly due to academic agenda (Gibbons et al., 1994, p. 347), is being replaced by Mode 2 knowledge production. Five core characteristics define Mode 2



knowledge production- (1) knowledge generation in the context of an application, (2) transdisciplinary, i.e., mobilisation of a range of theoretical perspectives and practical methodologies to solve problems, (3) knowledge is highly reflexive, which means that the single epistemological ideal of a neutral "view from nowhere" has been replaced by multiple views, with each situated somewhere, (4) diversity of sites in which knowledge is produced, (5) novel forms of quality control beyond the traditional disciplinary peer review. As argued by Nowotny et al., (2013) three key elements underpin the transition from Mode 1 to Mode 2. First, steering of research activities at the supranational level, national level, and system level. Second, the commercialisation of research because of the lack of public funding for research and researchers turning to alternative funding sources. Third, the management of research with an effort to evaluate its effectiveness and assess its quality. Mode 2 knowledge production has received much traction and has been used in different empirical settings, from artistic research to human resources (Gray et al., 2011; Guerri et al., 2019; Özdemir et al., 2012). Mode 2 knowledge production is especially relevant for this discussion because of its immediate relevance to environmental science-related research (Weingart, 1997). Mode 2 knowledge production has been one of the most popular contemporary framings of knowledge production; however, scholars for the last two decades have been critiquing it on the grounds of lack of empirical evidence (Crompton, 2007; Hessels & van Lente, 2008; Shinn, 2002; Weingart, 1997; Zapp & Powell, 2017).

### *Management and organisation theory*

The last thematic area of scholarly work explored is management and organisation theory. Management and organisation theory is the name given to a set of propositions constructed within the field of organisation science, which includes a study of organisations in practice. From observation and research, develop a body of knowledge that seeks to generalise the way elements of an organisation interact and how the organisation interacts with its environment (Winzenried et al., 2010). Within this context, two specific lines of inquiry are focussed upon, management fashion lifecycle (Abrahamson & Fairchild, 1999) and institutional theory (DiMaggio & Powell, 1983). Management fashion lifecycle is relevant to understand concept-field evolution because it provides an assessment of the trajectory of ideas and the actants associated with those ideas. Various scholars have used institutional theory to understand specific concepts and their related fields in various contexts ranging from entrepreneurship to sustainable business models (Aldrich, 2012; Ehrenfeld, 2004; Hess & Frickel, 2014; Lüdeke-Freund & Dembek, 2017; Mitnick, 2019; Owen et al., 2021; Vakkuri, 2004). Thus, in the following sections, these two lines of inquiry are introduced.

### *Lifecycle of management fashion*

A popular area of scientific inquiry for organisational theorists is the study of management fashion through the management discourse, i.e., what is written about management related issues and the

diffusion of the management fashion. Management fashion is a relatively transitory collective belief, disseminated by management fashion setters, that a management technique leads to rational management progress (Abrahamson, 1996). Scholarly works in management fashion have focused on understanding the reasons for the popularity of specific management practices and concepts over others, their evolution patterns, what causes such patterns to emerge, and more (Piazza & Abrahamson, 2020). Management fashions follow a typical bell-shaped pattern with extended periods of latency followed by an ephemeral wave-like pattern (Abrahamson & Fairchild, 1999). It has long been the agenda of management theorists to understand why certain management concepts are successful and why some of them fail (Grant, 2015). Management fashion can be evaluated from two aspects, i.e., discourse lifecycle and diffusion lifecycle, which is said to co-evolve (Abrahamson & Fairchild, 1999). Studies have attempted to understand the co-evolutionary pattern of various management fashions' discourse and diffusion lifecycle (Alcouffe & HEC, 2002; Kühne et al., 2011; Oesterreich et al., 2020). Discourse lifecycle is written about the management concept in various outlets such as articles, media, reports, whereas diffusion lifecycle is the adoption of the management concept across organisations.

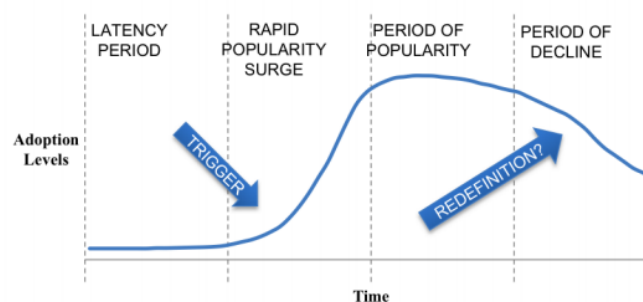


Figure 2-6: The lifecycle of management fashion (Source: Abrahamson & Fairchild, 1999)

### *Institutional Theory*

The label 'institutional theory' and 'institutionalism' was a slightly deviating field of work in organisation studies (Selznick, 1996) referring to a diverse set of ideas about how organisations function and change (Czarniawska, 2008) and how resilient social structures that provide societal stability are established (Scott, 1987). Within the institutional theory, scholars have focussed on how meso-level social orders such as sectors, organisational fields, networks, strategic action fields get institutionalised (Fligstein & McAdam, 2011). One of the most popular definitions for such meso level social orders is that of an organisational field defined by DiMaggio & Powell, (1983) as "organisations that, in the aggregate, constitute a recognised area of institutional life: key suppliers, resources and product customers, regulatory agencies, and other organisations that provide similar services or products." The action takes place in these meso-level social orders where actants (individual or collective) interact with knowledge of one another under a set of common understandings about the purposes of the field, the relationships in the field (including who has power and why), and the field's rules. The institutional theory stresses

the relationality between an organisation with its external environment (such as norms, institutions, and politics of the wider society) as sources of authorisation, endorsement and legitimisation of behaviour and logic within organisations (Greenwood et al., 2017; Scott, 1995). It draws attention towards concepts of legitimacy (Deephouse & Suchman, 2008) and their significance in maintaining the stability of existing institutions and the formation of new ones (DiMaggio & Powell, 1983). Taking an institutional theory perspective, a concept-field institutionalises by establishing interactions between actants and the rules according to which these interactions happen and influences different spheres of societal life (Ehrenfeld, 2004). The institutionalisation processes occur as actants within a field interact with one another, using and transforming the knowledge existing in the field about the issues of interest and their specific contexts (DiMaggio & Powell, 1983; Hoffman, 1999), thereby initiating channels of dialogue (Hoffman, 1999).

### 2.3. Synthesis of the literature review

In the discussion so far, a constellation of theoretical framings where the research problem could be situated has been covered, i.e., (a) philosophy of science, (b) sociology of science, (c) contemporary framings of knowledge production, and (d) management and organisation theory. The synthesis of these diverse strands of literature is a complex task; however, I bring them together to discuss their commonalities and differences and how choosing one of them impacts the empirical assessment in the later stages. The synthesis is centred around three aspects- the underlying process typologies, the inclusion of actors, and the application context.

#### *The underlying process typologies*

One of the aims of the research questions posed in this thesis is to understand the process of how the CE concept-field interacts and evolves. The operative keyword here being ‘process.’ Process-based explanations tell a narrative story about how a sequence of events unfolds to produce a particular outcome (Van de Ven & Engleman, 2004). A process-based approach is ideal for the research problem posed as it enables to understand the sequence of events through which the CE concept evolved and became prominent. Underpinned by this premise, it is helpful to outline the different process types to model change and development. For instance, Graetz & Smith, (2010) outline ten different philosophical approaches to change processes. According to the authors, change can be understood from various philosophical angles such as biological, resource-based, psychological, cultural, political, rational, institutional. Studies by Kezar, (2011) and van de Ven & Poole, (1995) also outline a typology of processes. The latter scanned 20 different change theories and outlined four overarching process typologies, i.e., lifecycle, teleological, dialectic, and evolutionary. I will focus on these four process typologies that are most used to explain change and development.

- Lifecycle process - In this process, an entity moves through a unitary sequence of stages that are irreversible. This model is suited for managing many recurrent and predictable changes. It represents an imminent program or a prescriptive logic within a particular entity.
- Teleological process - In this process, the development of an organisational entity proceeds towards a specific goal. The entity is assumed to be purposeful or adaptive, either by itself or interaction with others; moreover, the entity constructs an envisioned end state, takes action to reach it, and monitors the progress. Change occurs through the purposeful enactment of a particular entity. Thus, a teleological model is often seen as a cycle of dissatisfaction with the existing trends, goal formulation, seeking strategies, implementation of strategies, monitoring progress.
- Dialectical process- In this process, stability and change are explained by referring to the balance of power between opposing entities. Struggles and accommodations that maintain the status quo between oppositions produce stability. This model works best when different organisational units confront one another on an issue. Failure to navigate in conflict situations, however, blocks the process.
- Evolutionary process- In this process, multiple units compete for scarce resources by developing different approaches to serving a given market. Failure to ensure actual variation between the alternatives or no absolute resource scarcity defeats the purpose of using the evolutionary approach (Groskovs & Ulhøi, 2018).

In the different strands of literature introduced in the previous section, a plurality in process types can be observed. For instance, evolutionary epistemology focuses on an evolutionary type of change. Lifecycle in management fashion and academic fields as admittance seeking movements view change from a lifecycle perspective. Fractal development of disciplines views change from a fractal perspective wherein branching out of different knowledge bases occur. Lastly, SIM's picture change from a teleological cycle perspective. Based on the types of changes outlined in the literature review, there is a loss of hegemony of a single change process that could explain concept-field development. For example, adopting evolutionary epistemology as the theoretical framing would mean pre-determination of concept-field development as being evolutionary, or adopting lifecycle of management fashion would mean pre-determination of the concept-field development as being a lifecycle. From these typologies, it is clear that there is no one right way to understand change (Burnes, 1996). As an outcome of this, rather than articulating the process typology as a part of the theoretical framework, I intend to take a data-driven exploratory investigation of the CE concept-field and determine the process typology based on empirical evidence.

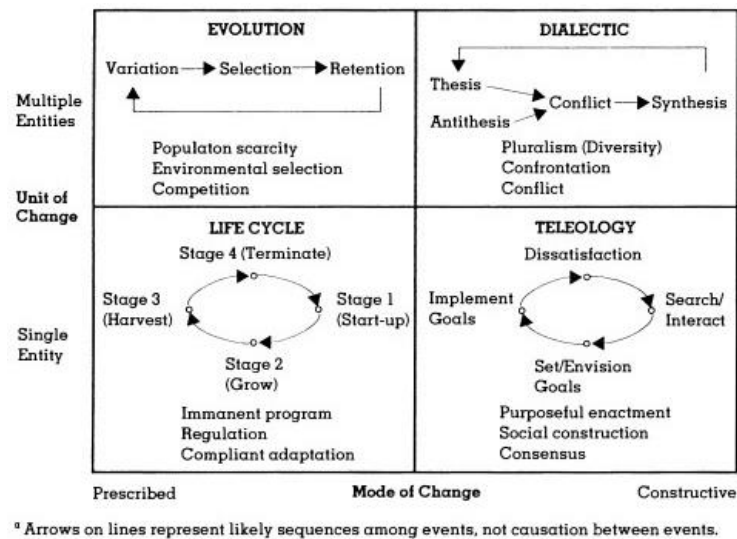


Figure 2-7: Process typologies (Source: van de Ven & Poole, (1995))

### Actors to be included in the assessment

Secondly, the aim of RQ 2 is to assess how different actors assemble around the CE concept and the resulting field characteristics. Each of the theoretical framings discussed so far consider different actors for the assessment. For instance- evolutionary epistemology, academic fields as admittance seeking movements and, fractal development of disciplines mainly focus on the role of academic researchers in generating knowledge. These theories enable us to map how academic fields are developing due to the interaction between various actants within academia. Contemporary framings such as academic capitalism, Mode 2 knowledge production, the triple helix of innovation systems focus on the role of policymakers, practitioners, and academic researchers together in the process of knowledge production. One of the common actors considered in all the theoretical framings discussed earlier is academic researchers. As the research questions focus on the CE field, it is essential to articulate which actors are considered part of the field. Only including researchers to understand concept-field interactions does not provide a complete picture because science is a cultural tradition (Ben-David & Sullivan, 1975) entangled between social and political factors (Hambrick & Chen, 2008). Moreover, in the case of CE, the concept has received much traction across different groups of stakeholders; thus, it is essential to factor in how actors outside of academia influence the field. This inclusion of non-academic actors is even more relevant given the changing nature of knowledge production in policy and practice relevant fields as articulated in the contemporary theoretical framings of knowledge production. The fruitful development of scientific inquiry is contingent on various activities and institutions which inadvertently or by design, have provided the setting for researchers to pursue scientific investigations (Ruse, 2021). Thus, the choice of the theoretical framing should enable to capture different types of actors, i.e., both academic and non-academic actors.

Going back to the researchers, it is essential to focus on researchers' motives because choosing a particular direction of research is consequential for both themselves and science (Foster et al., 2015). Earlier framings of SSK considered recognition at the heart of the reward system of science, considering it as a pillar upon which scientific careers are or at least can be built (Paul-Hus et al., 2017). However, increasingly the Mertonian idea of scientific norms was criticised for being overly idealistic and not considering the practical realities of scientific work and the negotiations by scientists to secure funding for their research work (Latour, 1979). As argued by Frickel & Gross, 2005 there is a 'richly variegated vocabulary of motives' that scientists and researchers draw upon which could explain their intellectual moves. Variegated motives are also evident in the different lines of literature discussed earlier. For example- academic capitalism draws on motives of revenue-generation whilst academic fields as admittance seeking movements draws on a different set of motives such as seeking journal space and professional associations. Although, the common thread running through most of the framings is that it is not only prestige and recognition that motivates researchers. Contemporary framings increasingly direct attention towards the researchers' reflexivity in their choice of which research direction, concept, method or approach they undertake (Hessels & van Lente, 2008). Given the diversity of actors presented in different strands of the literature that could influence concept-field development, it is difficult to zero on which actors to focus. Rather an approach that allows to include and explore a wide variety of actors who actively coalesce around the CE concept to form a field and exhibit certain field characteristics would be required.

#### *The application context of the theoretical framing*

The empirical settings discussed so far span across different levels of analysis like disciplines, concepts, methods, management fashions, and fields. For instance, philosophers of science studied evolutionary epistemology focussed on discipline level assessments like biology and physics (Bradie, 1986; Campbell, 1974; Hull, 2010). The theory of management fashion lifecycle accounts for change related to the management fashion such as total quality management, quality circles, self-managing teams and its uptake among actants (Abrahamson, 2006; Abrahamson & Fairchild, 1999; Nijholt & Benders, 2007). Fractal development of disciplines focussed on disciplines (sociology and history), methods (qualitative and quantitative) and the philosophical stance (positivist or interpretivist) (Abbott, 2010). Scientific and intellectual movements focussed on specific research fields like entrepreneurship (Aldrich, 2012) or rational choice theory (Foy et al., 2018). Contemporary framings of knowledge production have focussed on diverse areas such as environmental research (Funtowicz & Ravetz, 1993), activities of academics in specific universities (Münch, 2014; Slaughter & Leslie, 1997). Institutional theory has been used to analyse concepts-fields for instance, industrial ecology (Ehrenfeld, 2004), sustainable business models (Lüdeke-Freund & Dembek, 2017), responsible innovation (Owen et al., 2021). The outcome of studying different theoretical framings spanning different scales, levels and



objects of analysis is that in extending it to the context of this thesis, a clear articulation of the theoretical elements is essential because that influences the empirical assessment in the later stages. There are two parts to the analysis in this thesis, i.e., the concept and the field. Thus, the choice of the theoretical framing should be done in a manner that allows the careful articulation of the CE concept and its related field.

The research problem aimed towards understanding concept-field evolution led me to explore different lines of scholarly work where this research problem could be situated. This directs attention towards the complexities of the debate in terms of which process typology can explain concept-field development, who the main actors in the field are, and how they interact. It is also important to note that situating the research problem in one of the strands of literature would also mean making certain presumptions about the process typology and the inclusion of actors. Inspired by this diversity the direction that I intend to take is one which provides utmost flexibility wherein least possible assumptions are made. Out of the theoretical framings that have been discussed, ANT qualifies best in terms of this approach allowing a data-driven exploratory approach. ANT insists that apart from the capacity of actants to negotiate with and enrol other actants, no a priori assumptions are made about the matter under investigation (not even the type of actors who can be included) and attempts an understanding on the basis of studying the set of complex negotiations and trade-offs performed by the actants (Tatnall, 2005). Thus, it allows to understand the field characteristics, the process through which concept-field evolve by empirical evidence itself. The exploratory data driven approach of ANT also enables to explore the contemporary framings of knowledge production. For instance- does the CE field exhibit characteristics of post-normal science or Mode 2 knowledge production or academic capitalism. This exploration based on empirical evidence is also essential because one of the most popularly used framings of contemporary knowledge production has been critiqued for the last two decades on the grounds of lack of empirical evidence (Crompton, 2007; Hessels & van Lente, 2008; Shinn, 2002; Weingart, 1997; Zapp & Powell, 2017). Moreover, ANT has been used in unusual contexts like scallops, fishermen, and scientists (Callon, 1984), business process failure (Sarker et al., 2006), private gardens (Hitchings, 2003). Thus, the application of ANT does not restrict the usage in any context.

Bleakley, (2012) argue that ANT is not a 'theory in the conventional sense of a proposition or hypothesis that can be empirically tested. Instead, it is a practice or method. It places itself within the traditions of sociological thinking, suggesting that the 'social' is never given but achieved. ANT questions the assumption that there is a prior 'social.' Rather, the 'social' is always built up through associations, translations, mediations, and alliances that create networks or work-nets. A feature of ANT is its dislike of large scale, 'obvious,' tautological answers to the problem. For instance, according to Bleakley, (2012) statements like 'Visual Basic was adopted because its time had come' or 'Java developed enough

momentum to make its use inevitable' do not fit well with the ANT methodology. Thus, in the context of CE, it allows investigating the CE concept-field exploring the setting in which its prominence came about. ANT, therefore, can be regarded as an analytical technique that enables a researcher to follow the actants and understand what they do to create temporary social orders. Through this approach, ANT allows framing a story of how a particular social phenomenon came about (the prominence of CE). Thus, as an analytical technique, ANT is helpful to frame the research questions, guide data collection and analysis (Cresswell et al., 2010).

Moreover, as discussed earlier at the heart of the unusual set of empirical studies selected by the sociologists who were pioneers of ANT such as laboratory work (Latour, 1979), scallops, fisherman and scientists (Callon, 1984) were fundamental questions about how science and technology were produced, what made some claims successful whilst others failed. Thus, it applies to the context of this thesis to understand the prominence of CE through academic discourse analysis and the roles of different actants without pre-determining who the actants are and whether they are human or non-human. As Latour, 1987 suggests, setting boundaries for an actor-network and investigating it is a complex task. The decision on which actants to include in the network analysis is a pragmatic decision that rests on the researcher (Passoth & Rowland, 2010). The different actants in the network can be determined during the empirical investigation.

## 2.4. Theoretical framing- Actor-Network theory (a data driven approach)

Underpinned by the premise that actors translate concepts as they engage with the concept in different settings, ANT (Callon, 1984; Latour, 2005; Law, 2009) is used to frame the structure of a field and its relation to a concept. Based on ANT, a field is articulated as an actor-network centred around a concept as the source actant (ANT does not distinguish between human and non-human actors hence the usage of the term actant). Drawing from the definition of a field by Scott, 1994 the actors in the field partake of a shared meaning system where the meaning system is provided by the concept itself, thereby interacting more frequently and fatefully with one another than with components outside of the field. As discussed in the earlier section, choosing which actants to include in the actor-network is a pragmatic decision based on the researcher's judgement. The literature review provides a guide as to which actors must be included to assess the concept-field evolution.

The starting point of the actor-network is the source actant that is being translated, i.e., the CE concept in this case. The other actants around the concept forming a field could be anything ranging from ideas, practices, researchers, major organisations, resources. Further, concepts that belong to the same concept space (Gärdenfors, 2004), i.e., addressing similar issues or aim to achieve similar goals, often compete



for the same actant to form their actor-network. Actants often inhabit multiple actor-networks belonging to competing concepts. Thus, developing into a complex web of interlinked actor-networks forming a bigger network. The inter-linked actor-networks are like what has been called linked ecologies (Abbott, 2005), where ecologies represent their own set of actors and locations. Then the relationships and interactions between them are explored through linked ecologies. Somewhat similar ideation is also used by Fligstein & McAdam (2011) to explain strategic action fields. The authors use a Russian doll analogy to describe strategic action fields, wherein one strategic action field comprises another strategic action field and so on.

An example to illustrate this understanding is helpful- For instance- green economy (GE), bioeconomy (BE), CE are concepts that aim to address sustainability-related issues and represent the same concept space. The Journal of Cleaner Production publishes papers on the green economy, bioeconomy, CE. All these concepts have some overlapping conceptualisations, and researchers select one or all of these concepts in their research work (D'Amato et al., 2017; D'Amato et al., 2019). Thus, the same actors can associate with any of the concepts. An actor-network is formed around each of these concepts, with actants often inhabiting multiple networks. These interlinked networks of GE, BE, and CE form the larger network to solve sustainability-related issues.

The concept is the source actant being translated. As discussed in the introductory chapter, the interpretation of the term concept is often complicated because there are different interpretations of what the term concept itself means. It should also be appreciated that any definition of a concept has a sense of arbitrariness. Therefore, it is desirable to study concepts with as much flexibility as possible (Fokkens et al., 2016). The understanding of concepts adopted in this thesis is semantic labels (Margolis & Laurence, 2005). According to Benders & Verlaar, 2003 a concept may be loosely defined as a prescriptive, more-or-less coherent view on a particular issue under a specific label. Practices are embodied, materially mediated arrays of human activity centrally organised around shared practical understandings (Cetina et al., 2005).

Following Vayda, 1983, progressive contextualisation is followed in understanding the actor-network of heterogeneous components around the concept. Simply put, this enables focusing on significant human activities or people environment interactions and then explaining these interactions by placing them within progressively wider and denser contexts. Extending further on these lines' context shaping events is essential for the emergence and progression of the actor-network in specific directions; some events could foster or strengthen the actor-network by adding in more actors, whereas some events could lead to the dissolution of the actor-network. Drawing from Hoffman, 1999, there are various denominations of such events such as disruptive events (Hoffman, 1999), shocks (Fligstein, 1991), jolts

(Meyer, 1982), discontinuities (Lorange et al., 1986). Further Hannigan, 2014 distinguished events into three types, i.e., milestones (e.g., Earth Day, the Rio Summit); catastrophes (e.g., economic slowdowns, Great Depression, oil spills); and legal/administrative happenings (e.g., formulation of significant policies, parliamentary hearings, trials, the release of environmental white papers, the publication of the Brundtland Report). Whatever the type of such events, the idea is that they influence the field. These events shape the context in which the field evolves and often acts as triggers in steering the field through various stages.

### *The process of translation and its stages*

The actor-network is created through the process of translation. As put forward by Cordella & Shaikh, (2006) 'reality becomes real when actors interact'. The process through which the actors in the actor-network interact is called translation (Callon, 1980, 1984). The process of translation starts from the premise that "the initial idea barely counts" (Latour, 1996, p. 119). In its travel through the social world, a concept is reshaped, reinvented, and modified every time it is picked up by individuals and organisational members (Jiao & Boons, 2014). Through this process of translation, temporary social orders are created (Hardy et al., 2001). The translation happens through four mechanisms, i.e., problematisation, interessement, enrolment, and mobilisation (Callon, 1984).

- Problematisation- A focal actant seeks to become indispensable by defining other actors' problems and suggesting how those problems could be solved if they passed through an 'obligatory passage point.' Put simply, through problematisation; an actor attempts to define the nature of the problem, propose a solution, and define the roles of other actors to fit their proposed solution.
- Interessement and enrolment- Actants may already be enrolled in other, possibly competing networks. To enable such actors to become a part of a particular actor-network, the process of translation requires to disassociate, 'to free them from the inhibiting effect of the roles in competing actor-networks which are called interessement. If interessement strategies are successful, then actants begin to enrol on the actor-network. Inspired by institutional theory discussed earlier in the chapter, some of the strategies that allow successful interessement and enrolment of actors are:
  - Coercion is when an actant is forced to adopt a particular concept by another actant that holds power over it, such as the government issuing a rule or the availability of research funding around a specific concept.
  - Bandwagon effect wherein an actant may adopt a concept or practice seeing similar actants for status reasons or because it provides a way of dealing with uncertain situations.

- Materialisation is the process through which concepts are demonstrated through real-world practices (Czarniawska & Joerges, 2011). Thus, successful practical implementation or demonstration projects could be a good translation strategy to overcome resistance towards a particular concept.
- Training and professionalisation could be a source for individuals to learn about the concepts, practices, and ideas (for example, in higher education) and subsequently start applying them in their work environment (either academic or non-academic organisations).
- Mobilisation is to maintain the stability of the actor-network for which there must be an agreement between the actants. Through this mechanism, the actor-network becomes durable, and relations between actants become irreversible, allowing the network to behave like a single actant or a 'black box.'

Through the process of successful translation, the actor-network strengthens by adding more actants. Decoding the translation process begins with the focal actant (Bengtsson & Ågerfalk, 2011; Callon, 1984). This actant moves through the actor-network and engages in translation, and there is a resulting chain of translation creates the actor-network (Pipan & Czarniawska, 2010). In different stages of the actor-network, the focal actant could change. There could also be multiple focal actants. It is up to the analyst or researcher to select the focal actant they intend to follow (Sarker et al., 2006).

## 2.5. Summary

In this chapter first the different theoretical framings where the research problem could be situated have been discussed. The theoretical framings are based on different contexts, focus their attention on specific actors and outline a different underlying process form to explain change or development. Given the dialectic constellation of perspectives to address the research problem, a data-driven exploratory approach is to be followed, which allows to uncover the field characteristics and the process of concept-field evolution. To this end, the theoretical framing is based on ANT, which scholars have also called an analytical tool. ANT does not entail any a priori assumption, not even about the composition of the field or about the process underlying concept-field evolution. Instead, ANT only assumes that actants can negotiate, forming a network. Thus, using ANT as a framework:

- Allows to determine the process type that the CE concept-field follows through empirical evidence rather than assuming it as an outcome of the theoretical framework. Thus, no a priori assumption is made about the process typology of the CE concept-field follows.
- Allows to explore different actors (academic, non-academic, human, non-human) rather than pre-determining which actors are to be considered. The focal actant is followed and a complex web of actants forming the CE actor-network is revealed. Here the actant is defined as any

source of action regardless of its status as human or non-human (Latour, 2005). The idea being that any inanimate thing can also have agency. Thus, no a priori assumptions are made about the actants who form the CE concept-field rather anything that has agency is considered as an actant.

- Allows to take an exploratory and inductive approach to explore the contemporary framings of knowledge production. As argued by Turnpenny et al., (2011) exploratory and inductive approaches is often used to reveal characteristics of contemporary knowledge production. For instance- does the CE field exhibit characteristics of post-normal science or Mode 2 knowledge production or academic capitalism. This exploration based on empirical evidence is also essential because one of the most popularly used framings of contemporary knowledge production (Mode 2 knowledge production) has been critiqued for the last two decades on the grounds of lack of empirical evidence (Crompton, 2007; Hessels & van Lente, 2008; Shinn, 2002; Weingart, 1997; Zapp & Powell, 2017).
- Provides a vocabulary to assess concept-field development and acts as a ‘sensitising device’ (Manning et al., 2012) to understand concept-field development.

## Chapter 3 Methodology

*“Using a slogan from ANT, you have ‘to follow the actants themselves,’ that is try to catch up with their often wild innovations to learn from them what the collective existence has become in their hands, which methods they have elaborated to make it fit together, which accounts could best define the new associations that they have been forced to establish.” -*

*Bruno Latour in Reassembling the Social (Latour, 2005, p. 12)*

This chapter introduces the philosophy, research design, data, and methods for the thesis. First, the philosophical positioning, i.e., pragmatism, is presented. Second, the research design for the overall thesis and each of the questions are presented. Lastly, the methodological validity and limitations are discussed.

### 3.1. Introduction

This chapter focuses on the philosophy, research design, data, and methods to address the research questions. First, the philosophical approach of this thesis, i.e., pragmatism, is discussed in [Section 3.2](#). The pragmatic approach taken in the thesis does not restrict the use of a certain methodology; instead, it focuses on using a methodology appropriate for the research context (Onwuegbuzie & Leech, 2005). The comprehensive investigation in this thesis is approached like a single case study research (Yin, 2009) presented in [Section 3.3](#). Further, according to Eisenhardt, (1989), a common approach to assess complex cases is through different research questions wherein each research question is addressed separately with varying sets of data and methods. Following the advice of Yin, (2009) various forms of qualitative and quantitative data are collected and used to analyse the research questions. To this end, a unique research design for each research question is presented in [Section 3.3.1](#). In [Section 3.4](#) details about the semi-structured interviews are provided. In [Section 3.5](#) the analytical techniques are introduced and justified. Finally, a summary is provided in [Section 3.6](#).

### 3.2. Pragmatism as the philosophical orientation

The philosophical angle that a researcher undertakes determines the 'shared belief systems that influence the kinds of knowledge researchers seek and how they interpret the evidence they collect' (Morgan, 2007, p. 50). Social science research has been approached from many philosophical angles, including positivism, post-positivism, critical theory, constructivism (Guba & Lincoln, 1994), and pragmatism (Morgan, 2014). This thesis is grounded in pragmatism. The choice of the philosophical position determines the basic set of beliefs that guide the actions, define the researcher's worldview and methods. (Denzin & Lincoln, 2011). A pragmatist philosophy has been applied in broad areas of social science

research such as social work, healthcare, communication (Bishop, 2015; Kaushik & Walsh, 2019; Perry, 2001). There are two aspects of pragmatism that are important to consider. First, pragmatism, when regarded as an alternative philosophy to other competing philosophies, sidesteps issues of truth and reality and accepts philosophically that there exists singular and multiple facts that are open to empirical inquiry, thereby providing freedom to the researcher from the constraints imposed by the dichotomy of post-positivism and constructivism (Yvonne Feilzer, 2010). Second, pragmatist researchers are not bound by any particular method or techniques and choose the procedure that best meets their research objectives (Creswell & Creswell, 2007). Underpinned by these two aspects, pragmatism enables a researcher to be flexible in their investigative techniques to address various research questions that arise (Onwuegbuzie & Leech, 2005). Thus, Lincoln & Guba, (1985), p. 301, a pragmatic researcher is more likely to view research as a holistic endeavour that requires 'prolonged engagement, persistent observation and triangulation (Lincoln & Guba, 1985, p. 301).

### 3.3. Research design

According to Yin, (2009), a case study research is best suitable when the research addresses questions such as what happened, why it happened and how it happened? Thus, the overarching research problem of the thesis (*How and why did the concept of Circular Economy receive so much attention? Is it just a buzzword or an emerging field?*) is appropriate for case study research. A case study research design is suitable for this thesis because it allows for the use of multiple sources of evidence within the natural context to understand in depth a specified phenomenon (Creswell & Creswell, 2017), in this case, the prominence of the CE and concept-field evolution. Specifically, a single case study approach (Yin, 2009) focuses on CE as the central subject (or source actant in ANT terminologies). According to Eisenhardt, (1989) a complex case can be operationalised through different research questions entailing various sources of data and methods. To this end, the research problem posed in this thesis is operationalised through a unique research design for each research question. The overall case study draws from ANT's methodological starting point to 'follow the actor' (Murdoch, 1998, p. 369) and make a detailed description (Alhonnoro, 2014). According to Cowan et al., (2009), p. 282, research based on ANT benefits from two things- first, its reflexivity, and, second, 'the researcher's ability to "pick-and-mix" from different methodological jars'. Throughout the investigation, different actants are followed through different methodological techniques. First, the source actant that is being translated (CE concept) and then the target actants in the field who are translating the source actant. This allows constructing the actor-network around the CE concept. Since some of the methods have already been discussed in detail in the three research papers in Part B, I try to maintain minimum overlap with the papers and provide the reader with the page numbers where the relevant method has been

discussed in detail. In the following sections I will focus on a unique research design for each of the research questions.

### 3.3.1. Research Design for the research questions

*RQ 1: How has the CE concept changed over the years?*

The first research question is to assess the changes in the source actant, i.e., the CE concept itself. As discussed earlier in [Section 1.3.1](#), academic discourse represents a vast array of codified knowledge, the way of thinking and using language within researchers (and practitioners). Academic discourse is important because it enables complex social activities like educating students, demonstrating learning, disseminating ideas, and constructing knowledge (Hauser & Katz, 1998; Hyland, 2009). Thus, changes in the academic discourse are used as a proxy to understand changes in the concept. The assumption, which is a starting part of this analysis, is that researchers publish their most important findings in journals, conference papers, books, editorials which form the academic discourse (Fetscherin & Usunier, 2012; Geissdoerfer et al., 2017). These different forms of text are “vehicles” in the process of knowledge production through which scientists communicate their ideas to the world (Hull, 2010).

The data source used to collect the CE academic discourse is Scopus. The Scopus database was selected as the data source as it is considered one of the largest databases containing peer-reviewed literature, including scientific journals, books, and conference proceedings (Nobre & Tavares, 2017). To understand the changes in the CE academic discourse, the central subject of this analysis is the linguistic object 'circular economy.' Thus, literature that uses the central subject in its title, keywords, or abstracts is selected from Scopus. This includes peer-reviewed journal articles, books, conference proceedings, editorials published in English to ensure maximum coverage. Such a choice in documents allows capturing the broadest range of scientific activity relating to CE, with the advantage that it covers additional information about emerging CE related discussions that lesser-known journals and conference publications may contain (Geissdoerfer et al., 2017b; Türkeli et al., 2018). 3437 results were obtained from Scopus using the search criterion explained earlier. Given the enormous volume of academic discourse collected, a quantitative methodology, i.e., topic modelling, was used to analyse the discourse. Abstracts were considered the data source for topic modelling as they usually contain sufficient keywords about the research themes (Griffiths & Steyvers, 2004; Sun & Yin, 2017a). The rationale for selecting topic modelling and its execution has been discussed in detail in [research paper 1](#). The output of topic modelling enabled the detection of the underlying topics in the CE discourse and visually mapped the changes in the discourse.

Since topic modelling is an unsupervised method, there is no gold standard to validate the results. Therefore, a pilot workshop was conducted to validate the results discussed in research papers 1 and 3. After the pilot workshop, the topic modelling results were used as an input for an international Delphi study with 68 academic researchers. The rationale for choosing a Delphi study and details about its execution has been presented in research paper 3. A mixed-methods approach is illustrated by combining two distinct strands, one quantitative and qualitative, linked and each having its own rigorous data collection is conducted (Creswell & Tashakkori, 2007). Lastly, following the approach used by Navis & Glynn, (2010), the entire analysis is supplemented with a narrative to identify periods in the longitudinal development of the concept and contextualise emerging interpretations.

*RQ 2: What specific characteristics does the CE field exhibit as different actors assemble around the (evolving) CE concept?*

The aim of RQ 2 is to assess the field actants and how they assemble around the CE concept. To operationalise RQ2, the assemblage of the field actants can be understood from two aspects- the academic field and the non-academic field. Thus, this question is operationalised as two sub-parts.

For the academic field, researchers are chosen as the focal actant. They have a crucial role in knowledge generation since they are the ones who read the literature, perform experiments, publish the results, and pass on knowledge (Hull, 2010). They can provide further impetus to the process of conceptual changes (Edelenbos et al., 2008). According to Gustin, (1973) behind seemingly simple questions on ‘why scientists do science’ lies the diversity of individual human situations and motives and complex interaction between different actants. The key to an actor-network is the motivation of the actants to engage or remain in the network (McCarthy et al., 2021; Müller, 2015). To this end, researchers were asked what motivates them to use the CE concept during the first round of the Delphi study, which included 68 researchers. Further, during 16 semi-structured interviews, researchers were again posed with the same question, and their opinion was solicited. In various studies where researchers' motives are analysed, data is collected using surveys or other qualitative methods by engaging with the researchers directly. The narratives provided by the researcher provides an adequate representation of what motivates them to use the CE concept (Gagné & Deci, 2005; Gustin, 1973; Lam, 2011; Reiss, 2012; Ryan & Deci, 2000).

The sample size is an important aspect that must be considered when drawing generalisations about a population. In this case, generalisations are being drawn about the researchers' motives and their perspectives on the concept-field development. The sample size estimation for a population is based on a pre-determined confidence interval, and margin of error wherein the selection of the acceptable confidence interval and margin of error is arbitrary (Hazra, 2017). When setting confidence intervals



and margin of error, there is nothing sacrosanct rather they are entirely conventional choices (for example: confidence intervals of 95% or 90% and margin of error of 5% or 10%) such that the selection is acceptable personally to the researcher and the audience (Hardy, 2004). To this end, the confidence interval and margin of error that is used to determine the sample size of researchers in this study is 90% and 10%, respectively which have been acceptable and conventional standards in various research contexts (Adams & Winkelman, 2016; Bovea et al., 2018; Ghiasi & Grunwald, 2000; LeMoyne et al., 2008). In a search dated 1st October 2020 in the Scopus database, the number of researchers working on the CE concept was 7469 (i.e., population size) using the keyword “Circular Economy” in titles, abstracts, and keywords. All authors of any CE publication were counted based on the unique author ID assigned by Scopus irrespective of the authorship sequence to determine this population size. All duplicate author IDs were removed. For the population size of 7469, 90% confidence interval, and 10% margin of error, the adequate sample size is 68<sup>5</sup>. Given that this study considers opinion of 84 researchers (68 in the Delphi study and 16 in the interviews) it can be considered as adequate. However, there has been a consistent increase in the number of researchers since October 2020 when this data was collected hence both the population and sample size that has been used would have changed by the time the data is analysed and published.

Overall, 84 narratives explaining the motivation of the researchers was collected from the Delphi study and semi-structured interviews. The analysis of motives was done through an inductive data analysis procedure outlined by Williams & Moser, (2019) wherein the analysis was done using an open, axial, and selective coding strategy. This strategy enables a cyclical and evolving data loop in which the researcher interacts with the data, compares it, applies data reduction and consolidation techniques. The coding strategy allows converging from many pages of text in interviews and responses in the Delphi study to 5 specific research motivations (see Figure 3.1 below). Through this assessment, the motives of the researchers were outlined. Some of the researchers were approached again to clarify the motives and the conclusions being drawn. When researchers were approached the second time, it was also used as a triangulation exercise to validate the results that were being presented.

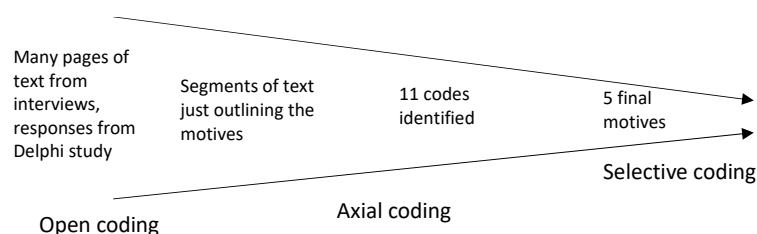


Figure 3-1: Open, axial, and selective coding strategy (Adapted from Williams & Moser, 2019)

<sup>5</sup> Calculating adequate sample size: <https://www.qualtrics.com/blog/calculating-sample-size/>

Additional data sources are collected to provide deeper context for each of the motives to reveal the field characteristics, including data on employment, journal space, funding, research centres, and conferences. Along with CE related articles data was collected on other ‘competing concepts’. These insights were specifically drawn from Research Paper 2 where one of the goals was to analyse the conceptual evolution of CE with respect to other competing concepts. A supplementary corpus of academic abstracts on 20 other concepts that have similar or overlapping conceptualisations with CE was collected from the period 2005–2019. The related concepts are based on literature (D’Amato et al. 2017, Geisendorf & Pietrulla 2018) and a Delphi study which has been presented in Research Paper 3. In the Delphi study the researchers were asked what other concepts they use in their research apart from CE and based on that the list was created. The 20 related concepts and their definitions are presented in Appendix A. A total of 61,444 abstracts was included in this supplementary corpus. The abstracts were collected from the Scopus database using the concept as the keyword (for example- “industrial ecology”). The search strategy for the abstracts was the same as that used for the CE-related articles that has been discussed earlier.

Collecting data on journal space was done from the Scopus database. Data on CE-related funding was collected from Scopus, and the Horizon 2020 project lists available on the European Commission (EC) website<sup>6</sup>. For research centres, desk-based research using the google search engine was conducted to prepare a list of CE research centres. For the conference-related information, experts were first asked which conferences they attend. Further, the themes of the conferences were sourced from the archived conference web pages. After collecting data on each of these aspects and recording them systematically in a document, a narrative was constructed to explain the motives of researchers and their impacts on the concept and the field based on progressive contextualisation (Vayda, 1983). By assessing the motivation of the researchers, the academic part of the actor-network is decoded.

The second part of the research question is operationalised by analysing the non-academic actants who engage with the CE concept. In the case of academic actants, it was a relatively more straightforward choice because of following the researchers as the only focal actant. However, amidst non-academic actants, it is a difficult task to determine which actants to follow. During the interviews and the Delphi study, when the researchers were asked who the most important actants in the CE discussion were, several actants were outlined. But to operationalise ANT, a decision is made to follow certain actants. According to Passoth & Rowland (2010), this is a pragmatic decision based on the researcher’s judgement. Thus, based on the information solicited during the interviews and Delphi study, a choice is made to focus on three focal actants. Explaining the development through multiple actants (Islam et

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<sup>6</sup> <https://ec.europa.eu/programmes/horizon2020/en/h2020-sections-projects>

al., 2019; Mayes et al., 2021; Shelley et al., 2020; Shim & Shin, 2016) is helpful to outline the dynamic nature of the actor-network over time. The focal actants are important in achieving narrative coherence (Czarniawska, 2009). The three focal actants are chosen based on different geographical settings and timelines in the CE discussion. By following these focal actants, a deep sense of the CE field is achieved.

- The first focal actant chosen is the New Economics Foundation (NEF)<sup>7</sup>, a British think tank that aimed to promote social, environmental, and economic justice established in 1986. The choice of NEF as the focal actant was made based on the opinion solicited from experts during the interviews. Also, NEF was the only organisation that used the CE concept in the early 1990s.
- The second focal actant that is chosen is SEPA, inspired by the expert opinion solicited during the interview and from the process analysis of policy translation in China by Jiao & Boons, (2017) where SEPA was outlined as the policy pioneer that brought CE into the Chinese national context. Further, several other studies have also presented SEPA along with NDRC as the main actants propelling the CE discussion in China (for instance: Yong, 2007; Yuan et al., 2006; Zhang et al., 2010; Zhou et al., 2014).
- Moving to the European context, an organisation mentioned in most articles on CE for its role in popularising the CE concept is the Ellen MacArthur Foundation (EMF). Literature on CE has outlined the role of the EMF in energising the CE concept (however not explored in detail in any study). For instance, van der Heijden et al., (2021) and Xu, (2012) highlight the emergence of EU regulations and recycling targets after the publication of the first report of the EMF. Geissdoerfer et al., (2017) also mention the work of the EMF in supporting the growth of the CE debate, acting as a collaborative hub for business, policymakers, and academics. Borrello et al., (2020) also highlight the role of the EMF as crucial in influencing the CE narrative and its entry into European policymaking. Choosing EMF over the EC as the focal actant was that EMF had been argued to be the ‘policy entrepreneur’ that brought the CE concept to the European policy context (Fitch-Roy et al., 2020).

The data on the developments of the CE field centred around these focal actants were collected from various sources such as the Delphi study, interviews, news archives, web pages, policy documents. All observations were recorded as a digital log and inductively assessed by reading and re-reading. A progressive contextualisation outlined by Vayda (1983) is used to build a narrative of how the field was developing. Further, to analyse and categorise the text, ANT theory and terminologies are used as a “sensitising device.” This means that the terminologies presented in Table 3.1 are used as themes to make sense of the data. Finally, following the strategies outlined by Langley, (1999) to analyse process-related data, a combination of narrative and temporal bracketing strategies is used to present the findings

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<sup>7</sup> <https://neweconomics.org/>

from the analysis. A narrative approach entails constructing a detailed story with contextual details from the inductive study of the raw data. A temporal bracketing strategy is used along with the narrative strategy to break down the data into specific periods.

*Table 3.1: ANT terminologies*

<b>Terminology</b>	<b>Definition</b>
Actor	Any actor, human or non-human, causes others to become dependent upon themselves (Callon, 1984; Latour, 1996; Sarker et al., 2006).
Actor-network	A heterogeneous network of aligned interests that includes different actants. It is often used interchangeably with actor-networks (Müller, 2015).
Focal actant	The actor with the capacity to establish and control an actor-network (Callon, 1984).
Source actant	The actor is being translated by other actants in the actor-network (Silvis & Alexander, 2014). The source actant is same as the central subject for process studies.
Translation	The process of creating a temporary social order, or the movement from one order to another, through changes in the alignment of interests in a network(Sarker et al., 2006).
Problematisation	The first moment of translation, during which the focal actant defines the identity and interests of the other actants as consistent with its own, thus renders itself indispensable (Callon, 1984).
Interessement	The second moment of translation involving negotiation with actants to accept the definition of the focal actant (Callon, 1984).
Enrolment	The third moment of translation, in which the other actants in the network accept (or become aligned with) the interests and roles defined for them by the focal actant (Callon, 1984).
Mobilisation	A set of methods used by the focal actant to ensure that all the actants' representatives or spokespersons act according to the agreement and do not betray the initiator's interest (Callon, 1984).
Trojan actant	A potentially fatal threat by an actor to its host actor-network can betray the initial problematisation (Mähring et al., 2004).
Swift translation	A process by which an embedded actor-network rapidly inherits actants, relationships, roles, and agreements from its host actor-network with little involvement of careful negotiation (Mähring et al., 2004).

*RQ 3: How does the CE concept interact with its related field? What mechanisms and processes underpin this interaction?*

In RQ 3, no additional data sources are used; instead, the insights presented in RQ 1 and RQ 2 are used to understand the interactions between the concept and its related field and outline a process typology. The idea here is to understand the change in the concept-field through the different theories of change outlined in [Chapter 2](#), i.e., evolutionary, teleological, dialectical, lifecycle. An inductive data analysis approach is taken here. First, the mechanisms of concept-field evolution are outlined in detail based on the empirical evidence that is gained through addressing RQ 1 and RQ 2. Further understanding of the

mechanisms inductively against the background of the different theories allows to outline which process typology underpins the evolution of the CE concept-field.

### 3.4. Semi-structured interviews

Semi-structured interviews are a standard method to generate data in social science (Kvale, 2008; Vogt et al., 2012). For this research, interviews were conducted with CE academic experts and policymakers. The interviews enabled us to understand how the CE field evolved, what motivated the researchers to use the concept, their opinion on the status of the concept and the field (whether it is coherent or dispersed, or if there is emerging conceptual contestation or critique), the key actants in the discussion in different stages and the context shaping events. The semi-structured interviews were conducted with experts who had a long-standing engagement with the CE concept and with sustainability issues in general. Of the 16 experts interviewed, 14 were academic researchers, 2 were policymakers. By the time the interviews were conducted, there was a fair bit of idea about the CE field. Thus, the experts were selected to provide novel insights into the field of evolution, given their experience. In Table 3.2 below, the profile of the interviewees is presented. Given that previously twelve interviews have been shown to result in data saturation (Guest et al., 2006) and that other data is included in the research project, the number of interviews conducted can be considered sufficient. The analysis was performed as an iterative and open inductive content analysis aimed at identifying and exploring the diversity represented by the participants regarding the different research questions.

*Table 3.2: Profile of the interviewees*

	Profile of the interviewee
Interviewee 1	Assistant Professor, United Kingdom Worked extensively in EPSRC funded projects on CE
Interviewee 2	Professor, United Kingdom Among the few researchers who published papers using the CE concept in the 1990s
Interviewee 3 (2 interviews)	Research Fellow, United States of America, A senior member of the industrial ecology community and editor of a leading journal
Interviewee 4 (2 interviews)	Senior Lecturer, United Kingdom Worked closely with the EMF before transitioning to academia
Interviewee 5 (2 interviews)	Professor, United Kingdom Senior academic who has also served as an advisor in the EU Resource Efficiency Panel
Interviewee 6	Assistant Professor, United States of America Worked closely with the UNEP, works as an academic institution partner with EMF
Interviewee 7	Professor, United Kingdom Advisor in the EU resource efficiency panel, Member of the Internal Resource Panel
Interviewee 8	Assistant Professor, China Senior academic in a Chinese University, also has a position in a Canadian University
Interviewee 9	Professor, Sweden Approaches CE from a critical perspective
Interviewee 10	Assistant Professor, United Kingdom Approaches CE from a critical perspective

Interviewee 11	Directorate-General for the Environment in the European Union, Circular Economy & Green Growth
Interviewee 12	Retired Dutch politician and academic who served in various positions in Europe
Interviewee 13	Senior Lecturer, United Kingdom Academic research on LCA and CE teaches a course on CE in a leading UK university
Interviewee 14	Assistant Professor, China Senior academic in a Chinese university published several research papers on CE
Interviewee 15	Research Fellow, Brazil Working with Latin American think tanks and NGOs to develop CE in Latin America
Interviewee 16	Assistant Professor, United Kingdom Approaches CE from a critical perspective

### 3.5. Analytical methods used in the thesis

Several analytical methods are used in the thesis, presented in detail in [Research papers 1](#) and [2](#). In this section, I briefly summarise some of the analytical techniques that have been used and the justifications for using the same. I intend to do this by maintaining minimum overlap with [Research papers 1](#) and [2](#) where these methods have been discussed in detail.

To address the research problems posed in the thesis, there is a requirement of assessing textual information, i.e., the CE literature. Given the volume of the textual information, automated analytical methods are imperative (Delen & Crossland, 2008). The process of extracting interesting information or knowledge, or patterns from the unstructured text is text-mining (Inzalkar & Sharma, 2015). Text mining entails different tasks such as clustering, classification, relationship mining, pattern matching, data exploration (Gaikwad et al., 2014). Drawing from Hashimi et al., (2015), the selection of the appropriate text mining techniques can be understood from different aspects such as usability, comprehensiveness and flexibility and inspired by these criteria and the state-of-the-art technique which allows drawing inferences from the textual information in the CE literature different analytical techniques have been used in this thesis.

#### *Latent Dirichlet Allocation*

To explore underlying topics in the CE literature and the changes in the topics over time, topic modelling is used. Topic modelling algorithms allow the analysis of words in texts to discover themes that run through them, how they are connected, and how they change over time. An important feature of topic modelling is that it organises and summarises documents at a scale that is not possible by manual inspection (Nikolenko et al., 2017). The topic modelling algorithm used in this thesis is based on Latent Dirichlet Allocation (LDA) (Blei et al., 2003), a generative probabilistic model of a corpus that represents documents as random mixtures over latent topics where each topic is a distribution of words. Since the intent is to generate topics and investigate their prevalence over time, one could argue that LDA is not meant to explicitly model temporal patterns in a text corpus. There are other models, which have been developed to consider the time dimension, such as Dynamic Topic Models (DTM)

(Blei & Lafferty, 2006) and Topics over Time (TOT) (Wang & McCallum, 2006). DTM represents time as a discrete Markov process, where topics evolve according to a Gaussian distribution. This model, however, penalizes abrupt changes between successive periods, discouraging fluctuation in topics over time (Chen et al., 2016). Given the nature of CE literature, which has abrupt fluctuations in terms of sudden rise in the production of articles, it is anticipated that there will be fluctuations in topic proportions in successive time periods. Hence, the preference is not to use the DTM algorithm. TOT represents time as a continuous beta distribution, solving the issue in DTMs. However, the beta distribution is still inflexible since it assumes that evolution of topics will have only a single point of the rise and a single point of fall in the entire corpus (Chen et al., 2016). This means that the model will not accommodate a situation where a topic has a period of rising followed by a fall and then a subsequent rise. Hence, a decision is made to choose LDA, a simpler and more intuitive model. The 'lda' (Chang, 2017) and 'topic models' (Grun & Hornik, 2011) package in R generates the topics. LDA is applied over the entire corpus together, and then the probability is calculated across topics for each document. The topic probabilities for each topic are then summed for each year based on the time stamp associated with each document and visualised graphically in a stacked plot to assess the trend in the topics over the years.

#### *Automated Coherence scoring*

The number of topics ( $k$ ) is a predetermined criterion for parameterised models such as LDA. This selection of  $k$  is essential as it impacts the interpretability of the topic model. While a lower value of  $k$  can divide the corpus into generic semantic contexts, a higher value can generate overlapping or uninterpretable topics (Zhao et al., 2015). The determination of  $k$  can be based on scientific evidence or human judgement (Shin et al., 2018). Automated coherence scoring provides scientific evidence to determine the optimal value of  $k$ . Topic coherence measures score a single topic by measuring the degree of semantic similarity between high scoring words in the topic, thereby distinguishing between semantically interpretable topics and topics that are only artefacts of statistical inference (Stevens et al., 2012). The two coherence measures, which are designed for LDA, matching well with human judgements of topic quality are:

- The UCI measures (Newman et al., 2010), which are calculated over an external corpus such as Wikipedia. This metric is an external comparison to known semantic valuations
- The UMass measures (Mimno et al., 2011), which is an intrinsic score that computes coherence scores over the original corpus that has been used to train the models.

In their study, Rosner et al. (2014) compare the correlation of various coherence measures with human judgment and the UCI metric is shown to be significantly outperforming the UMass metric. While the



any-any and one-any metrics slightly exceed the UCI metric, they pose challenges like exponential running time and difficulty in practical application. Hence, the UCI metric is used to calculate coherence scores and determine the quality of topics.

### *Training and visualising word embeddings*

Word embeddings are useful to encode both syntactic and semantic information of words into continuous vectors such that similar words are close in vector space (Hamilton et al., 2016). Word embeddings map high-dimension word vectors (usually produced using simple one-hot encoding representations) to low-dimension vectors to obtain global semantics (Tang 2018). Word embedding techniques that rely on the local context of the target words include Word2vec (Mikolov, Chen, et al. 2013) and Glove (Pennington et al. 2014). The aim of research paper 2 was to compute the semantic change in the CE concept, which enables understanding how the concept has changed diachronically in terms of the language used. Word embeddings enabled to fulfil this task and in this thesis the training of the word embedding model is done using Word2Vec. The word embedding vectors were trained on different time periods and then aligned using orthogonal Procrustes transformation (Schönemann 1966), which was applied to detect semantic change diachronically (Hamilton et al. 2016, Dubossarsky et al. 2017, Abercrombie & Batista-Navarro 2019).

Visualizing data is very important for exploratory data analysis. Many methods have been developed to visualize data which have only a few dimensions, but in current machine learning applications, the dimensionality of data is very high. A popular high dimensional data visualization algorithm is the t-distributed stochastic neighbour embedding (t-sne). This data visualisation algorithm visualises high-dimensional data by giving each datapoint a location in a two or three-dimensional map. The technique is a variation of Stochastic Neighbour Embedding (Hinton and Roweis, 2002) that is much easier to optimise and produces significantly better visualizations by reducing the tendency to crowd points together in the centre of the map. t-sne is better than existing techniques at creating a single map that reveals structure at many different scales. t-sne can capture much of the local structure of the high-dimensional data very well, while also revealing global structure such as the presence of clusters at several scales (Van der Maaten & Hinton, 2008). After training the word embeddings they were visualised using t-sne plots.

### *Word co-occurrence network*

Co-occurrence vectors are employed in various ways to detect word level changes such as in context vectors, pointwise mutual information, temporal random indexing, or entropy in word-level change detection (Tahmasebi et al. 2018). In Research Paper 2, co-occurrence networks are constructed based on the keywords associated with the documents. Visual keyword frequency data provides useful insights



by revealing predominant trends in the keyword network of the analysed literature, demonstrating a birds-eye view knowledge map (Li et al. 2019). The nodes of the network correspond to keywords (with a node for CE as the centroid), and edges indicated the co-occurrences; edge thickness represents the frequency of co-occurrence. The development of the co-occurrence network is the first step to detecting the nature of changes in the CE concept diachronically. While keyword cooccurrence networks provide high-level and straightforward information of a field, such networks are limited in their capacity because they only focus on high-frequency words. The inclusion of words with lower frequencies will limit the interpretability of the network structure.

### *Use of cosine similarity*

One of the most common methods of measuring the similarity between two words in the vector-space is to compute the cosine similarity between the corresponding word vectors (Faruqui et al., 2016). Cosine similarity implicitly measures the similarity between two unit length vectors. This prevents any biases in favour of frequent words which are longer as they are updated more often during training. In this study, cosine similarity is used to measure the similarity in the trained word embedding. Whilst Chiclana et al., (2013) argued that different similarity measures could produce different results, there has been an extensive amount of prior research that justifies the use of cosine similarity (Li et al., 2016; Moran et al., 2016). As argued by Mikolov et al., (2013), prior research shows that the cosine similarity between word embeddings is correlated with the semantic relatedness between corresponding words. Cosine similarity is often preferred over other similarity measures as it is independent of the vector magnitudes (Thakur et al., 2019). Thus, to assess the relatedness of the word embeddings cosine similarity measures are used in research paper 2.

### **3.6. Summary**

In the discussion so far, the philosophical positioning of this thesis, the overall research design of the thesis following a case study approach and a unique research design for each of the questions have also been outlined. Following this summarisation of the analytical methods have been provided. For specific details on each of the methods or data sources the reader has been referred to the papers in Part B of the thesis so that there is minimum overlap.

## Chapter 4 An overview of Circular Economy

*The circular economy can help save the planet – if we start innovating now- World Economic Forum, February 2021*

In this chapter, an initiation of the empirical context of CE is provided to the reader. To a novice reader this chapter provides a brief overview of CE bringing forward its prominence amidst various stakeholders and to a reader who knows the CE concept-field this is a reiteration of the prominence that is investigated in this thesis.

The concept of CE is not new, and its theoretical lineage lies in various predecessor concepts such as IE, IS, regenerative design, biomimicry, performance economy, cradle to cradle, cleaner production, closed-loop thinking, zero waste and eco-design (Corvellec & Hultman, 2012; Reike et al., 2018; Valenzuela & Böhm, 2017). The concept was first introduced by Pearce & Turner, (1990) in the context that traditional economies were developing without the tendency to recycle or circulate outputs, and the environment was being treated as a reservoir of residues. This was influenced by the initial work conducted by Boulding, (1966), which described the earth as a closed and circular system with limited assimilative capacity, concluding that the environment and economy needed to co-exist (George et al., 2015; Greyson, 2007; Korhonen et al., 2018; Murray et al., 2017). However, despite the early conceptualisations, the concept remained dormant throughout 1990s, barring a few independent mentions in the literature (see Cooper, 1994, 1999). It was not until the early 2000s when the Chinese interest in the CE concept started to grow. This was reflected in the emerging practical implementations, policies, and academic discourse. In China, CE was understood as the environmental dimension of the wider vision of China as a harmonious society, formulated by the 16th Party Congress in 2002 in response to the social and environmental problems following in the wake of the unfettered economic growth policy of China after Mao Zedong's death in 1976 (Naustdalslid, 2014). In China, there has been a continued commitment towards CE through early implementation of CE-related policies in China such as an entire chapter in the 11th five-year plan (2006-2010) devoted to the CE, the 2008 CE promotion law demanding consideration from local and provincial governments to consider the CE in their investment and development strategies. CE was also upgraded as the national development strategy in the 12th five-year plan (2011-2015) (Mathews & Tan, 2016). There have been various action plans, such as the State Council, 2013, which aims to provide further details for specific sectors and provide clarity on implementing the provisions of the CE promotion law (McDowall et al., 2017). A further reference to the CE is also present in the 43rd chapter of the 13th five-year plan (2016-2020) (Pesce et al., 2020).

Starting from 2010-2011, the Chinese interest in CE was matched with an interest from the EU with EMF entering the scene. EMF framed CE as a solution for businesses and policymakers in Europe

(Fitch-Roy et al., 2020). Soon, CE found a place in the policies of the Barroso Commission in 2014. Following this, the EU interest in CE has been growing with various reports and policy proposals such as the CE package (European Commission, 2016), a monitoring framework for the CE (European Commission, 2018), the implementation of the CE action plan (European Commission, 2019). Most recently, the EU Green Deal, launched in 2020, places the CE concept at the centre in the transformation of the EU into a fair and prosperous society by way of decoupling economic growth and resource use (European Commission 2020).

Whilst China and Europe have predominated the policy space on CE; other countries are soon catching up. Recently CE has gained prominence in Latin America and the Caribbean to achieve sustainable development. Countries in these regions have either implemented or are planning new circular economy policies, public initiatives and roadmaps (Schröder, Albaladejo, et al., 2020). From 2019 onwards, CE has started to gain significant traction at the regional level in Latin American countries. In November 2019, the Intersessional Meeting of the Forum of Ministers of Environment of Latin America and the Caribbean announced proposals for a Regional Coalition on Circular Economy (Coalición Regional de Economía Circular), ‘with the main objectives of developing a common regional vision and strategy on circular economy to have a bigger impact, to build cooperation and exchange best practices’, tasking the UN Environment Programme (UNEP) with building the coalition in close cooperation with the United Nations Industrial Development Organization (UNIDO)(ibid).

The initiatives from environmental organisations, civil societies, think tanks, and NGOs are also significantly promoting the CE transition (Ghisellini et al., 2016). Several supra and transnational organisations and policy institutes publish CE-related research to help governments and societies transition towards a CE. For instance, OECD has published some recent articles on policy scenarios for a transition to a more resource-efficient and circular economy (OECD, 2020), policy alignment for international trade and CE (Shunta, 2021), the jobs potential of a transition towards a resource-efficient and CE (Chateau & Mavroeidi, 2020). World Economic Forum (WEF) has also published several policy documents to aid the transition to a CE, for instance, one in collaboration with EMF to accelerate the scale-up of CE across global supply chains (World Economic Forum, 2014), a more recent one on a policy research agenda for automotive circularity (World Economic Forum, 2020). Several other organisations such as UKRI, Amsterdam City council, US Chamber of Commerce Foundation, World business council for sustainable development work extensively on the CE and have all published policy reports on the CE.

Lastly, the academic traction received by CE is remarkable. One could argue that there has been a proliferation in the world scientific output since the 1990s (Horta & Veloso, 2007), and the case of CE

is no outlier amidst this proliferation. While to some extent this is true, however, to further put into perspective the remarkable increase of the CE academic discourse in recent years, the compounded annual growth rate of the academic discourse on sustainable development is 24% and 12% from 1987 to 2019 and 2004-2019 respectively, whereas, for CE, it is 51% from 2004 to 2019 (see Figure 4.1). No doubt, the absolute number of articles produced on sustainable development is much higher than CE. Still, CE is comparatively a newer concept, and the growth rate of the CE academic discourse is remarkable.

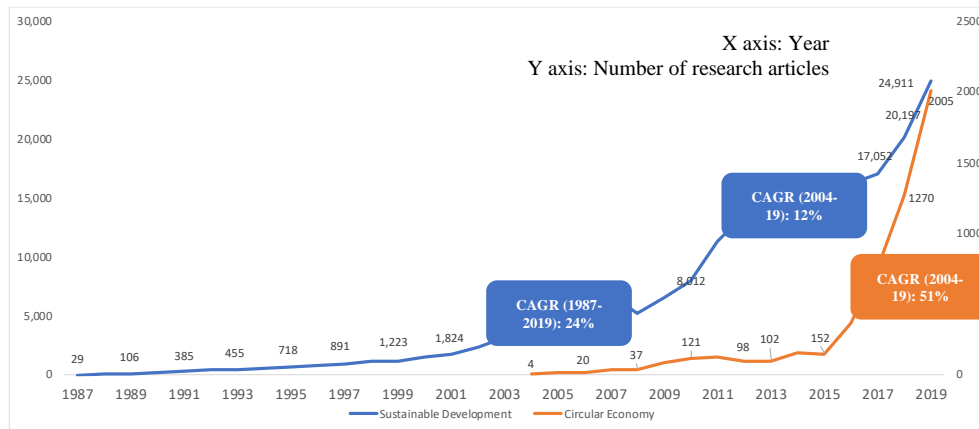


Figure 4-1: Compounded annual growth rate (CAGR) of academic discourse on Sustainable Development & CE (Source: author)

*\*Articles were sourced from Scopus using the search criterion “circular economy” and “sustainable development” in the keywords, titles, and abstracts (Source: author)*

The short discussion provided in this chapter directs attention towards the speed at which the prominence of CE has been spreading across different stakeholders in different geographical settings. This prominence motivated the investigation of the CE concept-field in this thesis.

## Chapter 5 Results and Discussion

In this chapter, an integrated results and discussion is presented to address the thesis questions. Some of the insights presented in this chapter are drawn from the three research papers presented in Part B. But it is important to note that the research papers in Part B were written as individual papers submitted and accepted in a journal and two book chapters during the PhD journey. As the research continued, additional insights were gained. Thus, there could be a break in continuity between the chapters. This chapter brings together the results from these papers and additional insights to present an integrated and coherent discussion for the thesis.

### 5.1. Introduction

The introductory chapter presented the research problem: How and why did the concept of Circular Economy come to receive so much attention? Is it just a buzzword or an emerging field?

This research problem was further operationalised through three research questions:

RQ1: How has the CE concept changed over the years?

RQ2: What specific characteristics does the CE field exhibit as different actors assemble around the CE concept?

RQ3: How does the CE concept interact with its related field? What mechanisms and processes underpin this interaction?

This chapter provides insights to address these research questions and the overarching research problem. This chapter builds on empirical evidence from the three papers in Part B. In the discussion presented below, the reader is referred to the page numbers from the research papers in Part B wherever applicable. The discussion first starts with mapping the changes in the CE concept in [Section 5.2](#). Then it moves towards investigating the field by following the academic actants in [Section 5.3.1](#) and non-academic actants in [Section 5.3.2](#). Based on the investigation of the academic and non-academic actants, a summary and reflection foregrounding the field characteristics are presented in [Section 5.4](#). Lastly, by amalgamating the insights from the previous sections, the interaction between the CE concept-field is discussed in [Section 5.5](#).

### 5.2. Mapping the changes in the CE concept

The discussion presented in this section deepens the insights gained in [research papers 1](#) and [3](#). The following section outlines the changes in the central subject or source actant as evidenced in the academic discourse. Topic modelling was used to visualise the changes in the discourse comprising 3300 articles starting from January 2005 to May 2019. Figure 5.1 is a representation of the changes in

the topic proportions over time. Each stacked bar is representative of the relative topic proportion in each year. Apart from the relative proportion of each topic, it is also essential to appreciate the evident increase in the absolute number of articles published each year as indicated by the counts on top of each stack. Figure 5.1 maps both the volume and content of the discourse. An evident structural change in terms of the content and volume of the discourse is observed in the topic modelling results, which breaks the discourse into two parts: 2005-2014 and then 2015 onwards, as indicated in the figure below.

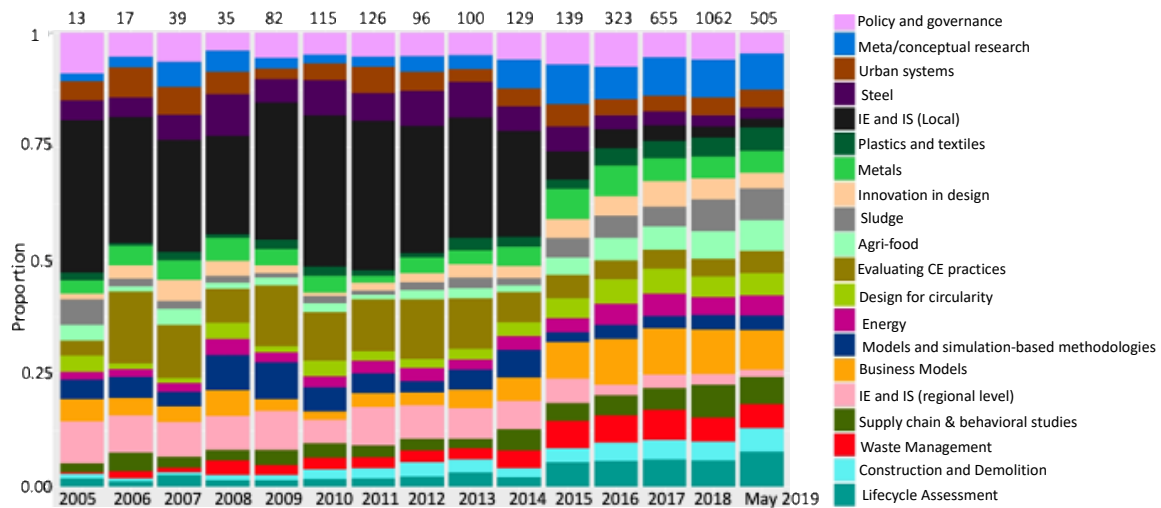


Figure 5-1: Changes in the CE concept from 2005 to 2019 (Source: author)

In analysing the changes in the discourse over time, firstly, an immense proliferation in the number of academic articles using the CE concept from 2015 onwards is revealed. The discourse in the earlier stages showed strong conceptual affinity between the concepts of IE and CE due to CE's theoretical origins embedded in IE. (Bruel et al., 2019; Saavedra et al., 2018; Saidani et al., 2019). Previous studies have put forth a direction of research where IE could contribute to CE's theoretical development and implementation (Blomsma & Brennan, 2017). However, the recent trend has been a “mission drift” (Henry et al., 2021) wherein the CE concept no longer conforms to its theoretical origins, at the least in the language that CE discourse has adopted. Key to the changes in the discourse is the CE concept developing as an increasingly distinct line of inquiry from IE. Thus, rather than drawing from IE, CE research is developing independently from it. Interestingly, the number of research articles using the concept of IE did not diminish. So, both the IE and the CE concepts show a growth in the period after the structural change.

There have been previous assessments of the literature that have aimed to organise and cluster CE research. For instance, Homrich, Galvao, et al., (2018) organise CE literature into (1) IE and IS in a Chinese context and (2) supply chains, material closed loops and business models. Winans, Kendall and Deng, (2017) cluster CE research into (1) policy instruments and approaches; (2) value chains,

material flows, and product-specific applications; and (3) technological, organisational, and social innovation. Merli, Preziosi and Acampora, (2018) use a range of dimensions to organise CE research. Whilst such organisations form a broad organisation of the literature on CE; the topic modelling detects 20 topics in CE scientific discourse based on 3300 abstracts so is much detailed by nature due to coverage of the discourse. Before the structural change, one of the key topics was IE and IS in a Chinese context, as identified by Homrich, Galvao, *et al.*, (2018). Following the previous point, as CE research is developing a distinct line of inquiry from IE, the diversity of the topics in CE research is developing further. For instance, in Figure 5.1 IE and IS hold the highest proportion before the change between 2014-2015. However, in recent years the literature on CE has developed so that the attention is almost equally divided across different topics ranging from plastics to textiles. In the period after the structural change, the proportion of topics has been stable. In recent years, another shift of focus in CE discourse has been from macro to micro-level interventions for sustainable development, such as business models and product design studies. In a previous study by Merli, Preziosi and Acampora, (2018) a higher proportion of the CE research was geared towards macro-level interventions; however, the analysis was based on only 565 CE-related articles. This was before the latest developments in the CE discourse. The shift also entails CE research adopting a language that is much easier to link to business strategy and communications. Lastly, there has been a geographical shift in research production. Between 2005-2014 most of the discourse was produced in China; however, starting from 2015 onwards, Europe has been leading the production of the discourse.

To further assess the degree of shift in the language of the discourse between the two stages, i.e., 2005-2014 and 2015-2019, the closest neighbouring words have been mapped on a t-sne plot in Figure 5.4 below. The methodological details for how the plot presented in Figure 5.2 has been made is shown in [research paper 2](#). Between 2005-2014 the discourse was more closely linked to IE, IS, Eco-industrial parks (EIPs). However, it moved towards more business-oriented terminologies such as companies, business models, innovation, strategies from 2015 onwards. The cosine similarity in the discourse in the two stages is 0.195, which is quite low, indicating a shift in the language of the discourse. Lower cosine similarity is indicative of a higher difference in the meaning, usage, and context of the term ([research paper 2](#)).



Figure 5-2: Mapping of keywords related to CE in Stage 2 and Stage 3 on a 2D plane (Source: author)



In the above analyses, two stages in the discourse development can be outlined- 2005-2014 and 2015 onwards. It is a common approach to map CE-related discourse from 2005 onwards because this was when the first article on CE was mapped on both Scopus and Web of Science (Schöggel et al., 2020). However, several articles have agreed that the introduction of the CE concept was made by Pearce & Turner, (1990) (Geissdoerfer et al., 2017; Ghisellini et al., 2016b; Su et al., 2013). Throughout the 1990s until the early 2000s, the concept underwent a dormant phase barring a few mentions. In terms of the conceptual understanding, Pearce & Turner, 1990 use the CE concept only to refer to the feedback loops between natural stocks and the use of nature as a sink for wastes. Following this, there were a handful of articles where the CE concept was used (Cooper, 1994, 1999; Jackson, 1993; Jacobs, 1993). In an article by Cooper, 1994 entitled *Beyond recycling: A longer life option*, the CE concept is recognised as the path through which sustainable development can be reached wherein the aim of a CE being minimisation of the throughput of energy and raw materials in the economy without sacrificing future wellbeing. Further in Cooper, (1999) it was pointed out that the CE would mean a shift from the manufacturing to the services sector where the focus would be on reuse, repair, upgrading and recycling. Jackson, (1993) also mention the importance of CE in the future to achieve sustainable development. This article discusses CE mainly from the perspective of recycling goods. The conceptualisations of CE in these articles did not link to the IE concept, whereas later in the stage starting from 2005-2014, the academic discourse shows closeness to the IE and IS concepts. In short, the usage of the concept by Pearce & Turner, (1990) was merely used to refer to feedback loops between natural stocks and the use of nature as a sink for wastes. It did not invoke the CE concept in its contemporary sense, i.e., to extend the productive life of resources. Later publications brought to the forefront the idea of extending the productive life of resources and the ability of CE as a concept to operationalise sustainable development.

While the mapping of the changes in the academic discourse is focussed on the developments of the concept up to 2020 when research paper 3 was written and submitted to the *Journal of Cleaner Production*, as the PhD project progressed, through semi-structured interviews, an assessment of the following stages of the academic discourse was made. While the academic discourse continues to be produced in China and Europe, a fresh discourse that discusses CE from a Latin American perspective is emerging. Brazil is increasingly producing substantial CE-related research. Although CE initiatives in Latin America started much later compared to Europe or China, there is significant work underway to identify barriers and implement CE initiatives along with a call for better conceptualisation suiting a Latin American perspective (Morales & Sossa, 2020; Schröder, Albaladejo, et al., 2020; van Hoof & Duque-Hernández, 2020). As quoted by Researcher 72, a researcher in Brazil, *“...Management of municipal organic waste in Brazil is a big issue, and that’s where my research area was positioned long before using CE. CE is being presented as an economic model that highlights business opportunities that could capture and deliver value to the whole supply chain, create new jobs, new technologies and enable operationalising sustainable development in general .... While we are taking a lot of cues from Europe, where*



*CE is big, we need to do a lot more work to bring CE to a Latin American context. Because we are bringing an idea from the Global North to the Global South....”*

### 5.3. Mapping the CE field

In the previous section the analysis focussed on understanding the changes in the source actant i.e., the CE concept. In the following sections the focus will be towards analysing the target actants that translates the source actant. That discussion will be focussed on understanding how different actants are coalescing around the CE concept creating specific circumstances in which the CE concept is changing and developing. The vocabulary of ANT is used to describe how a network of social actants emerged around the CE concept and the roles they played thereby leading to the emergence and development of CE.

#### 5.3.1. Following the academic actants

In the following section, the academic actants are followed. Precisely, researchers are followed as focal actants since they are the ones who read the literature, perform experiments, publish results and pass on knowledge through the academic discourse using textbooks and journal articles in this process of knowledge production (Hull, 2010). The discussion is focused on why they engage with the CE concept and its impact on the concept-field. By following the focal actant i.e., researchers and investigating their motives other actants in the actor-network are revealed which includes funding, funding agencies, employment, journals, research fit, universities, courses which will be discussed in the following sections. Each of these are actants as they have the agency to enrol more actors into the network.

According to Foster et al., 2015 choosing a particular research direction is consequential for the scientists and science itself. Further, after analysing researchers' motives in pursuing a specific research direction in the context of agricultural research, Busch et al., (1983) note that despite the seemingly straightforward character of decisions about the choice of research direction reveals an extraordinarily complex process. As the scale of knowledge production is increasing, the options of research directions are also growing. In the case of addressing sustainability-related issues, the question is that given there are several concepts that have overlapping (Geisendorf & Pietrulla, 2018), synergetic (Blomsma & Brennan, 2017; D'Amato et al., 2017; Henry et al., 2021; Reike et al., 2018b; Tóth, 2019), embedded (Sauvé et al., 2016) conceptualisations with CE then what motivates a researcher to engage with the CE concept and use it in their research. To this end, opinion was solicited from 84 scholars (68 scholars during the first survey round of the Delphi study and 16 scholars during the interview) using the CE concept as to what motivates them to use the CE concept. Often in the opinions, most researchers provided multiple motives to use the CE concept. Based on the assessment, five key motives can be outlined (1) availability of funding, (2) employment opportunities, (3) availability of audience for a

trending topic, (4) CE in higher education (5) research fit. Only one expert indicated that they use the CE concept in their research because of its perceived usefulness in addressing sustainability transitions (problem-solving motive). Most of the other motives are extrinsically driven, which scholars are internalising for their career advancement (Ryan & Deci, 2000). The motives, to some extent, reflect the researchers' opinion on the dominance of CE in sustainability-related discussions, which has been presented in research paper 3. Despite the efforts to make CE an inclusive concept in addressing sustainability-related questions, researchers believed that CE does not adequately address long-term environmental concerns and social dimensions of sustainability, hence, they do not consider it dominant. This indicates that researchers choose to engage with CE not due to the logical superiority of the concept over its predecessor or competing concepts but extrinsically driven motives.

Some motives foreground familiar academic aphorisms such as “publish or perish” or academic researchers seeking recognition from their peers (Foster et al., 2015; Gustin, 1973; Knorr-Cetina, 1981; Lam, 2011; Wagner, 2009, p. 8). However, two main aspects come into light as the discussion progresses in the following sections. The first is that the motives neatly fits what Nowotny et al., (2003) calls ‘steering of research priorities’ to produce application oriented knowledge in Mode 2 knowledge production. Secondly, the institutionalisation tendencies within the academic field. The steering of research priorities and institutionalisation of the field will be revisited in detail in Section 5.4. In the discussion going forward, the motives of researchers and their influence on the concept-field are outlined.

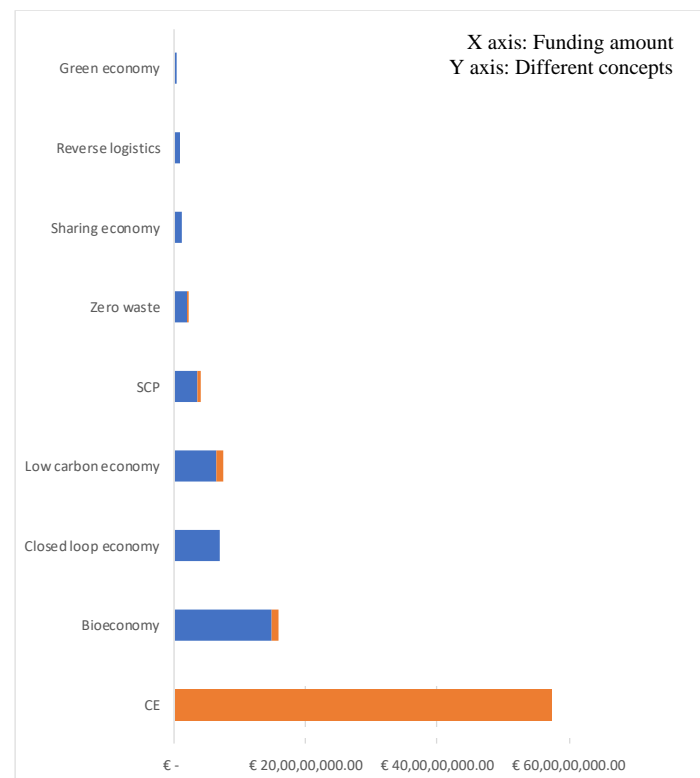
### *Availability of funding*

Out of the 84 scholars, 53 researchers cited funding as a motive in engaging with CE research. Funding, an actant in the actor-network is said to have a palpable influence on research (Etzkowitz & Kemelgor, 1998). At an individual level, securing funding is one of the most critical factors for researchers, enabling them to carry out their research projects (Ebadi & Schiffauerova, 2015). As the public funding dedicated for research is becoming less pronounced, researchers are turning to alternative ways of attaining funding (Nowotny et al., 2006). Research funding for CE can be outlined as coming from three levels mainly (1) supranational level (for example, the European Union Framework Programmes) (2) national level (including various national-level governments and ministries, for example, Chinese Academy of Sciences and other ministries under the Chinese government) (3) at the level of research councils and businesses (for example UKRI). Empirical evidence is drawn from the successive European community framework programmes<sup>8</sup> to explore the availability of funding comparatively for CE and other competing concepts. These framework programs have been one of the main financial tools

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<sup>8</sup> <https://ec.europa.eu/programmes/horizon2020/en/home>

through which the EU supports research and development activities. To this end, the projects funded by the Horizon 2020 framework programme (2014-2020) are investigated. The title and the project's objective were analysed to understand which concept the project was engaging with. In Figure 5.3 below, a comparative graph showing the funding for different concepts from the Horizon 2020 framework programme has been mapped. The funding received by CE is significantly more than any of the competing concepts. Also, some of the projects used the CE concept simultaneously along with a different concept (depicted by the orange bars). The Horizon 2020 framework programme has provided CE related funding amounting to ~573 million euros (search dated November 2020).



*Figure 5-3: Comparison of funding amounts in the Horizon 2020 framework programme for CE and other concepts (Source: author)*

Regarding funding availability in China, it was not possible to secure the exact funding amount dedicated to CE-related research because documents are in Chinese language. However, based on the interviews, a background of research funding availability in China was gathered; this information was corroborated with the available literature. Following the cultural revolution in China from 1966 to 1976, a paradigm shift that occurred was the consideration towards science, technology, and scientific advice. The new bureaucracy that developed in China was in support of pragmatic policies with social and economic benefits. The new group of bureaucrats was receptive to the engagement with scientists. From the year 1977, engagement with scientists was restored after the cultural revolution. According to Du et al., (2018) the total amount of funding provided to the National Natural Science Foundation of China

(NNSFC) increased from 80 million yuan to about 26.8 billion yuan in 2015, increasing more than 300 times. In CE-related research, over 300 research articles attribute the funding sponsor as NNSFC (as indicated in Figure 5.4 below). CE implementation in China has been articulated as a top-down approach (Merli et al., 2018; Ogunmakinde, 2019), where funding was explicitly provided for CE-related research starting from the early 2000s.

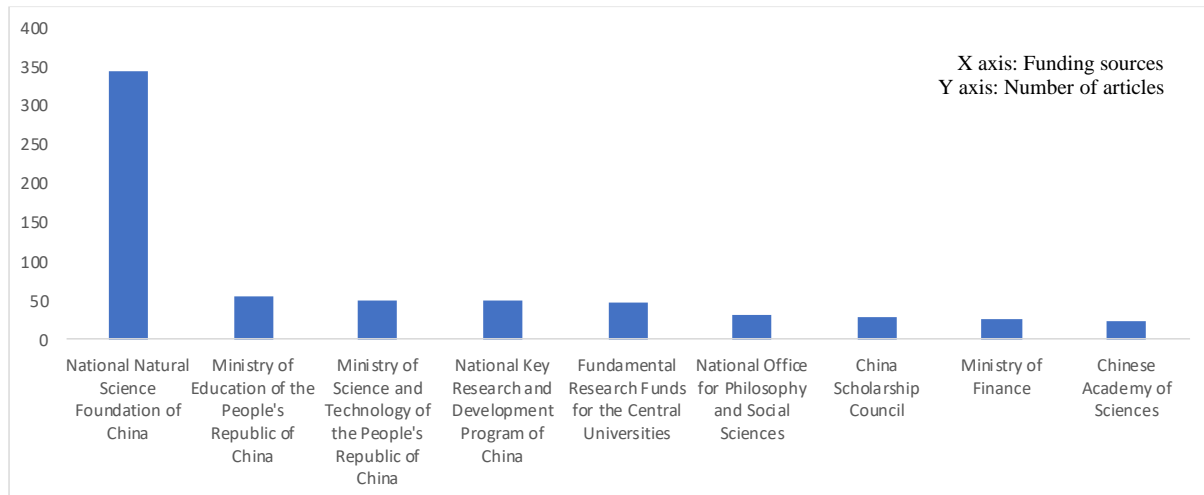


Figure 5-4: Number of research papers funded by Chinese governmental agencies and research councils (Source: author)

Further, funding can be of two kinds - 'hard funding' and 'soft funding' (Boehm, 2001). Hard funding is bound to tasks, specific resources, and deliverables. Most of the funding arrangements fall under this category, where there are deliverables that must be met. Soft funding is more challenging to acquire as it often needs long term collaborations of industry and research organisations. Such sponsorships may not be bound to specific outcomes or deliverables. To acquire such funding, there is often a non-explicit understanding between sponsors and beneficiaries of the overall positive influence that a specific area of research can provide. In the case of CE, researchers have indicated that most of the funding for research is 'hard funding;' thus, there are deliverables that must be met. For instance, researcher 9 from Germany mentioned – *"I joined a 12-month project in the bio-based sector, and the use of the CE concept in the project was decided before I came in"*. Further, Researcher 41 from the Netherlands mentioned that- *"I started using CE in my research as a result of a collaborative European research project where successful business model practices pertaining to CE were being investigated"*.

Two schools of thought have emerged in the context of steering research priorities (Nowotny et al., 2006; P. Scott, 2003) through funding. One school of thought critiques this steering because it does not allow 'blue sky' and disinterested research. The other argues that such steering can promote a more active role of research in society because research fulfils the pragmatic requirements of policymakers and practitioners. Scholars who are critical of the steering of research priorities due to funding argue that the growing pressure to produce 'policy-relevant research' diminishes the capacity of academia to

provide a space in which innovative and transformative ideas can be developed; instead, it promotes institutionalised and vehicular ideas (Scott, 2003; Smith, 2010). Scholars who are not overly critical about this aspect argue that it provides researchers with a more active role in producing relevant knowledge liaising with policy and industry (Etzkowitz & Leydesdorff, 2000). From the interviews with scholars regarding how funding impacts CE related research. One point of view was that the steering of research priorities has an underlying objective to promote a biased positive perspective of CE. For instance, as quoted by one of the interviewees, a Professor in Sweden- *“Some research funders are inclined towards a positive view of the CE. They may even make a living on selling the “CE is good for you” narrative. For example, can you imagine the EMF financing or collaborating in a study on the theoretical hinders to CE? Or it may be because the industry has made sure that a collaboration with the industry is a condition to funding research, for example, the Swedish Innovation Agency. As I do not think any company would like to have an anti-CE image, where will you find companies ready to collaborate on a CE-critical project?”*

However, there was another view that was solicited was that there are some funding agencies that do not propagate a particular version of CE; however, there is a political dimension to CE related funding that does promote a biased positive perspective and cannot be ignored. As quoted by one of the interviewees, a Professor in United Kingdom- *My critical analysis of the CE emerged from doing research on the petrochemical industry, which was funded by the European Research Council, but my original focus was not on the CE as such. So, we didn't really apply for CE related funding directly. So that way, I think some funding agencies may be open to “critical” perspectives or “high risk” research, but again government funding agencies have priority areas, so there are so many political dimensions to funding a positive view of CE.”*

Notwithstanding that some funding agencies are open to critically addressing CE, the researcher's direct attention towards steering of research priorities in ways where there is a biased positive view of CE being created. This biased optimistic narrative seeks CE to reconcile economy and environment without transforming the ongoing capitalist order. It views CE as a fundamental part of sustainability transitions, and there is an effort to find specific actions that make it possible. As indicated during the interviews, the steering of research priorities tends to consider CE as the only means to achieve a sustainable society; consequently, the aim is to find means to achieve it. Still, it does not question the fundamental objectives that are underlying the CE framing. Therefore, this promotes research that is more of ‘how’ kind within a backdrop that CE is the only way forward.

### *Employment opportunities*

Out of the 84 researchers, 18 researchers cited employment as a reason for engaging with the CE concept. Thus, employment as an actant came across as being an important factor that drives research

motivation and is a part of the CE actor-network. With the institutionalisation of universities, other means of earning for scholars such as patronage arrangements and charities dried up (Frickel & Gross, 2005). While several researchers continue to be employed in the industry, some continue doing independent work; many researchers turn to academia for jobs. Thus, the academic labour market also determines the choice of research priorities to some extent. As quoted by Researcher 12, from the United Kingdom, *“a lot of jobs in academia are now related to CE. For me personally, my area of work started in product-service systems. Then while applying to jobs related to PSS a number of them were CE focussed. So, I had to position my research accordingly”*. To this end, on further exploration, it is found that several full professorships, chairs, and other academic positions are being dedicated to CE with titles such as “Professor of CE” or “Lecturer of CE” which signify long-term commitment of universities towards CE related positions. Such positions can be found in various universities across Europe and China.

Further, it is also helpful to look at the emerging CE centres in various universities, which are sources of employment for researchers and reveal the long-term commitment related to CE from universities. Boardman & Gray, (2010), p. 450 define a research centre as “an organisation or unit within a larger organisation that performs research and also has an explicit mission (and related activities) to promote, directly or indirectly, cross-sector collaboration, knowledge and technology transfer, and ultimately innovation”. A centre can be understood as a more formal scientific organisation than a research group, providing an organisational framework for coordination and expansion of research, a means of gathering internal resources and attracting external attention and support for research (Etzkowitz & Kemelgor, 1998). Over the years, centres have become a part of the academic scene, shifting the balance of activity from teaching to research. Scholars have attributed various reasons that drive the formation of research centres- the first being intense competition in fast-growing disciplinary fields, the second being that a theoretical or practical problem can be attacked from different investigators drawn from various disciplines, and lastly it also allows the management of resources such as equipment or funds (ibid). Researchers are drawn to such centres for the employment and collaboration opportunities. In the case of CE, there are several dedicated research centres in universities focussing on the CE. In the investigation of motives, researchers specifically outlined the importance of employment in these research centres and career advancement opportunities. The first CE centre, Yangtze River Delta Research Academy of Circular Economy, was founded by Professor Du Huanzheng in China in the year 2005 (Circular Vision in the East). In the recent years dedicated CE research centres have emerged in various universities such as University College London, University of Cambridge Judge Business School, University of Exeter, University of Strathclyde, Leiden University, the Technical University of Delft and Erasmus University. These centres signify the employment opportunities it provides to CE

researchers and showcase the long-term commitment of universities towards CE, thus showing signs of institutionalisation.

Another specific type of research centre that is recently emerging in the CE context is one wherein both academic and industry partners are members and is funded by an external funding agency. For example- the United Kingdom Research Council (UKRI)-funded CE hub<sup>9</sup>. The anticipated outcome of such centres is joint, extensive, and long-term research programmes bringing together policymakers, academic researchers, industries, and civil society. The funding agencies view the research centres as a tool for developing the society in the direction decided by the government. Consequently, the funding agencies evaluate the research centres based on how well the centres comply with the directions and goals given (Lind et al., 2013). Such centres have only recently emerged; hence a detailed investigation of the research programmes that develop from these centres will have to be investigated at a later point. However, these centres direct attention towards the institutionalisation of CE exhibiting a long-term commitment.

#### *Availability of audience*

Out of the 84 researchers, 32 researchers cited that CE is a trending topic; hence there is the availability of audience for the research, which motivates them to use the concept. According to Knorr-Cetina, (1981), p. 7 scientists constantly relate their decisions to the expected response of specific members of this community of 'validators' or the dictates of the journal they wish to publish. Decisions are based on what is 'hot' and what is 'out', on what one 'can' or 'cannot' do, on whom they will come up against and with whom they will have to associate by making a specific point. The essence of science being the publication of new knowledge, journals serve two roles in creating and transmitting new knowledge (Hull, 2010). Academics compete over journal space because a published journal article increases the prestige and reputation of the researcher (Campanario, 1996; Lam, 2011). With limited journal space, there is a competition as to what topics of inquiry have more journal space devoted to them versus others (Neale et al., 2005; Thorngate & Chowdhury, 2014). Several scholars cited the opportunities to publish and present their work encourages them to use the CE concept. In terms of publication opportunities, scholars posited that several leading journals accept CE-related papers. Specifically, in one of the interviews, the topic of CE special issues was brought up. As quoted by Researcher 26, an early career researcher in Belgium - *'We were targeting a specific journal for our sustainable agriculture paper, and then the special issue was announced on CE where we submitted because I was working on sustainable agriculture and circularity was sort of part of the discussion.'*

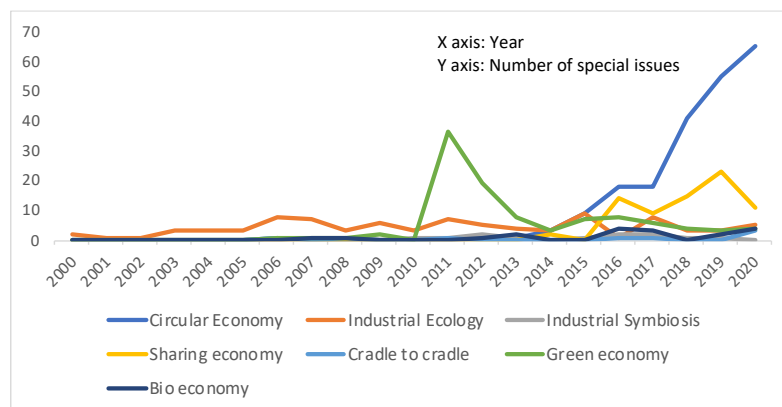
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<sup>9</sup>Website of the UKRI funded CE hub- <https://ce-hub.org/>



Taking the cue of ‘special issues’ forward, the number of special issues published on CE and some competing concepts are analysed. CE has a much higher number of special issues commissioned over the years, as indicated in Figure 5.5 below. According to Priem, (2007) special issues have a role in accelerating knowledge development as they shorten the time to publication whilst also maintaining journal standards. Special issues consolidate research on an emerging topic or focus on specific developments in a particular field of interest. It encourage researchers to submit papers on topics they would have otherwise not due to the enforced deadline (Priem, 2006). They also attract some scholars whose in-progress research already fits the topic (as indicated in the interview with Researcher 26). In some cases, scholars would make minor adjustments or steer their research to fit into the special issue, as indicated by one of the scholars during the interview. Further, special issues may have a domino effect whereby researchers focus on extending work that they previously submitted in a special issue (Priem, 2006). One of the critiques of special issues is that it ends up taking more journal space at the expense of other topics that also are worthwhile (ibid). Moreover, special issues foster mass production of articles that can fill journals with not so useful cloud of information (Starbuck, 2009). Thus, special issues are actants in the actor-network which enable the enrolment of more actants in the actor-network.

In the case of CE, in the special issues analysed, only one special issue published by the Journal Culture and Organisation (Corvellec et al., 2020) critically engages with the CE concept. As indicated by one of the researchers who is an editor in a leading journal, such special issues could lead to relabelling existing research into CE to find space in a special issue. This means further proliferation in the volume of research articles. This proliferation of research articles could become a cloud obscuring more meaningful studies. Moreover, the burgeoning discourse provides exemplars that new researchers take guidance from. Therefore, there is a chance that the academic discourse on CE is filled with repetitive studies on unimportant phenomena or overlooking some phenomena (Starbuck, 2009).



*Figure 5-5: Comparison of the volume of special issues on CE and other adjacent concepts (Source: author)*

Further, investigating this aspect about audience availability for research, the conferences related to CE are analysed and how they developed over the years. The high-level interest in CE has led to many



conferences offering special tracks and sessions dedicated to the discussions on the CE. There are also several dedicated CE conferences being organised. In table 5.1 below, several conferences with CE as the central conference theme or as one of the conference tracks have been presented. The list is collated based on the information provided by the interviewees as to which conferences they usually attend. From the conference archives, the names of the tracks or themes have been collated. The intent here is not to present an exhaustive list of conferences where CE was a theme but to indicate its growing presence in different areas of interest. The interdisciplinary CE community meets at regular intervals in these conferences for CE related discussions. As evidenced by Table 5.1 below, from 2015, there are dedicated conference tracks on CE in various conferences and several conferences emerging where the central theme of the discussion is CE itself. Further, researchers view conferences as a space for them to showcase their work and gain recognition in the research community along with other motives such as learning new skills, hearing from experts and building professional relationships (Edelheim et al., 2018).

Conferences as actants in the actor-network provide space for the network to collaborate and develop (Richards, 2015). Conferences have been called ‘Field configuring events’ (FCEs), defined as temporary social organisations that encapsulate and shape the development of professions, technologies, markets, and industries (Meyer et al., 2005). FCE’s are situated in the context of the evolution of fields acting as both drivers and products. As argued by Lampel & Meyer, 2008 by paying attention to such events, a researcher can witness a field in action. Thus, these CE conferences provide a temporary venue organised at regular intervals, for instance, annual or biannual. These conferences offer a critical venue for the formation of the field where they are not just clearing houses of information instead of as prime venues where field participants can potentially be persuaded or coerced as to the virtues of one approach over the other (Lampel & Meyer, 2008; McInerney, 2008). There have been several CE conferences emerging over recent years. The World Circular Economy Forum (WCEF) is an annual CE conference, a global initiative of Finland and the Finnish Innovation Fund, Sitra. The first WCEF was held in Helsinki, Finland, in June 2017, where over 1600 participants from nearly 100 countries participated. In 2018, the conference was organised in Yokohama, Japan, where more than 1100 CE experts where the discussion was focused on what needs to be done to create a ‘true CE’ by 2050. In 2019, the WCEF was again organised in Helsinki with over 2200 participants<sup>10</sup>. Practitioners, policymakers, and researchers attend the WCEF, and it has become a space to create more CE converts, thereby increasing the prominence of the CE concept. According to the framing of SITRA, the CE can increase the value of the Finnish economy by at least 3 billion euros by 2030, and the WCEF is a

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<sup>10</sup> Details source from the World Circular Economy Forum website- <https://www.sitra.fi/en/projects/wcef/#events>

platform that enables Finnish companies and industry seize this opportunity.<sup>11</sup> This indicates that the vision for CE is articulated as pro-growth with profit-oriented firms as the central actants.

Table 5.1: Conference themes and tracks pertaining to CE

SI No	Area of focus	Conference Name	2020	2019	2018	2017	2016	2015
2	Circular Economy	World Circular Economy Forum	Circular Economy	Next era of the CE and scaling up the transition	Circular Economy	Circular Economy		
1	Circular Economy	International Society for Circular Economy Conference	Circular Economy					
3	Circular Economy	Australian Circular Economy Conference	Unlocking value from waste resources through collaboration and technology		Circular Economy			
4	Circular Economy	Greenbiz Circularity	Circular Economy	Circular Economy				
5	Lifecycle Engineering	CIRP Lifecycle Engineering LCE conference	Circular Economy	CE: Enabling Technologies and Systems	Circular Economy	Circular Economy		
6	Management	Academy of Management	Theorizing for CE: Broadening our Sight of Organizations and Resources	CE and Management Theory: Developing Theoretical Underpinnings for an Emergent Concept	CE & Sustainability in Theory: Business Models, Economic Impact, & Application			
7	Management	WoodEMA		Digitalisation and CE: Forestry and Forestry Based Implications				
8	Product Service Systems	CIRP Conference on Industrial Product-Service Systems		Circularity through Industrial product service systems	Circular Economy	Circular Economy		
9	Sustainability Transitions	International Sustainability Transitions				Policy challenges for the CE		
10	Sustainable Consumption and Production	European Round Table for sustainable consumption and production (ERSCP)		Circular Economy		Circular Economy		
11	Sustainable Development	International Sustainable Development Research Society conference	CE and Innovation	CE and Innovation	CE, zero waste & innovation	CE, industrial ecology (resource management and sustainable regional economic development)	CE, industrial ecology (resource management and sustainable regional economic development)	CE and Industrial Ecology
12	Economics	International conference on Economic Management and Green Development	Circular Economy					
13	Computer Science	International Conference on Distributed Computing in Sensor Systems		International Workshop on Smart Circular Economy				
14	Biomass	European Biomass conference and exhibition proceedings		Circular Economy	Circular Economy			

\*Dark green cells indicate entire conference dedicated to CE; light green cells indicate conference tracks dedicated to CE

### CE in higher education

Out of 84 researchers, 6 early career researchers cited using the CE concept during their master's dissertation or PhD. For instance, as quoted by Researcher 51, from Germany, "*The research question of my PhD is the market acceptance of a circular economy. As of day one, I started reading into the CE and started using the label in my research.*" Further Researcher 71, United Kingdom quoted that "*I was introduced to the CE concept during my master's thesis and continued using it*".

Higher education has become a channel through which CE is becoming even more prominent. According to a report by the Ellen MacArthur Foundation<sup>12</sup>, 138 higher education institutions provide

<sup>11</sup> <https://www.sitra.fi/en/topics/a-circular-economy/>

<sup>12</sup> <https://indd.adobe.com/view/a76263e6-f75f-4f12-bbdc-920c01f42c6f>

CE learning offerings as part of their sustainability, engineering, business studies, and design programs. Several CE full-time courses are being offered at the university level, such as (1) CIRCLE - Erasmus Mundus International Master's Programme on CE has been designed in cognisance with the EU needs of the "Europe 2020 strategy" and the CE package. It combines natural, social, and technical sciences and will equip the students with the necessary tools to contribute significantly to transition into a more sustainable society. This program is run as a partnership between the University of Graz, Chalmers University of Technology, Delft University of Technology, Leiden University, Norwegian University of Science and Technology, Curtin University, Tsinghua University, Waseda University (2) University of Bradford offers an MBA focused on the CE. This programme has been developed in partnership with the EMF. (3) The Centre for Sustainability Leiden-Delft-Erasmus Universities offers a master's programme specialising in CE. This programme covers different aspects of sustainability, such as the business side or systemic approach, or an engineering perspective. It provides the students with the flexibility to choose from one of these branches. (4) A CE Masters Programme is also offered by Leiden University, Delft University of Technology and Erasmus University of Rotterdam (5) Master of Science in NTNU.

Master-pupil apprenticeships are regarded as one of the primary sources of transmission of knowledge (Bradie, 1986). Thus, with the increasing number of higher education courses and PhD's on CE (Kirchherr & Piscicelli, 2019), several early-career researchers are motivated to start using the concept based on their educational background. However, the inclusion of CE in higher education comes with a risk. Biswas & Biswas, 1982 argue that higher education in environmental science is often marked with dogmatism. Hence, there is a risk that due to the positive or enthusiastic discourse on CE, the critiques of the current popular framing remain masked. Inclusion of critical elements of CE in higher education was also indicated in a recent study by Kirchherr & Piscicelli, (2019) where the authors outline CE teaching principles in higher education, one of them being a non-dogmatic approach to CE in higher education. This directs attention to the requirement for higher education academics to be more reflexive in how they present CE to early career researchers. As quoted by one of the interviewees who teaches an MSc level course on CE. *"people mostly associate CE with "good for the environment". For example, I questioned my MSc students during my lectures, and they instantly agreed with the idea of a CE being always good for the environment. I think we are still not sufficiently aware of the trade-offs arising from certain strategies. And this is more so the case with young students."*

### *Research Fit*

Out of the 84 researchers, 15 researchers cited that CE 'fits' their research as it combines various schools of thought; hence they use it. Researchers provided different narratives of how CE fits their research due to its interpretive variability. For instance, Researcher 17 quoted, *"It is merely used as a term that*

*can enable communication of the idea more effectively. Terms such as industrial ecology often get too technical.”* Researcher 22 quoted that *“it is a convenient term capturing a range of aspects”*. Researcher 36 quoted, *“Everyone seems to be finding a way to fit CE into their research context”*.

To further investigate this aspect about ‘research fit,’ insights from [research paper 2](#) are helpful where the discourse of 20 competing concepts, including CE, is mapped (a total of 61,444 abstracts). The idea here is that language is a crucial indicator of ideas (Kuhn, 1990); hence by analysing the language used in the discourse for CE and its competing concepts, it will be helpful to understand how CE compares with its competing concepts. Figure 5.6 maps the words used in the discourse on a vector space. It allows to represent the discourses on the different concepts visually. The space occupied by the discourse on the CE concept roughly demarcated by the dotted lines does not occupy a unique space in the map, unlike most other concepts, rather it is scattered and shows closeness with all the different concepts. This directs attention towards the shared language between CE and its competing concepts. Figure 5.6 allows visualising the CE academic discourse in a way that it straddles the areas of different concepts because of the borrowed or overlapping conceptualisations functioning like a ‘boundary object.’ Boundary objects have been defined as ‘objects that both inhabit several communities of practice and satisfy the informational requirements of each of them. Boundary objects are thus plastic enough to adapt to local needs and the constraints of the several parties employing them. Creating and managing boundary objects is a key process in developing and maintaining coherence across intersecting communities’ (Bowker & Star, 1999, p. 297). This boundary object like character provides CE with a relatively large degree of ‘interpretive viability’ (Benders & Van Veen, 2001), allowing researchers to select elements that appeal to them. This characteristic enables CE to be of broader use to different stakeholders. This links back to a few researchers who consider CE as dominant only because it can be applied in different contexts ([research paper 3](#)). This interpretive viability allows users to select elements that appeal to them. While the language used by scholars is continuously evolving, they choose variations of a concept and define those concepts in a way that fits their research questions (Boons et al., 2017). The study by Kirchherr et al., (2017) outlines over 100 definitions of CE, directing attention towards the flexibility with which various actants have defined the concept. Whilst the positive aspect of this would be that CE is being translated in a way that it can fit different functional areas, it also questions whether it is an outcome of the plain relabelling of older concepts. This has been evidenced as one of the reasons for the burgeoning discourse in [research paper 3](#). Further, as quoted in one of the interviews by an editor of a leading journal- *“There is so much relabelling that is happening, it’s evident in the papers that we receive, and then the question is what is CE and what is not.”* As quoted by another interviewee, Assistant Professor, University of Cardiff- *‘I have seen cases when plain recycling is relabelled as CE because no one wants to say recycling anymore. CE is fancier.’* This aspect threatens the production of a more meaningful discourse around CE.

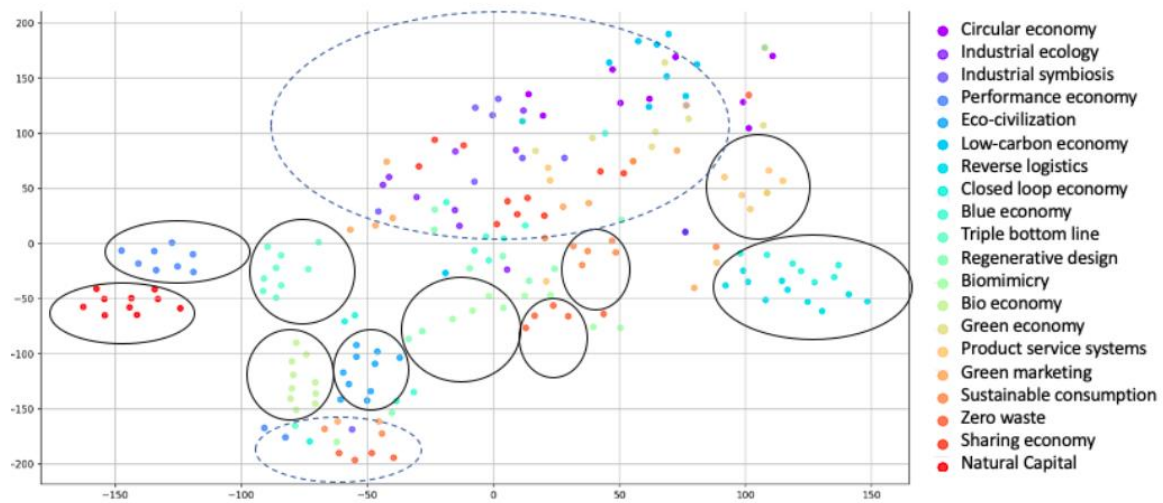


Figure 5-6: t-sne plot presenting CE and other concept competing concepts (Source: author)

### 5.3.2. Following the non-academic actants

The discussion hereafter follows various non-academic actants and how they engaged with the CE concept. The narrative shifts as different focal actants are presented over time across different geographical settings.

#### *NEF as the focal actant emerging in the early 1990s*

*“The NEF was probably the only organisation that was promoting CE in the 1990s. In those times other labels such as industrial ecology, green economy, corporate social responsibility was much more prevalent.” - Researcher 70*

In 1992, the Rio Summit reiterated the importance of sustainable development put forward by the Brundtland report in 1987. The complexities of the debate on managing waste and resources and tackling environmental issues kept increasing but, there remained a lack of clear answers. In response to these rising complexities of the situation, concepts such as zero waste, resource efficiency, extended producer responsibility, sustainable consumption and production, industrial ecology, green economy were either emerging or reiterated (Blomsma & Brennan, 2017). The overlapping conceptualisations where concepts are used interchangeably (Geisendorf & Pietrulla, 2018) add further complexities to the debate. In this period, probably one of the only organisations that engaged with the CE concept was NEF. The mission of the NEF was to work with different organisations, thereby creating an economy that works for people and is within planetary boundaries. The framing of CE by NEF considered that even in a CE, the finite resources would be depleted, and waste would be created, in line with laws of thermodynamics. Still, CE will reduce the environmental impact when compared to the linear economy.

Moreover, it was outlined that if sustainable development had to be reached, then a CE transition is required.

#### *Visualisation of the CE by NEF*

The NEF created a visualisation comparing the CE and linear economy, presented in Figure 5.7 below. Researchers employed by the NEF published papers on the CE (see, for example (Cooper, 1994, 1999)). These are among the few research papers that used the CE concept after Pearce and Turner coined the term in 1990. The NEF CE diagram found its place in some of the research articles that have been published (see, Blomsma & Brennan, 2017; Cooper, 1999, 1999). However, the NEF was not immensely successful in the translation process, and they could not enrol other actants into the network. Thus, through the 1990s up until the early 2000s, a stable actor-network did not emerge. Based on the interviews one reason as to why a successful chain of translation did not start from the NEF was because the organisation's main agenda was not CE. For instance, the NEF was engaged in other discussions such as planned obsolescence (Wieser, 2016); some of the researchers involved in NEF also engaged with different concepts such as a 'sustainable economy' (Ball, 1990). Overall, there was a lack of recognition of NEF's engagement with the CE concept at this stage which led to breakdown of the translation chain by NEF.

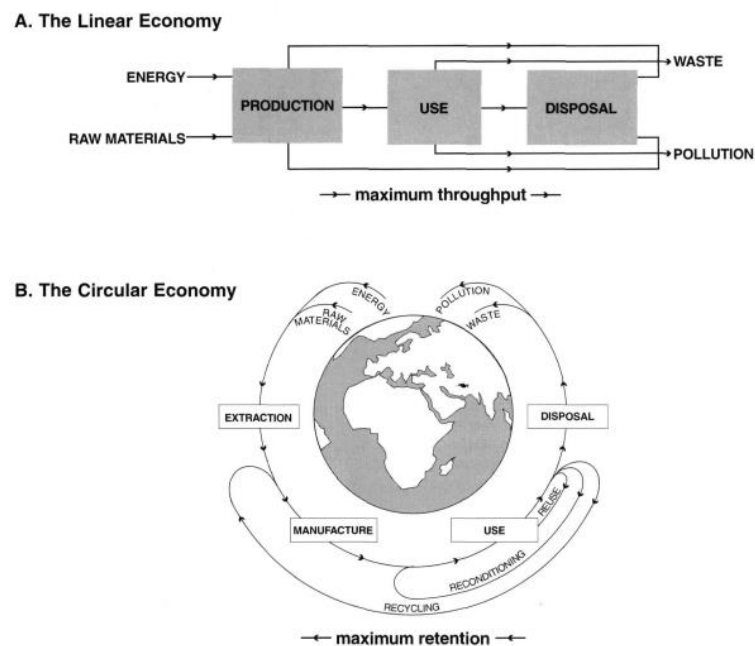


Figure 5-7: Visualisation by the New Economics Foundation to depict a circular economy (Source: NEF)

#### *SEPA as the focal actant emerging in the early 2000s*

*“The role of SEPA and NDRC is key I think, moreover the shift in power from SEPA to NDRC was a landmark for the changed framing”- Researcher 16*



Whilst NEF was engaged with the concept in the 1990s, the breakthrough stage for the field only came when SEPA entered in the scene. Before proceeding further with the insights presented in this section, it is essential to take note that the analysis in this section was conducted “from scratch”; however, it is inspired and benefitted heavily from the study by Jiao & Boons, (2017), which analysed the emergence of CE as a policy concept in China. Moreover, the analysis in this section was difficult with my lack of knowledge of the Chinese language. Thus, the insights have been drawn from the semi-structured interviews, and corroborating information from different scholarly works.

In China, after Mao Zedong died in 1976, an unfettered growth policy characterised by industrialisation and highly resource-intensive activities were followed. This growth policy led to a rapid increase in the growth rate of the Chinese economy and a strengthening of the Chinese industries (Geng et al., 2016; Naustdalslid, 2014). But this unfettered growth policy came under immense scrutiny as China, the most populous developing country, started facing many resource supply and waste assimilation challenges, including land degradation, desertification, acid rain, deforestation, water resource depletion, greenhouse gas emissions, and loss of biodiversity (Jie & Nianfeng, 1995). To this end, in China, various measures to solve the environmental crisis were being explored. In 1994, the government of China formulated and approved China's Agenda 21 - the White Paper on Population, Environment and Development of China in the twenty-first Century (“China’s Agenda 21,” 1994). As a part of operationalising the targets in Agenda 21, several IS systems in the form of EIPs sprung out following the detailed content of this agenda from the year 1999 (Yang et al., 2011). The key organisations involved at this stage was SEPA, the State Planning Commission (SPC), and State Science and Technology Commission (SSTC)

As a part of the Agenda 21 operationalisations, SEPA, a national central government agency, promoted the policy concepts of EIP and Cleaner Production at the meso and micro level, respectively, before CE’s emergence. Further, inspired by German and Japanese implementations, SEPA, with the help of its local bureaus and academic researchers, first promoted CE principles within existing EIPs. SEPA’s framing of CE was primarily geared towards environmental protection and cleaner production within the existing EIP’s. SEPA was successful in enrolling further actants into the network through *swift translation*. Swift translation happened because actants were already engaged with the EIP’s that had been implemented as a part of the Agenda 21 operationalisations. SEPA introduced CE in China through demonstration projects within the existing EIPs. As indicated by Yuan et al., (2006) researchers had started to work on the CE concept in China at this stage. They had backgrounds in engineering. The initial projects implemented in China became a source of accumulated experience for knowledge used by researchers in the later stages of CE development.

SEPA became the first central government agency to promote CE in China when it launched a series of projects. SEPA's role in enrolling more actants into the network can be understood from two aspects. First, it supported both scientific investigations and demonstration projects within existing EIPs, recycling regions city and provincial level. Second, by networking and negotiation SEPA made recommendations to the State Council, drawing attention and importance to a circular economy. Owing to SEPA's efforts, former President Jiang Zemin – for the first time stated the necessity of promoting a CE in China at the Members' Assembly of the Second Global Environment Facility held in Beijing in October 2002. This event implied that the CE would be included in the agenda of the national government (Yong, 2007).

SEPA was successful in the enrolment of several actants into the actor-network in China. The success of SEPA can be attributed to three reasons. Firstly, the elite status of SEPA as a national government agency to bring CE to the forefront in the national policy context. Secondly, SEPA was already engaged with EIP's and EIP's were already a part of China's Agenda 21. Thus, there was a familiarity with EIP in the Chinese national context, which allowed 'softening up' to the idea of CE before its emergence. Also, SEPA's initial implementation of CE was within the EIP's itself, which allowed the swift translation. Thirdly, there were already successful implementations of social and economic practices in Germany and Japan, inspiring SEPA's CE framing. The demonstration of successful implementations from other countries increased the receptivity for the CE concept in the Chinese national policy context.

#### *State Council as the trojan actant and NDRC becomes the new focal actant*

In the next stage of CE development, China's State Council appointed the National Development and Reform Commission (NDRC) to take over as the major coordinator for CE promotion from SEPA in 2004. NDRC is a unit of the State Council studies and analyses the economic situation in China and formulates and implements strategies of national economic and social development, annual plans, and medium and long-term development plans (Yuan et al., 2006). While SEPA's framing of CE was more inclined towards cleaner production and environment protection, NDRC, on the other hand, framed CE as a tool for sustainable economic development along with environment protection. The framing of the CE concept was a response to the environmental degradation in China and was based on the idea that economic development and environmental protection can co-exist. This change can be understood as the organisational goals of SEPA and NDRC itself. While SEPA was the organisation responsible for managing the environment in China, NDRC as an organisation manages the economic situation in China. Thus, the State Council became the *trojan actant* that threatened the initial *problematization* by SEPA, and subsequently, NDRC became the focal actant that took the CE discussion forward in China. The agenda of CE started strengthening in China with major organisations such as the State Council, NDRC and SEPA, Ministry of Science and Technology, Ministry of Finance, National Bureau of



Statistics actively engaging with the CE concept. There was increased practical implementation projects through national demonstration projects and increased funding for Chinese researchers. In 2005 ‘The Several Opinions on Accelerating the Development of Circular Economy’ published by the State Council was the first programmatic document on the CE, indicating that the CE is the new development model<sup>13</sup>. This document aimed to accelerate the uptake of CE and proposed the guiding ideologies, major objectives, critical tasks, and policy measures for the development of CE. The actants' enrolling into the actor-network was mainly done as a top-down approach stemming from the governmental agencies through coercive mechanisms. The idea was that policies would be implemented top-down through scientific knowledge. That means policy goals will first be established and then scientific insight on society, social and economic mechanisms, and natural processes, based on empirical data and scientific methods, will guide the authorities in the practical implementation of policies (Geng et al., 2012). From implementing the CE promotion Law in 2008, China continues its commitment towards CE through its inclusion in every five-year plan. China upgraded CE as the national development strategy in the 12th five-year plan (2011-2015) (Mathews & Tan, 2016). There have been various action plans, such as the State Council, 2013, which provide further details for specific sectors and provide clarity on implementing the provisions of the CE promotion law (McDowall et al., 2017). A further reference to the CE is also present in the 43rd chapter of the 13th five-year plan (2016-2020) (Pesce et al., 2020). This has caused the continued *mobilisation* of the actor-network whereby coercion through regulation, policies and funding keep the actor-network together, and actants continue to engage with the CE concept. Until 2010, China was the only country engaging with the CE concept; however, soon after, the CE concept was translated to fit into the European context which will be discussed in the next section.

### *EMF as the focal actant emerging 2010 onwards*

*“It was an exercise in framing, quite deliberate and fiercely partisan in its aims” - Researcher 4*

EMF emerged as a focal actant in the European context of CE starting from 2010 onwards. EMF played a crucial role in enrolling industry practitioners, national governments, universities to create a large actor-network around the CE concept. In the subsequent sections, the narrative is focussed on EMF bringing CE to the EU supranational policy context and then framing of CE in EU policies. Firstly, it is helpful to begin the narrative with the context of the events when the EMF emerged as the focal actant in the CE discussions. There have been a few focusing events; for instance, the year 2009 was marked as a tipping point when the Lehman Brothers collapsed after the 2008 recession. The 2008 crisis marked the end of the post-World War II long-term development cycle, where 2009 was the first year since

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<sup>13</sup> see [go.nature.com/cnozhg](https://go.nature.com/cnozhg); in Chinese (I used Google translate for this document)

1945 when the global economy shrank. After the financial crash, the green economy concept was taken up by the EU in its resource efficiency agenda. However, according to an EEA report (EEA, 2014), the green economy movement in Europe was moving too slow. The early 2010s was a difficult time for the EU, recovering from the economic crisis. This opened the ‘policy window’ (Mintrom & Norman, 2009), where EU policymakers were trying to find new ways to address the environmental and economic crisis. Further, In July 2010, Flemish Environment Minister Joke Schauvliege became President of the EU’s Environment Council and placed sustainable materials management on top of her mandate’s focal points, thus giving closed-loop and life cycle approach new visibility and political backup. Taking advantage of the European Union Council’s rotating presidency, the Flemish Minister for Environment, Nature and Culture aimed to make the issue a political one, presenting the closed-loop vision to all 27 EU member states. Thus, in the EU policy arena, there was “softening up” towards the closed-loop vision. Amidst this backdrop, in October 2010, EMF declared its commitment to achieving sustainability. Following this, EMF’s mission statement clearly stated its intent to develop and promote the CE by working with businesses, academics, policymakers, and institutions<sup>14</sup>. The direction of EMF to engage with the CE concept was inspired by Dr Walter R Stahel (Venables, 2013). Established by a celebrity, Dame Ellen MacArthur, the foundation engaged five big industry players as founding partners, i.e., B&Q, BT, Cisco, National Grid and Renault, to support the EMF financially to promote the CE concept. Further, EMF became the ‘policy entrepreneur’ (Fitch-Roy et al., 2020) that brought the CE concept to the European policy context

### *The EMF- McKinsey report*

By liaising with the founding partners and McKinsey, a leading consulting company, EMF published the first report on CE in 2013 titled: Towards a Circular Economy (EMF, 2013). This report's release has been considered one of the key events that marked the growing interest towards CE (van der Heijden et al., 2021; Xu, 2012) hence it is an important actant in the actor-network. Moreover, the report had the famous “butterfly diagram” an actant created by other the actants in the network (EMF and McKinsey). This report had forewords from Janez Potočnik, EU Commissioner for green affairs and CEOs of five leading companies (the founding partners). Thus, this report showcased that CE had buy-in from major organisations in policy and practice. This report was also presented at the European Resource Efficiency Platform (EREP)<sup>15</sup> earlier in June 2012 by Dame Ellen MacArthur. The objective of the EREP was to provide high-level guidance to the European Commission, member states, local and regional authorities, and private actants on the transition process towards a more resource-efficient economy. The platform went on to publish a manifesto in December 2012 that called on stakeholders

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<sup>14</sup> Mission statement of the EMF-“At the Ellen MacArthur Foundation, we develop and promote the idea of a circular economy. We work with, and inspire, business, academia, policymakers, and institutions to mobilise systems solutions at scale, globally.”

<sup>15</sup> European Resource Efficiency Platform- [https://ec.europa.eu/environment/resource\\_efficiency/re\\_platform/about/objective\\_mandate/index\\_en.htm](https://ec.europa.eu/environment/resource_efficiency/re_platform/about/objective_mandate/index_en.htm)

such as businesses and civil society leaders to support the transition to a CE which will include reuse, high quality recycles and much less reliance on primary raw materials. This marked the initiation of CE in the EU policy context.

### *The EMF butterfly diagram*

The butterfly diagram (see figure 5.8) and the entire report became the highlight of the CE discussion and gained much traction. The diagram suggests a belief in a perfect natural environment where waste does not exist (the biological wing) and that people are separate from nature and live in a technosphere that is wasteful (the technical wing) which is different from the notion of ecosystem stewardship in which people are an integral part and embedded in the environment (Velenturf & Purnell, 2017). Thus, academic discourse engaged extensively with this butterfly diagram, trying to debunk it or develop it further, or some trying to use it as is in their research (Chang & Huang, 2020; Howard et al., 2019; Schröder, Lemille, et al., 2020; Velenturf et al., 2019). Both the report and the butterfly diagram became crucial actants in the actor-network which enrolled more actants into the network.

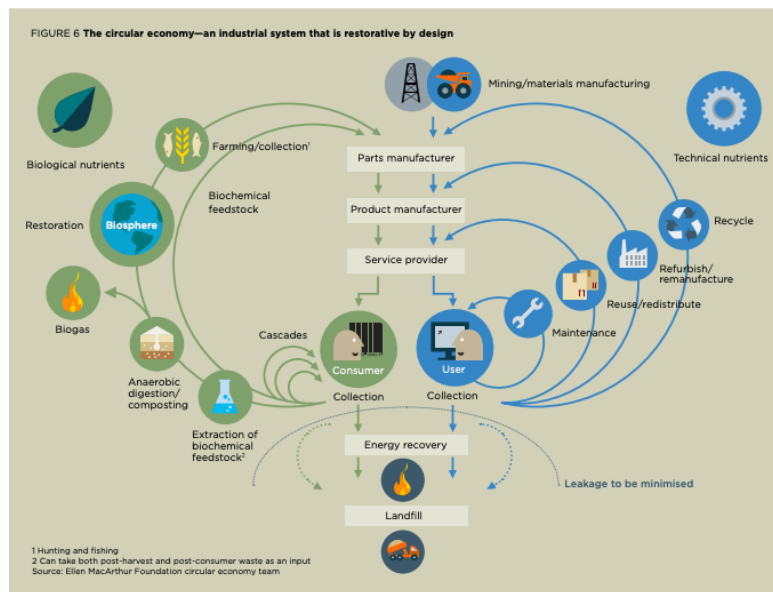


Figure 5-8: EMF's butterfly diagram (EMF 2013)

For instance- a search titled “butterfly diagram” AND “circular economy” on google scholar gives about 317 results<sup>16</sup>. In Figure 5.9 below the increasing number of mentions of the ‘butterfly diagram’ in academic articles has been mapped over the years.

<sup>16</sup> Google scholar search dated 12th September 2021

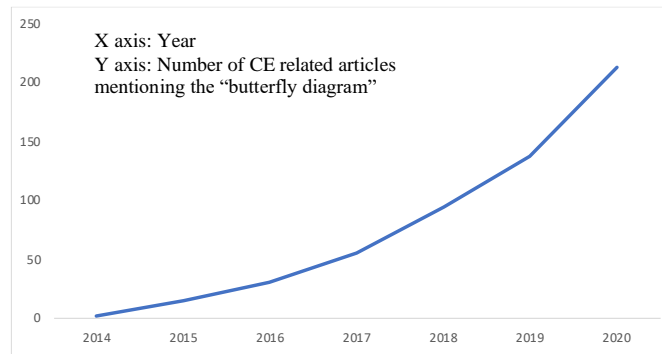


Figure 5-9: Number of CE related research articles mentioning the "butterfly diagram" (Source: author)

EMF's success in enrolling a wide range of actants in the actor network can be attributed to the following reasons. As indicated by one of the interviews who worked closely with the EMF, EMF successfully brought CE to the forefront due to successful issue framing. According to Cairney, (2018) if policymakers are simply bombarded with evidence, they have little reason to read it. However, if the framing battle is won, policymakers will demand evidence on your problem and solution. The EMF report with McKinsey framed CE as an economically viable and scalable solution that could bring in cost savings of up to 380 billion USD, going up to USD 630 billion (EMF 2013). The report's 'business-oriented' tone articulated CE as a solution to the mounting pressures from the 2009 economic crisis which had resulted in increasing price volatility and curbed economic growth (p. 19). Throughout the report the notion of economic growth or increased consumption is not challenged rather CE is framed as a way through which 'upcoming growth in demand (p.23)' can be met which the linear economy cannot fulfil. This report establishes the optimistic narrative around CE that can reconcile the environment and economy. Secondly, by displaying social acuity, the EMF was successful in further popularising the CE concept. As one of the interviewees who worked closely with the EMF- "*Ellen was a celebrity; she had her way of doing things and getting people to listen to her.*" Scholars have called this 'displaying social acuity', which means understanding stakeholders' ideas, motives, and concerns and responding effectively (Cairney, 2018; Mintrom & Luetjens, 2017; Mintrom & Norman, 2009). Thirdly, a lot of EMF's effort was in building a CE network including businesses, policymakers, consultants, universities, thus fostering collective action towards CE. One of the outcomes of this networking has been the CE100 initiative launched by EMF. As quoted in the foundation's website, the 'network brings together businesses, innovators, universities, and thought leaders to build and scale a circular economy.' EMF's networking extended at all levels ranging including high schools, national governments (for instance the French Economic, Social and Environmental Council (ESEC), cities, WEF (EMF has been an integral part of the WEF Annual meeting held in January every year), OECD. In Figure 5.9 below, the increasing number of organisations in the CE100 network from 2012 to 2021 have been mapped based on the information collected from the EMF news archives. Through

networking and negotiation, EMF became more like an *obligatory passage point* in the CE field. In short, as quoted in one of the interviews, “*Ellen MacArthur brought CE into the world stage.*”

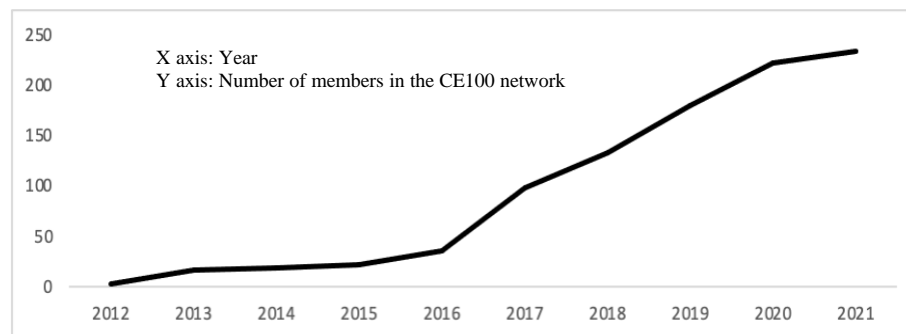


Figure 5-10: Increasing number of CE 100 institutions (data collected from EMF news archives from 2012 to 2021)  
(Source: author)

### *The emergence of EU CE policies by the Barroso Commission*

Through EMF’s effort and an available window of opportunity (Cohen, 2016; Mintrom & Norman, 2009), CE was adopted in the EU policy sphere. In July 2014, the Barroso led European Commission (EC) published a communication: Towards a circular economy: a zero-waste programme for Europe (European Commission, 2014). This policy document was another actant in the network which facilitated the translation process by enrolling more actors into the network who were lured by its policy relevance. The framing of CE in this document was based on the premise that resources were ‘leaking’ from the economy and CE will enable to navigate through the increasing demand for finite and ‘sometimes’ scarce resources. The Barroso commission framed CE to promote resource efficiency, and waste management claiming a savings potential of 630 billion euros per year. While the core agenda was resource efficiency and waste management the economic angle to CE was also evident. As quoted in the report- ‘Europe can benefit economically and environmentally from making better use of those resources.’ In this document CE was called a development strategy that entails economic growth without increasing resource consumption, deeply transform production chains and consumption habits and redesign industrial systems at the system level.

### *Juncker Commission as the trojan actant*

In late 2014, the European Commission changed the presidency to Jean-Claude Juncker, and a revision of existing policies accompanied the change in the presidency. The new Juncker commission withdrew the CE package of the Barroso Commission. Thus, the Juncker commission became the trojan actant betraying the actor-network. As quoted by one of the interviewees from the Directorate-General for the Environment, the reason for the cut was that- “*The Juncker Commission was very heavily influenced by the economic crisis and wanted to foreground economic issues.*” However, this scrapping came under immense scrutiny and protest from various groups, and the Juncker commission promised a more

‘ambitious package.’ Interestingly in these protests, one of the letters to Prime Minister Juncker was from CEOs of four companies (Michelin, Philips International, Suez Environment, Unilever) who were a part of the CE100 initiative of EMF. This letter quotes ‘A CE is an economic growth agenda’<sup>17</sup>, hence building a case of why it should not be scrapped from the EU policy agenda.

Between 28th May and 20th August 2015, public consultations were held, accompanied by an EC stakeholder consultation conference on the 25th of June; this led to the new Closing the loop- An EU action plan for the circular economy package released in December 2015 (European Commission, 2015). The main novelty of the second Communication is a clear focus on economic growth. While the Barroso Commission led report started with the premise of resource shortage, the Juncker Commission led report starts with the premise of how CE will boost EU’s competitiveness by protecting businesses against the scarcity of resources and volatile prices thereby producing new business opportunities and more innovative ways of producing and consuming. This was also evident in the ten priorities of the Juncker Commission, from which environmental concerns mainly were absent, as indicated during multiple interviews. This change also partly reflects the difference in sponsors, as new actants joined the CE discussion, i.e., the Directorate General for Growth in the European Commission. This is a similar pattern like China where managing the CE transition went from the hands of SEPA to NDRC. In both these countries the initial framing of CE went through a change as the next actor (Juncker Commission and NDRC) have a clear economic growth motive. As quoted by one of the interviewees from the Directorate-General for the Environment - *“In this phase, CE widened beyond waste policy and more directorates were involved including Agriculture, Health and Food Safety, Research and Innovation, Mobility and Transport, and for Regional and Urban policy.”* This framing of CE remained until 2019 when the next Commission came to power. Between launching the first package in 2015 to 2019 there were several other policy documents released. In January 2018 a monitoring framework was released which adopts a series of indicators to monitor progress towards the circular economy. The monitoring framework includes waste management, innovation, and economic growth and represents the attempt to mainstream waste management into economic narratives (European Commission, 2018).

Further, in December 2019, the Von der Leyen Commission published a European Green Deal was presented to the EU and its community as a new development strategy by the European Commission (EC). The key goal of the European Green Deal is to reshape the EU into an ethical society with efficient use of resources and a modern-competitive economy. Moreover, the Green Deal is also one of the 6 Commission priorities for 2019-2024, a shift from the Juncker Commission where environmental

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<sup>17</sup> Access the letter here:  
<https://www.municipalwasteeurope.eu/sites/default/files/Industry%20coalition%20Letter%20Circular%20Economy%20FINAL.pdf>

priorities did not feature. The European Commission targets an absolute reduction of greenhouse gas net emissions by 2050 in all EU through the Green Deal. Thus, one of the necessary actions in implementing this new growth strategy, “EGD,” is coordinating the industry for a circular and clean economy. These schemes aim to strengthen the EU’s 2030 goal of reducing emissions up to 55 from 40 per cent, presenting a carbon border tariff, developing a sustainable Europe Investment Plan, reshaping the EU Investment Bank from unsustainable banks, and creating a new industrial European strategy (EU 2019). One of the main building block of the EU green deals is the Circular Economic Action plan called Europe’s new agenda for ‘sustainable growth’ (New Circular Economic Action Plan, 2020).

The increasing importance of CE in the policy circles is also evidenced from the increasing number of policy documents published on CE. The data on policy documents was collected from the Dimensions database<sup>18</sup> dated October 2020 and has been presented in Figure 5-11. These policy documents are actants in the actor-network which facilitate the translation process through which more actants are enrolled into the CE network. As evidenced in the Delphi study in Research Paper 3 one of the reasons of CE’s increasing prominence is its uptake in the policy circles, thus such documents carry the agency through which more actants are enrolled into the network.

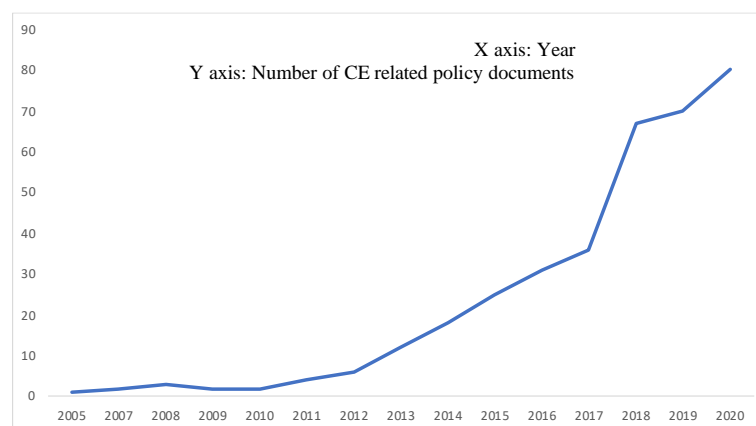


Figure 5-11: CE-related policy documents published over the years (Source: author)

#### 5.4. Reflections and field characteristics

By following the academic and non-academic actants in the discussion so far, a complex network of actants (both human and non-human) engaging with the CE concept is formed. A simplified version of the actor-network highlighting different actors has been presented in Figure 5.12 below.

<sup>18</sup> <https://www.dimensions.ai/>



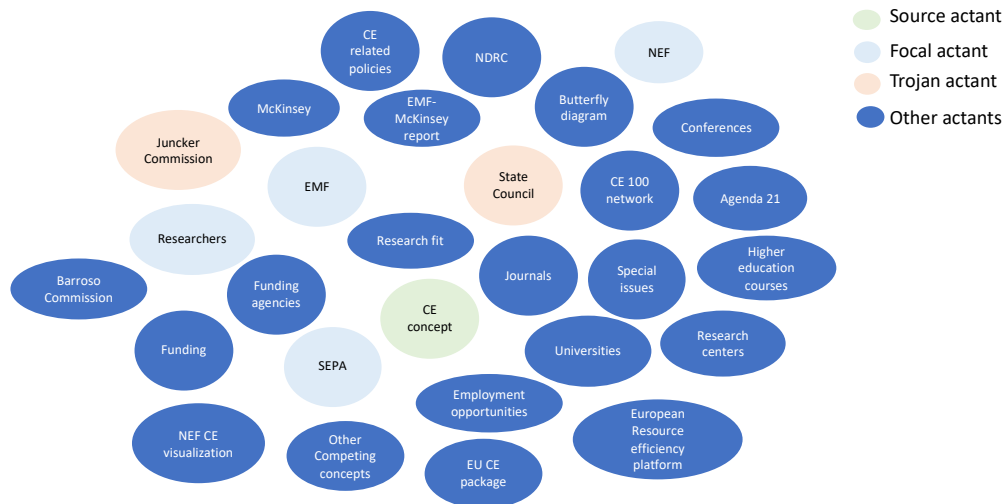


Figure 5-12: Simplified representation of the actor-network (Source: author)

One of the crucial reflections from the discussion so far is how the field actants are framing the CE concept in terms of economic growth. The EMF and McKinsey report, an important actant in the network, generated much traction around the CE concept, clearly articulated the benefits of CE through an economic narrative. The report framed CE as an 'economically viable concept' that could provide 'strategic opportunities' and 'cost savings up to 380 billion USD'. In the Chinese and the European context, the entry of the respective trojan actants, i.e., the State Council's appointment of NDRC and Juncker commission's rejection of the first CE package, marked a change in the framing of the CE concept towards an optimistic growth narrative. Both these trojan actants had goals of fostering continued economic growth in their respective countries and translated the CE concept in a way that fits their goals. In China, the entry of NDRC into the CE discussion changed the framing from SEPA's EIP, cleaner production and environmental protection focus to a 'sustainable growth' perspective that reconciles the economy and environment in China. While in Europe, the Juncker Commission scrapping the first CE package to frame the second 'more ambitious' CE package marked a shift from the resource efficiency and waste management focus to an economic narrative that increases the EU's competitiveness with businesses at the centre of the transition. This pro-growth narrative of CE continues to show in policy documents. As quoted in the WBCSD report, 'key to the Circular Economy Action Plan 2020 is its established agenda to promote sustainable growth, in alignment with the new EU Green Deal'. Some scholars have argued that the current EU institutions' CE narrative portrays bottom-up market forces and economic incentives as CE drivers (Calisto Friant et al., 2021; Leipold & Petit-Boix, 2018; Zink & Geyer, 2017).

While this optimistic growth narrative is reflected in the policy documents, it is also of interest to understand the growth narratives around CE that is present in the academic discourse. To this end, 3300 CE academic abstracts from 2005 to 2019 are analysed. While it is understandable that analysing full-text articles would give a detailed picture of the narratives, given the volume of scientific discourse



produced on CE, it is impossible to cover all the articles through manual inspection. Hence, abstracts are used for the analysis to ensure high coverage of the research articles. Moreover, it has been argued that abstracts contain sufficient information to reveal the underlying research themes (Griffiths & Steyvers, 2004; Sun & Yin, 2017). Also, a researcher would often read just the abstract to form an opinion or assessment of the research article before proceeding to read it (or not read it) further. Thus, it is helpful to sense how the abstracts frame growth in the CE context. To this end, three growth narratives are outlined based on the analysis, i.e., unsustainable growth due to the linear economy, fostering continued growth and growth critique. These narratives were further triangulated during the expert interviews to gauge the opinion of the experts and enhance the validity of the narratives presented.

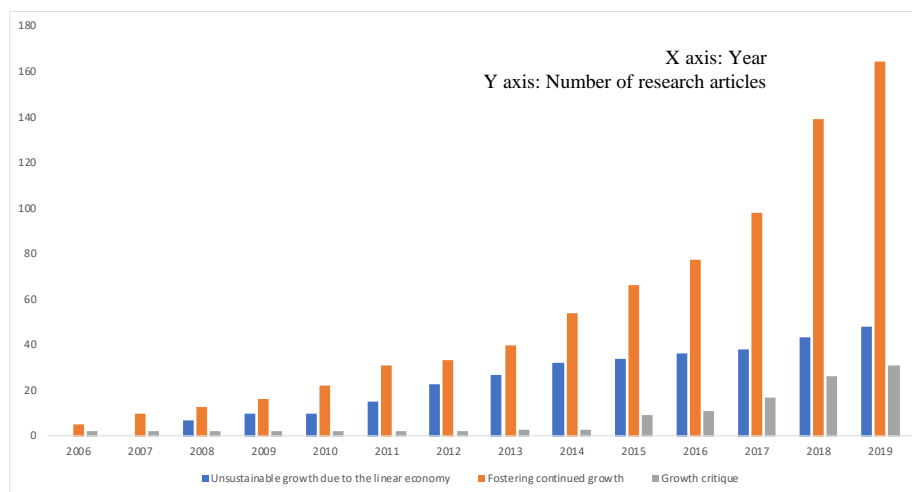
The first narrative of unsustainable growth due to linear economy is the initial premise of most articles on CE, which juxtaposes CE with the linear economy. This narrative includes mentions about increases in neo-classical indicators such as GDP at the cost of the environment, linear models of consumption and production, rising social disparity, which require immediate attention. This narrative provides a background that the initial economic growth in industrialised economies resulted from domestic resource extraction. However, this unfettered growth has come under scrutiny due to rising environmental concerns. Such narratives are often an introduction to why a CE is required to tackle the current unsustainable societal patterns and suggest a change from the predominant linear economy.

The second narrative is that of fostering continued growth by decoupling environmental protection and economic growth. This narrative does not question growth itself instead frames it as 'sustainable growth'. This narrative is based on the idea that a CE is used as a mobilising strategy for continued economic growth. Some researchers in this narrative articulate CE as a 'sustainable growth model' (Busu, 2019; George et al., 2015; Ranta, Aarikka-Stenroos, Ritala, et al., 2018). The language of decoupling economic growth from the environment remains an integral part of this narrative, and it considers CE a fundamental part of transitioning towards sustainability. Consequently, lessons focus on what we need to achieve a CE, which usually focuses on resource efficiency policies and business action at the local or national level, for instance, through business models, product design or extended producer responsibility.

The third narrative is critical of growth. This narrative is sceptical towards the existing idea of 'sustainable growth' but not essentially of the CE concept itself. For instance, D'Amato et al., 2019 point towards the under-explored potential of formulating synergic circular, green and bioeconomy policies, possibly without focusing on economic growth. This narrative also argues that economic indicators such as GDP were never designed to be comprehensive measures of prosperity and well-

being; however, it remains a crucial element of CE framings (Glavič, 2015). Lastly, the critical element of this narrative is CE's link to alternative discourses and transformative socio-cultural approaches like degrowth and steady-state economics (Charonis, 2012; Hobson & Lynch, 2016; Schröder et al., 2019). Within this narrative is a reformist perspective towards CE and is concerned with reformulating the current production and consumption patterns and policies. It focuses on re-orientation in the current socio-economic systems to bring about radical changes and depoliticise the CE discourse from policy and industry interventions.

In Figure 5.11, the proportion of these narratives in CE abstracts are mapped. Clearly, the narrative of fostering continued growth is significantly overpowering. The predominant framing of CE is it being posed as a model that can automatically ensure the combination of planet and profit. This directs attention that the dominant framing of CE is not geared towards radical transformation; instead, it enables fosters continued economic growth. Further, as evidenced in the Delphi study, despite the proposed resonance between CE and alternative socio-cultural approaches (like degrowth, steady-state economics, conviviality) in some studies, along with calls to align them, the choice of concepts used by researchers represents business-oriented and technical ones. With limited dialogue between the two aspects of the field with differing growth, narratives create a fragmented field.



*Figure 5-13: Distribution of growth narratives in CE abstracts from 2005-2019 (Source: author)*

### *CE Field characteristics*

Based on the discussion so far certain characteristics of the CE field can be outlined i.e., (1) steering of research priorities, (2) fragmented and dispersed field, (3) institutionalisation of CE in academia, policy, and practice.

### *Steering of research priorities*

Recapitulating on the motives of researchers in using the CE concept, out of the 84 researchers whose opinion was solicited, only one researcher indicated the perceived usefulness of CE in addressing sustainability-related issues, which motivated them to start engaging with the concept. This means that none of the other researchers was driven by an intrinsic motivation to use the CE concept because it addresses issues pertaining to sustainability. This is also in line with the assessment in research paper 3, where researchers do not consider CE a dominant concept in addressing sustainability-related issues. Researchers specifically indicated the inadequacies in the CE concept in the way it addresses social issues and long-term environmental concerns (research paper 3). Despite these inadequacies listed by the researchers, there is still a massive volume of academic research articles produced on CE. The motives of researchers to engage with the CE concept stems from the extrinsic motives that are the availability of funding (which was cited as one of the main motives during the Delphi study and the expert interviews). Primarily the motives of the researchers are the empirical evidence for a case where ‘pure’, ‘blue-skies’, fundamental, disinterested research being replaced by the ideas of application, relevance, contextualisation, reach-out, technology transfer, knowledge management (Scott, 2003). This means that academic research on CE is mainly controlled by funders or externalist pressures. Academic knowledge driven by the internal taxonomy of disciplines, autonomy of researchers and their host institutions has been replaced by a new type of knowledge production wherein research priorities are being ‘steered’ (Halvorsen & Nyhagen, 2011). The steering of research priorities in the case of CE by funding is in line with the contemporary framings of Mode 2 knowledge production (Nowotny et al., 2013). As a result of the steering of research priorities, an important aspect is a linkage between science and policy in the CE discussion. In simple terms, there are two ways the relationship between science and policy could be conceptualised, one being that science can inform policy and the second being that science is an object of policy. In analysing the motives of the researchers, they are mostly extrinsically driven by policy goals. Moreover, in understanding how the CE developed, it was not the classic research that informed policy in CE. In the interview with the DG Environment, when the question was posed if they engage with scientific research, the interviewee quoted, “*We usually use research reports from our research teams. So, I have not used a lot of academic papers in my work so far. The Resource Efficiency Platform did have a couple of academics on board, though!*” The role of researchers in the Chinese implementation of CE has been towards the implementation of CE policies through scientific evidence and empirical investigations but not in the selection of policies itself (Geng et al., 2012). In both Chinese and European contexts, the role of researchers has not been significant in CE policy formulation. The engagement of researchers started during the policy implementation stage with increased CE related funding.

As indicated in the interviews, the increased ‘steering’ of research priorities carries a risk that the CE academic discourse is more focussed on finding success stories of new policies or business models (for instance, increased resource recycling) without proving that these lead towards socio-environmental sustainability. While there are also researchers who stick to a reformist view of CE, which is focussed on political action and changing the current consumption-production patterns, which are crucial to the development of CE compared to technocratic advances, but this narrative of CE is not majorly influencing CE policies. Navigating through the science-policy interface is a challenging task for CE researchers, constrained by ‘short-term’ or ‘hard’ funding and pressure to produce immediate scientific input. But this is an essential task if CE research strives to contribute to policy and practice.

### *Fragmented and dispersed field*

In the analysis of the field so far, there is also fragmentation and dispersion that is evidenced. This fragmentation and dispersion can be explained from three perspectives. Firstly, this fragmentation and dispersion results from the multiple translations of the CE concept in various geographical settings. The Chinese translation of the CE concept is much different from the European translation of the concept. For instance, the framing of CE by SEPA was closely linked to IE, EIPs focusing on cleaner production and environmental protection. Whilst the framing of the Juncker Commission was focused on economic growth and increased competitiveness of Europe. The differences are also understandable as these economies are at different stages of development with varying governance structures, China being a sovereign state and the EU a supranational organisation (McDowall et al., 2017). Secondly, this fragmentation and dispersion can also be explained through the differing growth narratives within the field. As discussed in the preceding discussion, there are two narratives in the CE field, one that fosters continued growth and one that is critical of growth. However, both these narratives are in separate segments of the CE field, and with limited dialogue between the two segments, further fragmentation and dispersion happens. Lastly, to further investigate the fragmentation and dispersion of the field, the co-authorship network of researchers provides some evidence. Co-authorship patterns are often used as a proxy to understand the relational structures in a field (Glänzel, 2001; Ponomariov & Boardman, 2016). Co-authorship patterns will allow the investigation of how various researchers in the CE field collaborate. To this end, a co-authorship pattern is constructed through Vos Viewer<sup>19</sup>. Through the co-authorship pattern, 5000 researchers using the CE concept were segregated into 366 smaller clusters. Specific clusters which indicate a particular area of scientific activity have been demarcated. The co-authorship pattern further reveals the fragmented and dispersed parts of the field. For instance, in the co-authorship pattern, the cluster of lifecycle assessment is completely separated from that of business models. The cluster of engineering is separate from the supply chain. Even during the interviews,

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<sup>19</sup> <https://www.vosviewer.com/>

researchers would often say, ‘that area of CE is not my expertise’ or ‘I do not know much about that aspect of CE.’ As evidenced in the Delphi study, the CE concept has expanded to various areas of practical research in recent years. As an outcome of that, the field is getting increasingly dispersed and fragmented. This fragmentation and dispersion can exist because of the boundary object-like character of the CE concept where it gives it immense interpretive variability. This boundary object like character allows CE to have crossovers and incursions across different parts of the field.

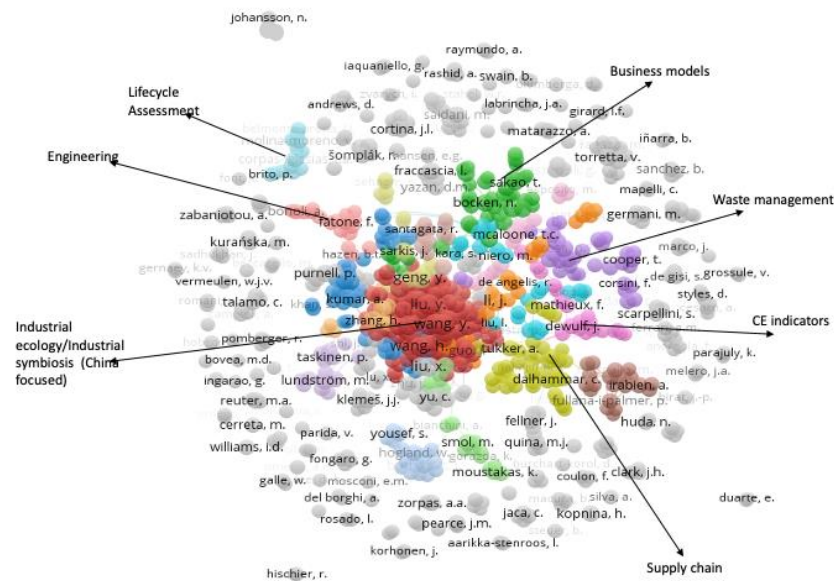


Figure 5-14: Co-authorship pattern of the CE field based on 5000 authors (Source: author)

### Institutionalised field

In the analysis of the CE field actants, the institutionalisation of the field is revealed. Institutionalisation allows the field to persist and develop over time through institutions and institutionalisation of knowledge, the field not only establishes the interactions between actants but also influences different spheres of societal life (Ehrenfeld, 2004). The academic field actants have formed a temporary social order around the CE concept. In the academic discussions this institutionalisation has come about through various means which were revealed in the previous sections i.e., dedicated professorships, chairs and other academic positions to CE, inclusion of CE in higher education institutions, several dedicated conferences on the CE concept and specific conference tracks on CE, and more recently a journal on CE titled CE and Sustainability by Springer. In summary, CE has found its place in every corner of academia. The uptake of CE in the EU and Chinese government has been discussed. Clearly there are dedicated institutions that are engaging with the CE concept and a chain of policies are being formulated using the CE language starting from early 2000s in China and from 2014 onwards in Europe. In the European Commission a specific Directorate of Circular Economy and Green Growth is present.

Moreover, the successive European community framework program (Horizon 2020) clearly articulates funding calls using the CE language.

Apart from the governmental uptake of the CE concept, there are various other institutions that are specifically geared towards managing the transitioning towards CE. For instance, EMF as a think tank has the mission to promote the CE. Other institutions such as Circle Economy in Netherlands, SITRA in Finland all specifically engage with the CE concept with the CE concept featuring in the vision and mission of these organisations. EMF, one of the key actants in the CE debate works with businesses and policymakers to mobilize circular solutions on a global scale. The CE100 initiative of EMF, where organizations and businesses globally come together to form a CE network. This network houses some of the major businesses around the world such as ABB, 3M, Amazon, Cargill, DuPont to name a few. All major consulting companies provide advisory and have published documents on the CE concept. For instance, companies such as McKinsey & Company, Accenture, Deloitte, Ernst and Young, KPMG have all published reports and provide advisory services on CE showcasing the popularity and acceptance of the CE concept in the business domain. Initiatives by various practitioners such as Nike, H&M, Puma, BMW, Cisco Systems has been discussed in these reports (Accenture, 2014; Deloitte, 2016; Ernst & Young Accountants LLP., 2015; KPMG, 2019; McKinsey, 2016). Thus, the CE field has institutionalised through structures that governs the actions of the field members.

### 5.5. Interaction of the CE concept and its related field

In the discussion so far, the changes in the concept and field were mapped separately, and the field characteristics were foregrounded. In this section, the empirically observed changes in the concept and the field will be amalgamated to assess how the concept and the field interact, thereby outlining a process typology that allows explaining the concept-field dynamics.

Firstly, the evolution of the CE concept-field can be articulated through a lifecycle that scholars have suggested following stages of birth, expansion, maturity (Abrahamson & Fairchild, 1999; Mullins, 1973). Articulating concept-field evolution as a lifecycle would mean an inherent prescriptive logic to this evolution (Kezar, 2011; van de Ven & Poole, 1995; Van de Ven & Poole, 2005). Scholars have mapped this lifecycle as an S-shaped curve (Bhattacharya & Packalen, 2020; Foulonneau, 2014; Foulonneau et al., 2014). The CE concept-field also neatly fits the phases of this lifecycle. The concept-field emerged in the 1990s, started to develop and expand from the early 2000s onwards with the Chinese translation of the CE concept followed by the European translation, and is now on a path to maturity with the field becoming institutionalised. Such lifecycle patterns have been observed in diverse contexts such as pilgrimage tourism (Collins-Kreiner, 2016), management fashions (Abrahamson &



Fairchild, 1999), industrial ecology (Ehrenfeld, 2004), sustainable business models (Lecocq et al., 2010). However, there are idiosyncrasies in each concept-field which a lifecycle perspective alone cannot justify. While sustainable business models, IE and CE are all being articulated as a lifecycle but there are differences in the lifecycle of each of the concepts. The argument that I try to make here is that despite the recurring lifecycle pattern in concept-field evolution, there are some idiosyncrasies in every concept-field evolution which must be investigated. All lifecycles cannot be identical; for instance, there could be differences in the S-shaped patterns where the slope of the S-shaped curve, the length of the stages in the S-shaped curve may differ. As Hambrick & Chen, (2008) explain that all fields do not get equal attention, some survive in minor ways, some end up with considerable traction, and some die very soon. Fernandez-Cano et al., (2004) in the context of academic discourse evolution, argue that the lifecycle model is insensitive to the social context in which the discourse is produced and contextual variations. To this end, the CE concept-field is not articulated as a lifecycle alone.

Drawing from the ANT vocabulary by mapping the translation of the CE concept by various actants, i.e., NEF, SEPA, NDRC, EMF, Barroso commission, Juncker Commission, and more recently, the Von der Leyen commission specific mechanisms have been observed. The first mechanism is *problematization*, where different focal actants emerge at different stages to translate the CE concept in a way that aligns with their own organisational goals. For instance, SEPA had the goal of environmental protection and cleaner production in China. Driven by these goals, SEPA translated CE into the Chinese context by implementing them in the existing EIPs. This was followed by the *interessement and enrolment* of new actants by SEPA, such as the State Council, through demonstration projects, networking, and negotiation. However, there was a *breakdown* of SEPA's *problematization* with the entry of the trojan actant State Council and the new focal actant NDRC. The new *problematization* by NDRC was focused on CE as a tool for sustainable economic growth and environmental protection. This was again followed by *interessement and enrolment* by NDRC (and State Council) by a top-down coercive approach through policies and funding. A new chain of translation started in Europe with the entry of EMF; the *problematization* of CE was based on a regenerative industrial system that could enable economic growth. Again, *interessement and enrolment* followed by way of successful issue framing, displaying social acuity, and networking and negotiation. A new chain of *problematization* started as the Barroso Commission issued the CE package focussed on resource productivity and waste management based on their organisational goal. However, there was a *breakdown* in this chain as soon as the Juncker Commission entered the scene, and a new *problematization* of CE started, which was focused on economic growth. Further, Juncker Commission continued successful *interessement and enrolment* through coercive mechanisms of CE related policies and funding. There was a breakdown of the Juncker Commission's framing with the end of their tenure. A renewed *problematization* was started

by the Von der Leyen commission, which was focussed on an ethical resource-efficient Europe and managing climate change.

Therefore, the field can be articulated through a repetitive sequence of problematisation, interessement and enrolment. Often the sequence is broken with the entry of the trojan actants like the State Council and Juncker Commission. This indicates purposeful enactment (Kezar, 2011; van de Ven & Poole, 1995; Van de Ven & Poole, 2005) of the actants in the field through which the CE concept is translated. Each of these actants has a specific goal, for example, promoting sustainable economic growth in the case of NDRC and Juncker Commission or environmental protection and cleaner production like SEPA or promoting the CE transition like EMF. Their goals are enacted through mechanisms like demonstration projects, coercion, displaying social acuity, networking, and negotiation. In some cases there is a breakdown (Van de Ven & Sun, 2011) due to the entry of the trojan actants. This purposeful enactment explains the changes in the concept over the years. In the early stages, the concept was more closely linked to IE and EIP's. In the later stages, the concept developed a closer link to business strategy and communication with the entry of EMF and EC. Thus purposeful enactment of the CE field actants indicates a teleological cycle and the entry of the trojan actants indicate breakdowns in the teleological cycle (Van de Ven & Sun, 2011). Thus, the evolution of the CE concept-field can be articulated through a combination of lifecycle and teleological processes wherein the prescriptive logic of the concept-field is combined with purposeful enactment of the field actants.

In the discussion so far, an important dynamic is the relative absence of dialectic processes in the evolution of the CE concept-field. There is no sign of a dialectic process in this development wherein conflicts emerge between the actants espousing the CE concept's different framings, colliding to produce a synthesis. As discussed earlier much of the discussion on CE follows the optimistic pro-growth narrative. There is limited engagement with alternative socio-cultural approaches like degrowth or steady-state economics. This was also evidenced in the Delphi study, where the choice of concepts indicated by researchers were primarily technical or suiting business requirements rather than transformative socio-cultural approaches. The choice of concepts by researchers to some extent reflects economically and politically framed responses to mounting environmental pressures. The usage expressed by researchers contradicts the resonance that has been proposed between CE and alternative discourses such as degrowth, steady-state economics, conviviality (Calisto Friant et al., 2020; Charonis, 2012; Ralph, 2021; Schröder et al., 2019). Currently, the CE field is predominated by the optimistic pro-growth narrative that aligns with business strategy and communications. However, as noted in the Further Research Avenues from the Delphi study, to allow for a more inclusive and comprehensive discussion on CE and enabling the transition to a more sustainable society, an alignment of CE with transformative socio-cultural approaches is a necessity.



## Chapter 6 Conclusion

This concluding chapter recapitulates the research problem and questions posed at the beginning of the thesis.

Answers to each question are provided based on the analysis presented in this thesis. It also articulates the contributions of this thesis. Finally, a reflection on the limitations, further research agenda is provided before outlining some recommendations.

### 6.1. Introduction

In the introductory chapter of the thesis an overarching research problem was posed: *How and why did the concept of Circular Economy come to receive so much attention? Is it just a buzzword or an emerging field in its own right?* The overarching research problem is operationalised through three research questions. In [Section 6.2](#), each of the three research questions is addressed. Then the overarching research problem is discussed in [Section 6.3](#). Following this, in [Section 6.4](#), the contributions of this thesis are discussed. Next, the research limitations and future research agenda are presented in [Section 6.5](#). The thesis ends with final reflections and recommendations in [Section 6.6](#).

### 6.2. Addressing the research questions

*RQ 1: How has the CE concept changed over the years?*

The CE concept emerged in 1990 in a book entitled: Economics of natural resources and the environment (Pearce & Turner, 1990). In this book, CE was referred to in the context of feedback loops that exist between natural stocks and nature as a sink for wastes. Following this emergence, the CE concept gained very little attention. It was referred to as an alternative to the linear economy, where efficiency would be defined as the effective use of physical resources rather than a purely financial criterion. However, following the conceptual emergence, barring a few mentions, the concept was almost nascent until the early 2000s, when it was adopted in China. With increased practical implementation within existing EIPs in China, the conceptual understanding was drawn from IE's closing the loop principle inspired by German and Japanese practices. Therefore, the conceptual affinity between CE and IE is evidenced during this period. This was the predominant conceptual understanding for almost a decade until the CE concept was adopted in Europe. Following the concept's uptake in Europe, there was a renewed conceptual framing to fit into the EU context. Due to the renewed framing, the CE concept developed as a distinct line of inquiry, distancing itself from IE. The practical implementation of the concept started to widen beyond EIPs into different areas of practical implementation. In terms of language and understanding, the concept was now strongly linked to business strategy and communications. Moreover, there was a shift in the conceptual applications

towards micro-level interventions for sustainable development, such as product design and business models.

*RQ 2: What specific characteristics does the CE field exhibit as different actors assemble around the (evolving) CE concept?*

By analysing the CE field, three field characteristics are foregrounded, i.e., (1) steering of research priorities, (2) fragmented and dispersed field, and (3) institutionalisation of the field

- **Steering of research priorities** - On investigating the motives of the researchers as to why they engage with the CE concept, most researchers stated extrinsic motives such as availability of funding, employment, audience, and additionally other motives such as higher education and the fact that CE ‘fits’ their research context. However, apart from one researcher, none cited a problem-solving motive in using the CE concept. That means none of the researchers mentioned that they use the CE concept because it enables them to address issues about sustainability. The Delphi study also indicated that researchers do not consider CE a dominant concept to address sustainability-related problems because of its inadequacy to address the social dimensions of sustainability and long-term environmental concerns. Therefore, based on the Delphi study and the interviews a clear pattern emerges where researchers engage with the CE concept not because they consider it to be logically superior to its competing concepts but due to the research priorities being steered by external motives (funding being one of the main ones). This is precisely what Nowotny et al., (2003, 2006, 2013) have called ‘steering of research priorities’ a characteristic of Mode 2 knowledge production. This change is driven by a lack of public funding for research and the corporatisation of universities in the last 30 years. This changing nature of the science system is evident in the CE field, wherein CE research priorities are being steered (primarily through hard funding) by supranational, national-level organisations, research councils, industry practitioners. This steering of research priorities through policy represents the motives of a capitalist order with profit-oriented firms as a basis and predominantly promotes a biased optimistic narrative of CE wherein CE is considered the main driver for sustainability transitions and efforts are being made to find ways to achieve it; however, it does not question the objectives associated with the CE concept. This observation about the field also directs attention to the science-policy interface where CE research is not informing the CE narrative in policy discussions. Instead, it exhibits CE research as an object of CE policy.
- **Fragmented and dispersed field** - In analysing the field, it is found that new conceptual understandings emerge as various actants translate the CE concept in different geographical settings. As this translation process unfolds, the field is becoming fragmented and dispersed in terms of conceptual understanding. For instance, the Chinese translation of the CE concept is that of a mode of economic development that protects the environment, prevents pollution, and facilitate

sustainable economic growth. In contrast, the European translation of the CE concept by the Juncker commission was a means to improve the economic competitiveness of Europe by maintaining resources in the economy for as long as possible and minimise waste generation. Moreover, there are divergent growth narratives for CE within the field. One promotes an optimist pro-growth perspective related to CE, and another aims to align CE with strong sustainability narratives like degrowth and steady-state economics. In the field's current state, these competing narratives exist in a way that causes the field to be fragmented and dispersed despite calls to align CE with strong sustainability narratives, as evidenced in the Delphi study. CE's application in various disciplinary contexts also contributes to this fragmentation and dispersion. As evidenced in the co-authorship patterns, different areas of CE research exist in fragmented parts. For example- LCA studies exist in a silo from studies on circular business models. Despite the fragmented and dispersed nature of the field, the CE concept's boundary object like character allows having crossovers and incursions within the field.

- **The institutionalisation of the field-** The CE field has been institutionalised, which is evident through established institutions around the CE concept. In academia, such institutionalisation is apparent through the dedicated professorships, chair, other academic positions, the establishment of CE centres in universities, specific higher education courses in universities imparting CE education, dedicated conferences on the CE concept. In policy, such institutionalisation is evident through the stream of policies that have been formulated in China and Europe in a way that CE is China's national development strategy (Mathews & Tan, 2016) and the political economy of Europe (Lazarevic & Valve, 2017). In the European Commission, there is a dedicated Directorate-General for CE. In practice, institutionalisation is evident through all major consulting companies providing CE related consulting advice and publishing reports on CE. Moreover, specific private institutions like the EMF, Circle Economy are set up with a core mission to promote the CE. Thus, there is deep institutionalisation of CE in academia, policy, and practice.

*RQ 3: How do the CE concept and its related field evolve? What mechanisms and processes underpin their interaction and evolution?*

The concept-field evolution at first glance can be first articulated as a lifecycle wherein it has undergone a unitary sequence of birth, expansion, and maturity so far. However, articulating the concept-field evolution as a lifecycle alone does not bring forward the idiosyncrasies in the concept-field. In the evolution of the CE concept-field, different focal actants emerge at different times and geographical settings throughout the lifecycle. Through problematisation, interessement and enrolment, each of these focal actants translate the CE concept. This chain of translation is often broken when a trojan actant betrays the existing actor network. In China, SEPA started the initial problematisation wherein they framed CE to enable environment protection and cleaner production. The next stage of translation was

interessement, and enrolment wherein SEPA successfully enrolled more actants into the network through demonstration projects, networking, and negotiation. However, this translation chain was broken as the State Council emerged as the trojan actant. NDRC became the new focal actant starting a new chain of translation wherein CE was framed as a concept that promotes sustainable economic growth. In Europe, EMF began the chain of translation by problematisation wherein they framed CE as an ‘economically viable solution.’ Further interessement and enrolment happened through issue framing, displaying social acuity, demonstration projects, networking, and negotiation. EMF continues the successful chain of translation. Further, the Barroso commission started another chain of translation by problematisation, where CE was framed in terms of resource efficiency and waste management. This translation chain was broken as the Juncker commission (trojan actor) entered and started a new translation chain by problematisation, where CE was framed from a purely economic growth agenda.

In the CE field, there is a tendency to go by an optimistic growth narrative promoting ‘sustainable growth.’ The entry of NDRC in China and the Juncker Commission in Europe signify moments wherein the framing of CE was changed to pursue sustainable growth. On further investigating, a pre-ponderance of an optimistic growth narrative is also found in the academic discourse. Thus, most of the field exhibits this optimistic growth narrative wherein CE will enable to decouple the economy and environment; however, the core notion of growth or even other objectives of CE remain unquestioned. An alternative narrative that aligns CE with strong sustainability concepts like degrowth and steady-state economics exists in a fragmented state. In the evolution of the concept-field focal actants emerge, and through their purposeful enactment a predominant framing of CE is produced. However, there is a relative absence of any dialectic process in the field. This means that the dominant framing of CE that promotes a pro-growth perspective in the capitalist order does not interact with the other narratives that promote degrowth or steady perspectives. This was also evidenced in the Delphi study while some scholars in the literature propose a resonance between CE and strong sustainability narratives; however, in the choice of the concepts used by the researchers, they do not specifically outline any of these strong sustainability concepts. The emergence of focal actants and their purposeful enactment to translate CE in specific ways according to their own goals fits the definition of teleology. Thus, the CE concept-field interact and evolve through a combination of lifecycle and teleological processes and a relative absence of any dialectic process. The specific mechanisms can be understood by the translation process itself wherein focal actants engage in problematisation, interessement and enrolment through coercion (funding and policies), demonstration projects, displaying social acuity, networking, and negotiation.

### 6.3. Addressing the overarching research problem

With the institutionalisation of CE through routine actions in academia, policy, practice, CE has transcended beyond being just a buzzword. In the context of academic fields, Hambrick & Chen, (2008), p. 34 define a group of actants in academia as a legitimate academic field ‘when a substantial number of major universities designate positions for its members, grant tenure to its members, and allow its members to supervise graduate students. CE as an institutionalised field is starting to fulfil these conditions, as evidenced in the discussion of the field characteristics. However, scholars have outlined other aspects essential while considering field status, for instance, a shared and established conceptual understanding and an authoritative structure that maintains conceptual coherence (Ehrenfeld, 2004; Lüdeke-Freund & Dembek, 2017). In the case of CE, the interpretive variability of the CE concept as a boundary object allows different actants to translate it as it fits their context. On the one hand, this increases the prominence of the CE concept, and more actants enrol into the actor-network; it also means that the conceptual understanding is being segregated with the absence of a shared understanding. This shared understanding is also becoming increasingly difficult to establish as CE is being translated in different geographical contexts with different governance structures and different goals. Over 300 research articles<sup>20</sup> on CE argue that there is *no accepted definition of CE*. Currently, the only shared understanding seems like CE is being juxtaposed with the linear economy. Moving to the second aspect, as different translations of the CE concept emerge in different geographical settings, is there an authoritative structure in the field? To this end, the role of EMF as the focal [actant](#) in the actor-network establishing itself as an obligatory passage point is important. EMF’s butterfly diagram, which gained much attention and enrolled more actants into the network and the growing CE100 network, indicates how it established an authoritative control over the network. Through successful issue framing, displaying social acuity, demonstration projects, networking and negotiation, EMF has successfully enrolled more actants into the actor network. However, assigning EMF as the authoritative structure in the field also means that the dominant framing of CE will continue to be business-oriented and pro-growth. As indicated during the interviews, EMF, through its pro-growth optimistic narrative of CE, does not engage with the strong sustainability narratives of degrowth or steady-state economics. This means that the relative absence of dialectic processes in the field would continue. The success of the authoritative structure would entail engaging in dialectic processes through which conceptual coherence can be achieved. In the case of IE, the Journal of industrial ecology became the authoritative structure maintaining conceptual coherence (Ehrenfeld, 2004). While a recent journal Circular Economy and Sustainability, has emerged, its position as an authoritative structure remains doubtful as the field characteristics of CE indicate that research priorities are steered wherein CE research is developing as an object of policy and not informing it.

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<sup>20</sup> Based on google scholar search dated 29<sup>th</sup> August 2021

CE is more than a buzzword and can be called an emerging field; however, not without caveats. It is a field that has been institutionalised around a concept with segregated conceptual understanding. In the current stage, the only shared meaning system that the CE field partakes in is using the linguistic object ‘circular economy’ juxtaposed with the linear economy. Establishing a shared meaning system is an urgent task because it aids cooperation amongst international actants to achieve sustainability transitions. However, this shared meaning system is not easy to establish especially when translations have happened across geographies in different governance structures and across countries which are at different stages in their development (for instance China is a sovereign state and EU is a supranational organisation in different stages of development). As scholars argue for a global CE transition (Garcia-Bernabeu et al., 2020; Levoso et al., 2020; Lieder & Rashid, 2016; Repp et al., 2021; Strothman & Sonnemann, 2017; Swain & Sweet, 2021) the implication of this lack of shared understanding on global value chains has to be explored further.

Further, the why and how of CE’s prominence can be summarised into three points discussed. *First*, it is not the logical superiority of the CE concept that underpins its prominence; rather, it stems from the ‘extra logical’ superiority of the status of the actants who translated the concept according to their organisational goals. As indicated during the Delphi study, despite the efforts to make CE an inclusive concept, there are inadequacies in how CE addresses the social dimension of sustainability and long-term environmental concerns. Thus, researchers try to seek other concepts that enhance the conceptual understanding of CE (however also important to note that the predominant choice of concepts as evidenced in the Delphi study were business-oriented or technical and not transformative socio-cultural approaches). Since several concepts have shared conceptualisations with CE, it is not the logical superiority of CE that has made CE more prominent. Rather, the superiority is based on the elite or high-status individuals or organisations who developed power and influence as they translated the CE concept in ways that fits their organisational goals (and of other actants who enrolled into the network). For instance, in China, SEPA initially framed CE to fit their goals of environmental protection and cleaner production. Further, the State Council and NDRC framed CE in a way that enables sustainable economic growth. In Europe, EMF’s goal was to engage businesses and policymakers; hence, their framing of CE was business-oriented, focusing on CE’s economic potential. Barroso Commission’s framing was focused on resource efficiency and waste management. Further, Juncker Commission’s framing was focused on driving an economic growth agenda through CE. Each of these translations of the CE concept by the actants who engaged with the concept was based on their own organisational goals. The power symbolism of these actants in the actor-network allowed them to enrol more actants, further increasing the prominence of CE. *Secondly*, CE’s boundary object-like character also attributes to its prominence. As a boundary object, the interpretive variability of the CE concept allowed it to

straddle in the domains of different concepts and allowed actants to translate it as per their organisational goals. Owing to this interpretive variability, CE now has over 100 definitions, enabling actants to choose what ‘fits’ their context. *Thirdly*, it was the ‘power of association’ as articulated by actor-network theorists (Czarniawska & Panozzo, 2008; Latour, 1984) wherein an idea that is well anchored or does not threaten the institutionalised thought structure enjoys more prominence. As evidenced earlier despite attempts to align CE with strong sustainability concepts such as degrowth or steady-state economics, the predominant framing fosters an optimistic growth narrative pertaining to CE. This optimistic narrative allows business as usual, i.e., an ongoing and unchanging situation despite difficulties or disturbances. This does not threaten the existing capitalist order; hence, actants can translate the concept in ways where it is framed to foster ‘sustainable growth.’ As argued by Victor 2008, the notion of growth under the banner of sustainable development now promotes more of the same rather than a radical departure from the pro-growth perspective as the top policy objective. Thus, there is no paradigm shift underlying the current framing of CE. With limited critique towards the CE concept and a dominating perception that CE is always good, the concept’s prominence is largely unquestioned. However, to enable a fruitful development of the CE discussion is important to enable dialectic processes in the field so that espousing different perspectives of the CE concept (pro-growth and degrowth) engage in a dialogue to produce a synthesis.

#### 6.4. Contributions

This thesis has been presented as a monograph in Part A and three papers in Part B that provide insights for the monograph. The contributions of this thesis are discussed in this section.

Firstly, CE has now become an inescapable part of sustainability-related discussions. At this juncture, this thesis takes a step back to investigate the prominence of the CE concept by analysing the concept-field evolution. By doing so, this thesis responds to the call to incorporate a broader politico-economic and cultural context in which CE is developing, which has been argued to be an urgent task given many claims are being made in its name today (Corvellec et al., 2020). This thesis reflects on the dynamically growing prominence of CE amidst different stakeholders by incorporating ANT. The questions posed in this thesis could be explored from different angles, such as philosophy of science, sociology of science, contemporary framings of knowledge production. However, situating the research in one of these strands of literature would entail making certain a priori assumptions regarding the process typology and inclusion of actors. However, by using ANT, no such a priori assumptions are made. Through empirical evidence, it was determined that the CE concept-field is evolving through a combination of a lifecycle and teleological process. With the plethora of concepts to address sustainability-related issues, it seems like a language game. At the face of it, the evolution of a concept-



field to address sustainability-related issues can be articulated as a classic life cycle, i.e., birth, expansion, maturity (and decline). Articulating developments as a lifecycle is often a seductive approach and has been used quite popularly. However, merely articulating the development of a concept-field as a lifecycle could mean that obvious and tautological answers are given to explain the dynamically growing prominence. For example, 'CE was adopted because its time had come' or 'CE gained enough traction to make its use inevitable' (Bleakley, 2012).

Using a data-driven approach underpinned by ANT provides evidence of how a lifecycle alone cannot express the idiosyncrasies of a concept-field evolution. In the case of CE, it is observed that a teleological process has supported the lifecycle process; it also shows the relative absence of a dialectic process which implies the absence of dialogue/debate among different parts of the field. It can be the case that for another concept-field, there is a dialectic process that supports the lifecycle of the concept-field. In providing a detailed account of concept-field evolution, this thesis provides evidence to look beyond a lifecycle process in concept-field evolution. This will enable understanding of the specific circumstances in which a concept field develops and its characteristics. Moreover, ANT allowed the exploration of various actants' roles within the academic and non-academic setting, thus revealing specific field characteristics pertaining to CE. Thus, this thesis provides evidence of how ANT can study dynamically growing fields and explain how the social order around such fields has come into being rather than taking it at face value.

Secondly, by undertaking the data-driven approach, this thesis also reveals characteristics of the CE concept-field. It was found that the CE concept-field exhibits characteristics of Mode 2 knowledge production. This is a response to the continued critique for Mode 2 knowledge production that scholars have provided over two decades (Crompton, 2007; Hessels & van Lente, 2008; Shinn, 2002; Weingart, 1997; Zapp & Powell, 2017). In their detailed assessment, Hessels & van Lente, 2008 call for a further empirical investigation on each of the characteristics of Mode 2 knowledge production separately. To this end, in exploring the CE concept-field, one of the characteristics of Mode 2 knowledge production specifically comes to light, i.e., steering of research priorities. This thesis corroborates this characteristic of Mode 2 knowledge providing empirical evidence. Along with that, it also outlines what the outcome of such steering has been on the CE concept-field.

Thirdly, in analysing the characteristics of the field, this thesis also investigates how the CE concept relates to pro-growth and degrowth perspectives. In a study by (Schröder et al., 2019), there is a call to align various sustainability narratives of CE and degrowth. However, there is no systematic assessment of how CE relates to growth and degrowth in the literature. By analysing the different growth narratives in the CE literature (which have been presented in Figure 6-13), it is revealed that the predominant



narrative in the CE literature is one that fosters continued growth and the different narratives (of continued growth and degrowth) exist in a fragmented form. Thus, by providing evidence for the lack of dialectic perspectives in the CE literature, these results could supplement calls to align different sustainability narratives with the help of empirical evidence.

Fourthly, in Research paper 3, the first interpretive assessment of the CE academic discourse combines a quantitative text mining methodology and a global Delphi study. It explores in detail the evolution of the CE academic discourse, the positioning of CE amidst its competing concepts and provides an informed research agenda.

Fifthly, specific methodological contributions have been made in the thesis. To begin with, the use of topic modelling to analyse the evolution of research topics in research paper 1 had not yet been applied in the CE context. In research paper 2, a detailed computational pipeline has been presented to detect semantic changes in concepts used in academic discourse. Earlier accounts of semantic changes mainly were based on core vocabulary and slang. The pipeline presented in research paper 2 specifically allows assessing semantic changes in concepts used in the academic discourse. In research paper 3, a combination of Delphi study and topic modelling has been presented, enabling us to provide a detailed interpretive assessment of the CE academic discourse. This mixed-methods approach is also a novel contribution to the research community.

## 6.5. Limitations of the research and future research agenda

The analysis using ANT carries with itself a degree of subjectivity because several decisions are left to the researcher. For instance, which actor to follow, the observations made about a specific actor and which actants to include in the network. To keep the study within reasonable bounds achievable within the PhD timelines, a decision was made to focus on the actants' more 'global' perspective. However, I also acknowledge that organisations in certain local contexts also influence the CE narrative around them, for instance, Circle Economic in Netherlands or SITRA in Finland. However, these actants were not chosen because their roles cannot be termed as 'focal.' If a similar study on the prominence of CE in the Netherlands or Finland were to be conducted, then these organisations would possibly be of greater importance. The current choice of actants is based on those that have influenced CE's overall translation on a global scale. Based on this limitation of inclusion of different actants, a possible research direction that can be explored is how the CE concept field's trajectory develops in specific contexts, for instance, specific countries, and how is that different from the global assessment that this thesis has provided. This will also enable us to compare the speed at which CE translations and

enrolment of actants came about in specific contexts. To this end, the first research question proposed is:

*How does the evolution of the concept-field happen in countries within the EU (for instance, the Netherlands, Finland, UK)? How similar or dissimilar is the concept-field evolution compared to the typology presented in this thesis?*

The investigation in this thesis is based on a single concept, i.e., CE, which enables an in-depth exploration of the CE concept and limits the ability to generalise the findings of the concept-field interaction to other concepts. Delphi evidence Given the complex conceptual landscape of sustainability issues with overlapping, synergetic and embedded concepts, one future direction could be a comparative study of CE with other concepts addressing sustainability-related matters that would deepen the insights into what development trajectories do concepts their related fields take. A specific direction, in this case, would be the comparison of CE with alternative socio-cultural approaches such as degrowth and steady-state economics and how they can be aligned. So, for instance, how would CE's trajectory compare with the competing concepts presented in research papers 2 and 3. This could be a theory-building exercise to explain concept-field development further. According to Bonaccorsi & Vargas, (2010) such comparative analysis between concepts is also helpful in understand science's dynamics. To this end, the second research question is:

*How similar or dissimilar is the concept-field evolution of different concepts pertaining to sustainability-related issues?*

The coverage of the scientific discourse on CE is only until May 2019. Since the analysis followed a sequential research design wherein the results from the text mining were used as input in the Delphi study, the coverage of the academic discourse could not be updated further. Given the pace of growth that the CE concept is witnessing, a status check by revisiting the findings and changes in the concept later would be a helpful research direction. This would also entail including the outcomes of the translation of the Van de Leyen Commission and the Latin American translation. Lastly, there was a limitation in engaging with Chinese researchers or policymakers in the Delphi studies and interviews. Although attempts to communicate to several researchers or policymakers were made, only 3 scholars could be accessed for the study.

## 6.6. Final reflections and recommendations

It is by no means the intention of this thesis to confute or reject the CE concept; instead, this thesis pleads for more cautious and circumspect use of the concept by the actants in the field. Echoing the thoughts of one of the interviewees, "I am critical because I want it to work." To this end, this thesis

concludes with four recommendations based on the insights gained during this PhD journey. Firstly, the analysis reveals the steering of research priorities pertaining to CE. The resultant outcome being that a biased optimistic narrative about CE fostering continued growth is predominant in the academic discourse. This narrative considers CE as the key enabler for sustainability transitions, and the focus is on how to achieve CE. However, in this narrative, the core objectives of CE are not questioned. This, in turn, also leads to the relative absence of dialectic processes in the CE field where the narrative of fostering continued growth by the CE transition and the calls to align CE with strong sustainability narratives (like degrowth and steady-state economics) happen in silos. CE research is now developing as an object of policy and not informing policy objectives. Since CE related funding is being driven by politicians who provide the funds to research councils for disbursement, there is a tendency to promote research aligned with the policy objectives. At the risk of sounding too sanctimonious, policymakers must be more open towards competing discourses and not steer research priorities in a direction where the other side of CE is left unexplored. There is an urgent need to look beyond CE's optimistic narrative, which looks for lessons that enable the transition to a CE. Increased soft funding rather than hard funding can be a possible step in this direction to allow researchers to provide relevant outputs and not be tied by deliverables of short-term funding. In assessing the changes in the academic discourse, it was found that the next stage of CE translation will be in the Latin American context. This translation could mean further fragmentation and disintegration of the field because of the difference in governance structures in Latin America, China, and Europe. However, based on the assessment of the concept-field, attention has been drawn towards problematic areas in the CE field, i.e., steering of research priorities to produce a biased optimistic narrative, absence of a dialectic process in the field. The argument here is that there is evidence for the Latin American actants translating the CE concept not to consider the current translation of the CE concept as exemplars. Actants enrolled on the actor-network in Latin America must acknowledge the success and critiques of the current conceptual understanding.

During the Delphi study and the interviews, it was highlighted that a lot is relabelling of older concepts to CE, which is possible because of the boundary object like the character of CE providing it with immense interpretive variability. Plain relabelling of older concepts to CE seeking publication or funding opportunities might create a situation like the 'Sokal Hoax' in the CE context. This plain relabelling threatens the production of a more meaningful discourse around the CE concept. Therefore, researchers must be more cautious in the use of the CE concept. This is again tied to the lack of shared conceptual understanding of CE, and as one of the interviewees mentioned, "*We are not sure what is CE and what is not.*" Lastly, the institutionalisation of CE in higher education institutions is a significant next step towards educating the next generation on matters of concern. However, during the interviews, it was pointed out that often students come with a very optimistic perspective about CE, not aware of the trade-offs. Given the current framings of CE, which pose CE '*as the only way forward,*'

there is a possibility of a dogmatic perception in CE higher education. Thus, academics in higher education must ensure that the critical perspectives of CE do not remain masked underneath the burgeoning celebratory and over-enthusiastic discourse.

## PART B

During the PhD journey 3 research papers were published which are presented as Part B of the thesis. However, before proceeding further with Part B it is essential to highlight that these papers were written as individual research papers and also geared towards different audiences. For instance, research papers 1 and 2 have been published in computer science related outlets i.e., Lecture Notes in Computer Science and a book titled Computational approaches to semantic change and research paper 3 in Journal of Cleaner Production, an international, transdisciplinary journal focusing on Cleaner Production, Environmental, and Sustainability research and practice. There are two specific points that I would like to highlight before proceeding further. In research papers 1 and 2, I articulate knowledge production through evolutionary epistemology which posits that knowledge generation follows an evolutionary mechanism. While this is a broader perspective of scientific knowledge production as the PhD project progressed and I started to focus on different process typologies I was able to detect a lifecycle and teleological aspect in CE concept-field which has been presented as one of the conclusions in Part A of the thesis. Further, when research paper 2 was being written the Delphi study was still in progress where only 66 researchers had responded till then. However, as it went ahead the total number of experts who participated was 68 which is the number mentioned in research paper 3.

# Research Paper 1: Studying the Evolution of the ‘Circular Economy’ Concept Using Topic Modelling

*Mahanty, S., Boons, F., Handl, J. and Batista-Navarro, R., 2019, November. Studying the Evolution of the ‘Circular Economy’ Concept Using Topic Modelling. In International Conference on Intelligent Data Engineering and Automated Learning (pp. 259-270). Springer, Cham.*

**Abstract:** Circular Economy has gained immense popularity for its perceived capacity to operationalise sustainable development. However, a comprehensive understanding of the concept, characterising its evolution in academic literature, has not yet been provided. As a first step, we apply unsupervised topic models on CE academic articles to identify patterns in concept evolution. We generate topics using LDA, and investigate topic prevalence over time. We determine the optimal number of topics for the model ( $k$ ) through coherence scorings and evaluate the topic model results by expert judgement. Specifying  $k$  as 20, we find topics in the literature focussing on resources, business models, process modelling, conceptual research and policies. We identify a shift in the research focus of contemporary literature, moving away from the Chinese predominance to a European perspective, along with a shift towards micro level interventions, e.g., circular design, business models, around 2014–2015.

**Keywords:** *Circular economy, Topic modelling, Concept evolution*

## 1. Introduction

In the last 15 years or so the concept of Circular Economy (CE) has gained immense traction amongst academics, practitioners and policy-makers for its perceived capacity to operationalise sustainable development (Geissdoerfer et al., 2017b; Ghisellini et al., 2016a; Kirchherr et al., 2017a). CE is defined as “an economic system that replaces the ‘end-of-life’ concept with reducing, reusing, recycling and recovering materials in production/distribution and consumption processes” (Kirchherr et al., 2017a). However, the concept of CE is not new (Blomsma & Brennan, 2017) and its theoretical underpinnings stem from a variety of fields such as cleaner production, industrial ecology, and environmental science (Lazarevic & Valve, 2017b). Since its inception the definition of CE has been extended to and evolved across a broad spectrum of cross-disciplinary subjects such as industrial ecology, regenerative design, cradle to cradle, performance economy (Merli et al., 2018a). Given that the concept of CE is “not new” (Blomsma & Brennan, 2017) and that it “has evolved” (Bocken et al., 2016; Geissdoerfer et al., 2017b) it is of interest to understand what is the way by which the concept of CE evolved over the years, emerging from its antecedent concepts to becoming a popular concept. To enable a careful empirical study, we build on the work of Jiao & Boons, 2017 and distinguish the label of ‘circular economy’ from the textual elements that become attached (or detached) to it over time, which are again distinct from the empirical practices that are referred to with the label of CE. Although the origins of the concept date back to the 1970s, it is only in the last 15 years that it has been referred to directly and independently

in academic literature, distancing itself from its antecedent concepts (Prendeville et al., 2018). CE has been discussed extensively in academic discourse, which is evident in the increasing number of publications. However, its development has not been adequately understood from a temporal perspective characterising the pattern of its evolution using data driven methods. There have been studies in the past addressing CE from a temporal perspective such as the work of (Blomsma & Brennan, 2017) where they adopt a narrative approach in explaining the emergence of CE in prolonging resource productivity. While such qualitative work is valuable, with the vast and rapidly growing literature on CE and limited cognitive capacity of humans (Shin et al., 2018) it is a difficult task to address all aspects of the CE concept. Thus, we use a quantitative data-driven methodologies to complement expert knowledge in the field by providing a holistic picture of the literature, unravel new findings and aid the formulation of new research questions. As grounding for this work we study the development of CE by conceptualising it as a process, drawing inspiration from the work of Boons and colleagues (Boons et al., 2011, 2014). We consider the development of CE as an evolutionary process, adopting the view that there is an analogy between knowledge gain and biological evolution (Bradie, 1986). According to this view, in the course of evolution, species become more adaptive to their natural environment by undergoing natural selection. Likewise, scientific progress is a result of selection mechanisms at the individual level (i.e., scientists) and at the group level (i.e., scientific communities). Scientists perform studies and produce new knowledge, a large part of which is academic literature. They select scientific communities to join or form based on cognitive, social and philosophical grounds (Hull, 2010). In this paper, we specifically analyse the CE concept in academic literature over a period of time noting periods of development and major structural changes. We make use of CE academic literature as the basis for carrying out our analysis, employing an unsupervised machine learning method, i.e., topic modelling based on Latent Dirichlet Allocation (LDA) (Blei et al., 2003b). This method generates topics from the CE literature where the topics constitute sets of textual elements that get attached (or detached) to the label of ‘Circular Economy’ over time enabling our empirical study.

## 2. Background

We draw inspiration for this paper from the work of Boons and colleagues (Boons et al., 2011, 2014a) who addressed process-oriented research questions in studying industrial symbiosis. They put forth the defining feature of process-oriented studies as viewing reality as a stream of events rather than a stable entity. In our study, we employ the backward approach proposed by Boons and colleagues (Boons et al., 2014a) whereby the outcome of interest is already known and processes leading to it are being uncovered. In our case the popularity of the CE concept in academic discourse addressing questions pertaining to sustainability is the outcome of interest and our aim in this paper is to address: “What is the way by which the concept of CE evolved in academic literature?” In order to define a process we need to define the central subject in the process (Spekkink, 2013). A central subject in the process can



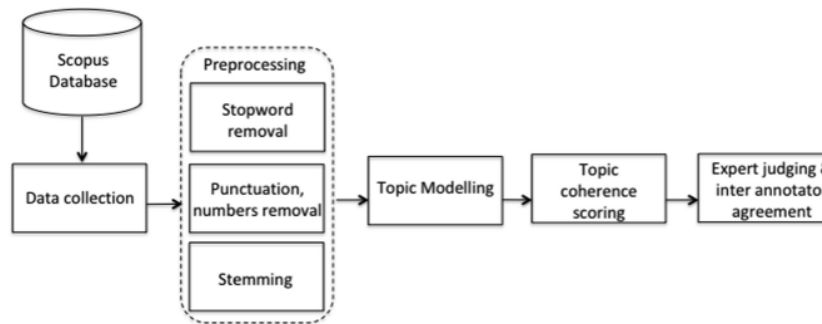
be any kind of entity such as an individual actor, a group of actants, a lineage, a social movement or a machine (Hull, 1975). The central subject in our process study is the concept of CE. A concept is defined as a mental representation of cognitive agents, which are crucial to psychological processes such as categorization, inference, memory, learning and decision-making representing through a label (Goertz, 2006; Margolis & Laurence, 2005). In order to define these concepts, members of the scientific community use the same language i.e., ‘lexicon-kind terms’ at the very least (Kuhn, 1990). Thus, the concept of CE will be associated with certain terms. The evolution of the CE concept will be studied by way of understanding the evolution of its associated terms. This brings us to our approach of using LDA topic modelling where the central subject i.e., the label ‘Circular Economy’ is fixed and we assess the evolution by the associated terms (generated from the topic model) with the central subject. LDA has been used as a methodology extensively to assess topics and its evolutionary pattern in the computer science domain such as evolution of topics in the Advanced Computational Linguistics (ACL) articles (Hall et al., 2008b), software development (Hindle et al., 2009), academic articles in the CiteSeer repository (Bolelli et al., 2009), source code histories (Thomas et al., 2014, 2011). However, in the area of sustainability research this methodology has not yet been extensively implemented. Shin et al., 2018 in their study to summarise sustainability literature in maritime studies have used LDA topic modelling however they do not assess the evolution of topics. Our application of this methodology on articles related to CE will enable summarising and assessing evolution of the topics over time which has not yet been applied in this field.

### 3. Methodology

Our approach to understanding the evolution of CE is depicted in Fig. 1. In this section, we describe in detail the steps involved, i.e., (a) Data collection and pre-processing, (b) Topic modelling (c) Topic coherence scoring (d) Expert judgement.

#### 3.1. Data collection and pre-processing

The analysis in this paper is based on academic articles published on CE. Data was collected using the Scopus database from 2005 to May 2019. We chose Scopus as it is considered to be one of the largest abstracts and citation databases of peer-reviewed literature, including scientific journals, books and conference proceedings (Nobre & Tavares, 2017).



**Fig. 1.** Diagram depicting our proposed approach

The keyword “circular economy” was used to arrive at selected articles. There are other terms, which have similar conceptualisations as circular economy and often used interchangeably (Geisendorf & Pietrulla, 2018). However, we limit our search criterion because we are interested in the use of the exact verbiage. We have used abstracts as a proxy for full articles, since abstracts are a compact representation of the whole article normally containing enough key words about research themes (Griffiths & Steyvers, 2004; Sun & Yin, 2017b). We obtain 3437 results from our search criterion out of which we consider 3300 and omit 137 due to unavailability of abstracts. The data (3300 abstracts) are read in a CSV format into the ‘tm’ (Feinerer, 2013) package in R and standard text mining pre-processing steps are applied over the entire corpus. These steps are as follows:

- (1) Lowercasing the corpus, which prevents a word with different capitalisation from being mistaken as two different words.
- (2) Removal of standard stopwords such as “a”, “an”, “and”, “the”. Such words do not contain information that is required in the analysis and impair the accuracy of the results (Shin et al., 2018)
- (3) Stemming of terms is conducted to remove pluralisation or other suffixes and to normalise different variations of the same word. This technique is often applied in text mining, in order to reduce similar words to a unique term (e.g., “predicting” and “predictive” are transformed into “predict”) (Kao & Poteet, 2007)
- (4) Additional pre-processing steps involve removing numbers, punctuation characters, and white spaces to avoid any impairment of the topic model results.

### 3.2. Topic Modelling

Our analysis is based on Latent Dirichlet Allocation (LDA) (Blei et al., 2003), a generative probabilistic model of a corpus that represents documents as random mixtures over latent topics where each topic is a distribution of words. Our intent in this paper is to generate topics and then investigate topic prevalence over time. One could argue that LDA does not explicitly model temporal patterns in a text corpus and there are other models, which have been developed to consider the time dimension such as Dynamic Topic Models (DTM) (Blei & Lafferty, 2006) and Topics over Time (TOT) (Wang & McCallum, 2006). DTM represents time as a discrete Markov process, where topics themselves evolve

according to a Gaussian distribution. This model, however, penalizes abrupt changes between successive time periods, discouraging fluctuation in topics over time (Chen et al., 2016). Given the nature of our data, which has abrupt fluctuations in terms of sudden rise in the production of articles, we anticipate that there will be fluctuations in topic proportions in successive time periods. Hence, we do not prefer using this model for our analysis. TOT represents time as a continuous beta distribution, solving the issue in DTMs. However, the beta distribution is still inflexible since it assumes that evolution of topics will have only a single point of rise and a single point of fall in the entire corpus (Chen et al., 2016). This means that the model will not accommodate a situation where a topic has a period of rise followed by a fall and then a subsequent rise. Hence, we choose LDA, which is a simple and intuitive model, and conduct some simple calculations after generating the topics and use it to assess topic evolution. We use the 'lda' (Chang, 2017) and 'topic models' (Grun & Hornik, 2011) package in R to generate the topics. We apply LDA over the entire corpus together and then calculate the probability distribution across topics for each document. The topic probabilities for each topic are then summed over each year based on the time stamp associated with each document and visualised graphically in a stacked plot to assess the trend in the topics over the years.

### 3.3. Automatic Topic Coherence Scorings

For parameterised models such as LDA, the number of topics ( $k$ ) is a predetermined criterion. There is emphasis on the selection of  $k$  since it impacts the interpretability of the topic model, a lower value can divide the corpus into generic semantic contexts while a higher value can generate overlapping or uninterpretable topics (Zhao et al., 2015). The determination of  $k$  can be based on scientific evidence or human judgement (Shin et al., 2018). In this section we discuss our approach for determining the optimal value of  $k$ . Topic coherence measures score a single topic by measuring the degree of semantic similarity between high scoring words in the topic thereby distinguishing between semantically interpretable topics and topics that are artefacts of statistical inference (Stevens et al., 2012). The two coherence measures, which are designed for LDA, matching well with human judgements of topic quality are: (a) the UCI measures (Newman et al., 2010), which are calculated over an external corpus such as Wikipedia. This metric is an external comparison to known semantic valuations (b) the UMass measure (Mimno et al., 2011), which is an intrinsic score that computes coherence scores over the original corpus that has been used to train the models. Rosner et al., (2014) in their study compare the correlation of various coherence measures with human judgment and the UCI metric is shown to be significantly outperforming the UMass metric. Although any-any and one-any metrics slightly outperform the UCI metric but they pose challenges like exponential running time and difficulty in practical application. Hence, we chose the UCI metric to calculate coherence scores and determine the quality of topics.

### 3.4. Evaluation

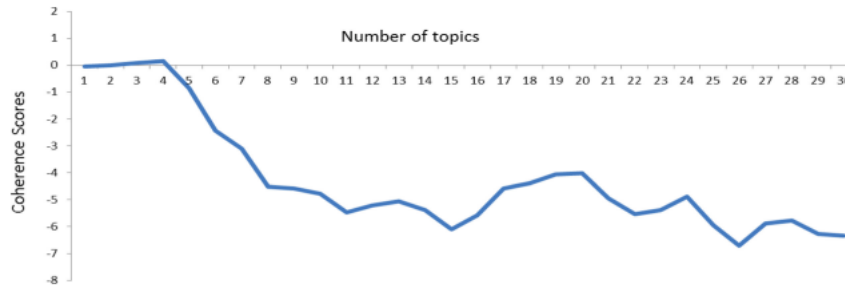
It is difficult to judge if the results generated from the topic modelling are entirely meaningful given it's an unsupervised method and there exists no gold standard list of topics for comparison. Whilst we tend to follow scientific evidence in this process, there have been studies showing automatically generated higher coherence scores could also mean lower topic interpretability in some cases (Chang, Boyd-Graber, Wang, et al., 2009). The gold standard for evaluation of topic coherence is human-produced topic rankings (Röder et al., 2015). This line of thought leads us to combining automatically generated coherence scores with expert opinion in evaluating the performance of our topic model. Thus, we conducted a workshop with seven participants who are active researchers in different application areas of CE. We consider their expert judgment in validating the topic model results. The workshop aimed to address two questions specifically: (a) Is there semantic coherence in the topics generated? (b) Are all aspects of the CE literature covered in the topic model results? To further validate the results and the human interpretability of topics we also calculated agreement between our approach and the experts in identifying the topics, based on F-measure (also known as F-score). In calculating the F-score the topic annotations by experts were treated as gold standard and those from the authors as response.

## 4. Results

In this section, we present the results we obtained upon conducting the evaluation strategy that we discussed in the previous section.

### 4.1. Optimal Number of Topics from Automatic Coherence Scoring

We compute UCI coherence scores for topics ( $k$ ) ranging from 1 to 30 and plot it on a graph (Fig. 2). The coherence score is highest until  $k = 4$  before declining. The coherence scores fluctuate until  $k = 18$ – $21$  where it stagnates before dropping again. Coherence scores at  $k = 18$ – $21$  plateau with the coherence scores at  $k = 7$ – $8$ . Our rationale for not selecting  $k$  as 4, which has the highest coherence value, is that it poses a risk of generating few generic topics (Thomas et al., 2014) and not capturing the wide range of application areas of the CE literature. Along similar lines we do not select  $k$  as 7 or 8 and rather select  $k$  as 20 which almost has the same coherence score as  $k = 7$ – $8$  and will possibly help in generating more meaningful topics. We determine the optimal number of topics to be 20 based on coherence scoring.



**Fig. 2.** UCI coherence scores corresponding to the number of topics ranging from 1 to 30

## 4.2. Expert Judgement

In this section we summarise the results from the workshop to solicit expert judgment on the topic model results. Expert opinion was sought on the following grounds.

### (1) *Is there semantic coherence in the topics generated by the model?*

There was no major disagreement in terms of annotating the topics and the experts reached consensus without much difficulty. There were two topics, which triggered questions.

#### (a) *Water, urban, citi, region, land, area, system, environ, resourc, ecology*

This topic was identified as relating to studies on cities and industrial ecology but the experts believed this could be clubbed with two other topics relating to Industrial ecology/symbiosis rather than being a separate topic.

#### (b) *Suppli, chain, compani, studi, barrier, practic, firm, consum, behavior*

This topic according to the experts could best be represented as two separate topics pertaining to circular supply chain and behavioural studies.

### (2) *Are all aspects of the CE literature covered in the topic model results?*

The experts opined two aspects not being covered in the results. Firstly the aspect of “Digitalisation”, in transitioning towards a CE. Secondly articles in the social sciences tend to use “circularity” in verbiage rather than CE although they discuss similar conceptualization. This is a limitation of the study since we are only focusing on the exact usage of the CE terminology and our search criterion of the articles is based on the same. Overall we can conclude that the topics generated by the model were semantically coherent and could, to a large extent, be matched with human judgment. The experts reached a consensus in assigning topic labels to each of the topics and further grouped the 20 topics into 7 thematic categories to establish broad themes of CE research.

## 4.3. Performance of Topic Models Against Experts

We obtained an F score of 0.921; which is quite high and is a revalidation of the human interpretability of the topics.

#### 4.4. Topic Model Results

In this section we present a summary of the topic model results. Table 1 shows the list of the terms in each topic, the topic names assigned to each based on the expert judgement, the proportion of the topics in the entire corpus and the broad thematic category i.e., resources, design for circularity, industrial ecology/symbiosis, process modelling, firms, businesses and consumers, meta/conceptual research, policy and governance identified by the experts. Industrial ecology/symbiosis is the topic with the maximum proportion, since industrial ecology is one of the primary antecedents of the CE concept (Merli et al., 2018a) followed by business models which is rapidly gaining popularity in contemporary CE literature. Topics pertaining to plastics, simulation based methodologies have the lowest proportion in the entire corpus.

**Table 1. Summary of topics**

Top 10 terms for each topic	Topic Name	Topic proportion	Thematic category
Wast, manag, recycl, landfill, collect, recoveri, solid, municip, generat, dispos	Waste management	5.03%	Resources
Watewat, treatment, metal, recoveri, sludg, extract, acid, concentr, remov, water	Sludge	4.86%	
Materi, recycl, flow, resourc, metal, raw, mine, product, stock, secondari	Metals	4.78%	
Food, product, digest, agricultur, nutrient, soil, farm, organ, biomass, wast	Food/Agriculture	4.69%	
Energi, plant, fuel, renew, electr, power, gas, technolog, carbon, bioga	Energy	3.91%	
Energ, emiss, consumpt, steel, carbon, china, reduc, reduct, industri, resource	Steel	3.78%	
Ash, properti, cement, materi, concret, test, slag, composit, result, raw	Cement/concrete	3.70%	
Recycl, plastic, packag, materi, wast, chemic, weee, textil, polym, product	Plastics	3.47%	
Product, remanufactur, design, reus, manufactr, compon, consum, diassembl, eol, electron	Design for circularity	4.34%	Design for circularity
Innov, design, project, build, sustain, educ, solut, engin, develop, new	Innovation in design	4.13%	
Develop, economi, circular, china, coal, resourc, enterpris, ecology, industri, mode	Industrial ecology/symbiosis (local)	9.07%	Industrial ecology/symbiosis
Water, urban, citi, region, land, area, system, environ, resourc, ecolog	Urban systems	3.89%	
Industri, park, symbiosi, eco, ecolog, china, chain, develop, chemic, eip	Industrial ecology/symbiosis (regional+national)	3.67%	
Evalu, system, indic, method, effici, circular, economi, index, model, eco	Evaluating CE	5.72%	Process modelling
Environment, impact, life, assess, cycl, product, lca, scenario, result, use	Lifecycle Assessment	5.13%	
System, model, research, design, network, base, optim, data, analysi, simul	Models and simulation based methodologies	3.51%	
Model, busi, circular, economu, valu, system, product, sustain, transit, resourc	Business Models	8.24%	Firms, businesses, consumers
Suppli, chain, compani, studi, barrier, practic, find, firm, consum, behavior	Supply chain + behavioural studies	5.28%	
Research, concept, review, literatur, practic, econom, sustain, framework, discuss	Meta/conceptual research	7.11%	Policy and governance
Polici, govern, european, public, social, regul, countri, econom, develop, environment	European policy and governance	5.69%	

Figure 3 shows the evolution of the topics over time. A significant structural change in the proportion of topics is witnessed in the year 2015. This structural change can be understood from two perspectives. Firstly, the shift in focus from macro-level topics such as industrial ecology to micro-level interventions such as circular product design, business models. Secondly, a shift from the Chinese pre-dominance to a more European context. Literature on CE has evolved along with the policy and focus of these economies i.e., 11th, 12th five year plans and CE promotion law in China (Su et al., 2013) and advocacy

by organisations like the Ellen McArthur Foundation and enactment of the Circular Economy Package in Europe (Masi et al., 2018).

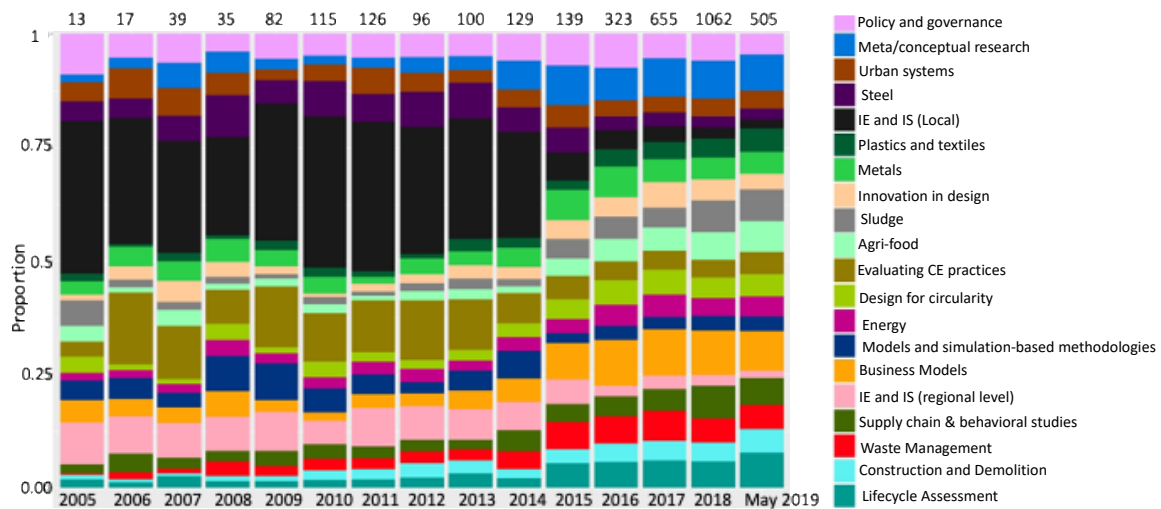


Figure 3: Evolution of topics over time

## 5. Conclusion and Future Research

Our analyses present a way to summarise the growing literature on the concept of CE from a temporal perspective using unsupervised topic models. We determine the optimal number of topics based on coherence scoring and then revalidate this through human judgement and find the results from the automated coherence scoring and human judgement to be highly correlated. We apply LDA to assess the evolution of topics over time by summing topic proportions across each document for a particular time stamp. This is a simple and intuitive approach and can be easily applied to different kinds of text corpus. Our analysis and visual representations show structural change in the CE literature around the year 2014–2015 shifting towards a European context and micro-level interventions such as circular product design, business models and supply chain from a Chinese predominance and macro level themes. Whilst this work provides a preliminary characterisation of the evolution of the concept we intend to use these results to further our research in answering how and why the concept of CE evolved in the way it did in the academic discourse.



## Research Paper 2: Computation of semantic change in scientific concepts: Case study of “circular economy”

*Mahanty, S., Boons, F., Handl, J. and Batista-Navarro, R., 2021. Computation of semantic change in scientific concepts: Case study of “circular economy”. Computational approaches to semantic change, 6, p.123.*

**Abstract:** In this chapter we aim to investigate semantic change in a scientific concept. The aim of this article is threefold. First is to distinguish semantic change computation in scientific concepts from that in core vocabulary and slang. Second is a multi-step analysis combining topic modelling, co-occurrence networks and word embeddings, along with a control condition setup thereby presenting a pipeline to compute semantic change in a scientific concept. Third is an analysis of a popular concept in sustainability studies, i.e., “circular economy”, seeking to advance research on this concept. In order to achieve our objectives, we use topic modelling to detect the point of change in a literature corpus and then we apply two approaches for detecting semantic change: co-occurrence networks and word embeddings. Furthermore, we compare the concept with other related concepts in the same semantic field and use word embeddings to detect if the concept has undergone any changes relative to other concepts.

### 1. Introduction

Scientists contribute to the process of scientific knowledge production acting as the central subjects in this process. They are the entities who read the literature, perform experiments, publish the results and pass on knowledge. Textbooks and journal articles serve as vehicles in this process (Hull, 2010). Philosophers of science have conceptualised this process of scientific knowledge production to be evolutionary (Hull, 2010; Toulmin, 1972; Toulmin, 1967), drawing analogies with biological evolution where concepts are linguistic labels given to abstract ideas (Fodor, 1975; Pinker, 1995) which are framed, selected, re-conceptualised, discarded leading to a continuous evolution of the language used by researchers (Boons et al., 2017). In order to define these concepts, members of the scientific community build upon the same language (i.e., lexicon-kind terms) at the very least. Language, thus, becomes a crucial indicator to assess the shift or development in ideas (Kuhn, 1990). Whilst philosophers of science have given much attention to scientific knowledge production in evolutionary terms, we intend to focus on this work from a computational perspective to understand how we can use computational methods to detect evolution in scientific knowledge production. In the past decade an emerging research topic in the field of computational linguistics has been on the topic of semantic change computation (Tang, 2018). Semantic change refers to any change in the word meaning over a period of time. Semantic change in words can sometimes happen to the extent that the modern meaning is radically different. In some cases, the semantic change that words undergo happens by means of acquiring additional meanings, rather than original meanings becoming outdated or being replaced. We

find useful the definition put forward by Bloomfield, (1933), where lexical semantic shifts or semantic change is defined as “innovations which change the lexical meaning rather than the grammatical function of a form”. In the process of scientific knowledge production, any change in science is termed as evolution of science, thus taking change and evolution to be synonymous (Bradie, 1986; Wuketits, 1984). Drawing from this we set out to understand the evolution of concepts in the scientific literature through the lens of semantic change. Thus, we propose that when there is an evolution in concepts over time, it can be detected through computation of semantic change. From an empirical perspective, a key assumption is that changes in a concept’s collocational patterns reflect changes in concept meaning, thus providing a usage-based account of semantics. We begin by analysing the related work and positioning of the research in Section 2. In Section 3 we present the case study for this research. In Section 4 we discuss the methodology in detail and present the results based on our case study in Section 5. Finally, we present the discussion and conclusion in Section 6.

## 2. Analysis of related work and positioning of the research

There are a number of studies which have harvested the availability of huge diachronic language data to advance the research on semantic change computation (Dubossarsky et al., 2017; Frermann & Lapata, 2016; Hamilton et al., 2016; Jatowt & Duh, 2014; Michel et al., 2011; Mitra et al., 2015; Rohrdantz et al., 2011; Sagi et al., 2009; Tang, 2018). From a computational perspective, semantic change has been approached from two aspects: word-level semantic change and concept-level semantic change (Tahmasebi et al., 2018). There have been a number of studies which have focused on concept-level semantic change providing valuable insights such as the idea of concept through time (CTT) (Wevers et al., 2015), parallelogram model of analogy (Orlikowski et al., 2018) and tracing concept vocabularies through a time-stamped corpus (Kenter et al., 2015; Recchia et al., 2016). However, there have been different ways in which the term concept has been approached in different studies. Since different domains have different interpretations of what a concept means, it should also be appreciated that any definition of a concept has a sense of arbitrariness and it is therefore desirable to study concepts with as much flexibility as possible (Fokkens et al., 2016). For instance, in studies by Kenter et al., (2015) and Orlikowski et al., (2018), there are concept terms which make up the conceptual core (core concept terms) from the rest of the vocabulary (characterising concept terms), thus distinguishing between the core and the margin of concepts. For example, for the concept of “economic efficiency”, core terms might be efficiency and efficient, while characterising terms might be robotisation, automatisisation or labour productivity. In other studies such as Wang et al., (2011), concepts not only exist in the textual information in the documents, but also refer to the quantity that a learning model is trying to predict, i.e., the variables. However, the understanding of concept that we use in this paper is based on some interpretations of the classical theory of concepts which treat concepts as a semantic labels which are one-to-one correspondence with word senses (Margolis & Laurence, 2005). While there are a number

of schools of thought pertaining to the definition of a concept, the understanding that we adopt in this article allows us to assess the evolution of a particular concept that is used in scientific literature. Thus, going by the parsimonious understanding of a concept in our study, if we were to investigate the evolution of the “economic efficiency” concept in scientific literature, we would focus on it verbatim. Hence, our computational approach is based on what has been called word level semantic change in previous research. However, there are certain aspects which make our study distinct from previous research and bring about the novelty. The first aspect is concerned with the nature of the data and the second aspect is concerned with the rate of change.

### *Nature of data used*

Previous studies of word-level semantic change detection are mostly based on data sources such as the Google Books Ngram corpus which is the largest text corpus used in semantic studies (Dubossarsky et al., 2017; Gulordava & Baroni, 2011; Hamilton et al., 2016; Jatowt & Duh, 2014; Michel et al., 2011; Xu & Kemp, 2015), the Corpus of Historical American English (COHA) (Hamilton et al., 2016; Neuman et al., 2017) and the Helsinki corpus of English texts (Sagi et al., 2009). Apart from the use of such text corpora, Twitter (Mitra et al., 2015) has also been used. For the purpose of this work, our interest is in concepts used in scientific literature and we find that work on semantic change based on scientific literature is limited. Chen et al., 2018 studied semantic changes in a scientific domain by analysing the same words which have different meanings in different domains. Rudolph & Blei, (2018) developed dynamic word embeddings using data from Association for Computing Machinery (ACM) abstracts and machine learning papers on the preprint database arXiv. However, most studies which use academic discourse and abstracts as a corpus are in the biomedical domain where the classic research problem focuses on semantic relatedness and similarity between biomedical terms (Zhu et al., 2017). A recent development on computational analysis of scientific literature has been the release of SciBERT, a new resource based on contextual embeddings demonstrated to improve performance on a range of natural language processing (NLP) tasks in the scientific domain. SciBERT is a pretrained language model based on BERT but trained on a large corpus of scientific text (Beltagy et al., 2019). In our study, we do not make use of SciBERT since: (1) we do not have access to a large enough “circular economy” corpus for training our own model, and (2) their publicly available pre-trained model was trained on a corpus where 18% of the papers were drawn from the computer science domain and 82% from the biomedical domain. Due to its narrow focus in terms of domains it is not applicable in our context. Thus, to the best of our knowledge there has been limited attention on semantic change drawn from scientific literature barring a few exceptions like the study by Dridi et al., (2019) which provides interesting insights on how to use temporal word embeddings to detect emerging scientific trends, although they do not specifically focus on semantic change. Furthermore, delving into the nature of the data, Wevers & Koolen, (2020) put forward certain considerations to reflect on before training a word

embedding model for computation of semantic change, i.e., (1) large enough data size spanning long time periods, (2) identification of optical character recognition (OCR) errors and spelling variations in the data, and (3) cultural and political bias in the data. These factors could affect the quality of the model being trained. However, we question if these hold true when using scientific literature as the corpus. For instance, for concepts used in the scientific discourse, the time period might not need to be so long as there is evidence of structural changes even within short time periods (Mahanty et al., 2019), which we believe can be detected through semantic change computation. Due to shorter time periods, the data that is available to study semantic change of concepts in scientific literature is often much smaller compared to studies using newspaper articles, Twitter data, movie reviews and books. Scientific text is more likely to be devoid of noise like OCR errors and spelling variations. Ideally, scientific literature is also devoid of any cultural and political bias since most journals have a criteria of using inclusive language in articles. Thus, the data drawn from scientific literature is of much better quality, therefore increasing the chances of obtaining a better trained model.

#### *Rate and nature of semantic change*

There are systemic irregularities in the rate of semantic change of words wherein the rate of change of some words is higher than that of others (Hamilton et al., 2016). Studies have established that the distributional properties of words implicate semantic change by showing that verbs change at a faster rate than nouns (Dubossarsky et al., 2016). Another study by Greenhill et al., (2017) is along the same line of thought and it again provides evidence on different rates of change in different aspects of language. They show that, in general, grammatical features tend to change faster and have higher amounts of conflicting signals than basic vocabulary, suggesting that subsystems of language show differing patterns of dynamics. When extending this to scientific concepts, we hypothesise that there is a difference in the rate of change between scientific concepts, core vocabulary and slang. While core vocabulary has been found to be more stable (Bengtsson & Ågerfalk, 2011), slang words are ephemeral (Wang, 2020). Meanwhile, scientific concepts often undergo changes such as reconceptualization, recombination and relabelling in the process of evolution (Bradie 1986), and are therefore borrowed, adapted or inflated. Thus, a blanket case of semantic change might not fit for scientific concepts.

This chapter focusses on the development of a computational pipeline for assessing conceptual evolution in the process of scientific knowledge production based on journal articles and abstracts. From a conceptual evolution perspective there are two aspects that can be investigated, i.e., firstly the evolution of a scientific concept exclusively and then the evolution of the concept with respect to other concepts in the same “semantic field”. Since we understand evolution of scientific concepts by the evolution of language used by scientists, we address the first strand of our work by analysing the change in a concept’s associated vocabulary. Meanwhile, for the latter strand of this work, we will investigate

what is called a “semantic field”, which is defined as a set of words which cover a particular semantic domain and bear structured relations with one another (Jurafsky & Martin, 2015). Semantic fields can be studied diachronically or synchronously. The former focusses on the origin and transformation of specific concepts while the latter deals with concepts appearing and their connection with other concepts. Thus, the understanding of a semantic field allows a better understanding of the meaning and the context of a concept with respect to other concepts. Our second goal will be to develop a computational pipeline to understand the evolution of a concept with respect to other concepts in the semantic field. In our previous work, we assessed the evolution of a concept using topic modelling (Mahanty et al., 2019). While that work enabled us to computationally detect conceptual evolution to some extent, we did not uncover the extent of change or evolution, nor determined if the change is statistically significant. These are now addressed in the work described in this chapter. Furthermore, building upon our previous work, we perform a comparison of a number of concepts within the same semantic field thereby tracing the shift in their contexts. Our contribution in this article are the following:

- a. We establish a case for semantic change in scientific concepts and its difference compared to core vocabulary and slang.
- b. From a methodological perspective, we present a pipeline based on multiangle analysis combining different methods along with a control condition setup for computation of semantic change. This can be broadly applied across disciplines to analyse a vast and expanding literature on any concept.
- c. From an application perspective, this study provides insights on a very popular concept in sustainability studies.

### 3. Case study: Circular Economy

In the sustainability debate, the concept of “circular economy” (CE) has received immense traction amidst scholars, practitioners and policymakers in the recent years. CE refers to a system of provision in which resources are circulated between production and consumption rather than linearly transformed from production to consumption to waste. While the CE term was coined by Pearce & Turner, (1990) it mostly underwent a dormant phase until early 2000s apart from a few mentions, for example, (Cooper, 1994, 1999). But from the early 2000s it has received immense attention in the academic discourse with over 1000 academic articles published in a single year. It became a popular policy agenda across European countries, China and Latin America. Another interesting aspect of CE is its relation to other concepts. The concept of CE is often studied in relation to other concepts such as bioeconomy, green-economy (D’Amato et al., 2017), cradle to cradle, industrial ecology, closed-loop supply chains, regenerative design, blue economy, industrial symbiosis, reverse logistics, performance economy, natural capitalism, and biomimicry (Geisendorf & Pietrulla, 2018). Some of these concepts are termed as the antecedents to the CE concept or CE schools of thought (Homrich, Galvao, et al., 2018). While

we assess the changes in the CE concept, it is also of interest to understand how it is evolving in relation to other concepts. It might also provide further evidence of evolution in the concept of CE, if there is any. Thus, we use the concept of circular economy as a case study to fulfil two of our goals i.e., study the evolution of a concept exclusively and study the evolution of a concept in relation to other concepts in a semantic field. We aim to uncover the conceptual evolution of the concept “circular economy” in academic literature through computational analysis of semantic change. We use academic articles published on CE from 2005 to 2019.

## 4. Methodology

In this section we discuss our methodology in detail. Figure 3.1 is a brief representation of the methodology.

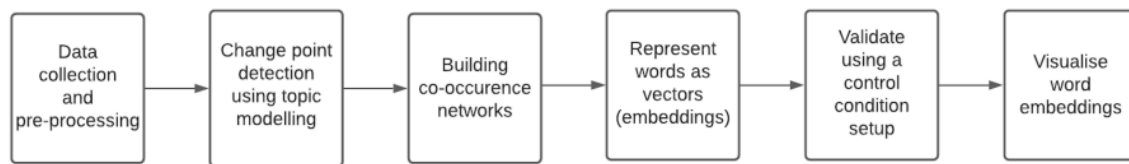


Figure 3.1: Methodology

### 4.1. Data collection and pre-processing

As our first step towards our first research goal, we retrieved data in English from the Scopus database using the keyword “circular economy” from the period 2005–2019. The title, abstract, author keywords, index keywords and year of publication were retrieved and stored in a comma-separated values (CSV) format. We also collected full text articles from Elsevier in XML format. This corpus consisted of 3,300 articles. In order to fulfil our second goal of analysing the conceptual evolution of CE with respect to other concepts, we created a supplementary corpus of academic abstracts on 20 other concepts that have similar or overlapping conceptualisations with CE from the period 2005–2019. The related concepts are based on literature and an ongoing Delphi study<sup>21</sup>, which we conducted with 66 academic researchers working on the CE concept. The 20 related concepts and their definitions are presented in Appendix A. A total of 61,444 abstracts was included in this supplementary corpus. In the pre-processing step we removed all instances of punctuation from the data, then the data was lower-cased and tokenised.

### 4.2. Change point detection

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<sup>21</sup> Delphi study is a qualitative assessment method based on the results of multiple rounds of questionnaires sent to a panel of experts. Several rounds of questionnaires are sent out to the group of experts, and the anonymous responses are aggregated and shared with the group after each round. We asked a question to the academic researchers about what other concepts they use in their research apart from “circular economy” and they provided other overlapping concepts which they tend to use in their research articles.

There has been a divergent policy articulation of the CE concept differentiating between its Chinese and European framings (McDowall et al., 2017a). Based on such insights from the literature we hypothesise that there was a change in the concept of CE within the period of study i.e., 2005–2019. We seek to determine whether the concept changed significantly, and if yes, to estimate the point in time when this happened. The formulation of the task as change point detection is appropriate because even if a word might change its meaning (usage) only gradually over time, we can expect that there will be a time period when the new usage becomes much more dominant (Aminikhanghahi & Cook, 2017). The identification of a change point is important because this will further form a basis for division of the corpus into “epochs” for further analysis. There have been various methods used for change point detection such as frequency analysis, syntactic analysis and distribution-based methods (Kulkarni et al., 2015). In this study we implement a distribution-based method to identify a change point. Specifically, our methodology is underpinned by topic modelling, a statistical approach whereby non-exclusive groupings of words (i.e., topics) are automatically induced based on their distribution in a corpus (Nikolenko et al., 2017). In topic modelling, every document (e.g., a journal article) is considered as consisting of a mixture of a number of topics, referred to as  $k$ . A well-known algorithm for topic modelling is Latent Dirichlet Allocation (LDA) (Blei et al., 2003), which we applied over the entire corpus using the `lda` (Chang, 2017) and topic models (Grun & Hornik, 2011) R packages. For each document  $d$  in the corpus, LDA computes the probability that  $d$  belongs to topic  $t$ , where  $t$  is any of the  $k$  topics automatically identified. The probabilities for each topic are then summed for each year based on the year of publication of each document. The sums are then visualised graphically in a stacked plot to assess the trend in the topics over the years. The determination of the number of topics and validation of the results is based on our previous work (Mahanty et al., 2019). We use the change point as reference to slice the corpus into two subsets with each subset belonging to before and after the change point. We refer to the documents in the period before the change point as the early dataset and those published in and after it as the contemporary dataset. Once we have the proportion of the topics for each year from 2005–2019 we find the mean topic proportion for each topic in the two subsets of the corpus. Then, we run a paired  $t$ -test overall for all the topics which further assesses if the point of change is statistically significant.

### 4.3. Building co-occurrence networks

Co-occurrence vectors are employed in various ways to detect word level changes such as in context vectors, pointwise mutual information, temporal random indexing, or entropy in word level change detection (Tahmasebi et al., 2018). We develop co-occurrence networks based on the keywords associated with the documents. Visual keyword frequency data provides useful insights by revealing predominant trends in the keyword network of the analysed literature demonstrating a birds-eye view knowledge map. In our study, nodes of the network correspond to the keywords (with a node for CE as



the centroid), and edges indicate the co-occurrences; edge thickness represents the frequency of co-occurrence. A co-occurrence network was generated using the bibliometrix<sup>22</sup> package in R, for each of the epochs that was identified in the previous step. The development of the co-occurrence network is the first step to detecting the nature of changes in the concept diachronically in the two epochs. While keyword co-occurrence networks provide simple and high level information of a field, such networks are limited in their capacity because they only focus on high frequency words. Inclusion of words with lower frequencies will limit the interpretability of the network structure.

#### 4.4. Training word embedding model

Word embeddings map high-dimension word vectors (usually produced using simple one-hot encoding representations) to low-dimension vectors to obtain global semantics (Tang, 2018). Word embedding techniques that rely on the local context of the target words include Word2vec (Mikolov et al., 2013) and Glove (Pennington et al., 2014). We trained two word embedding models using Word2Vec, one for each of the early and contemporary datasets. For this, we made use of the gensim<sup>23</sup> package, with a context window of four tokens and vector dimensionality of size 300 in line with the settings that have been used in previous work (Hamilton et al., 2016). The word embedding vectors were trained on each epoch and then aligned using orthogonal Procrustes transformation (Schönemann, 1966) which has been applied to detect semantic change between different time periods (Abercrombie & Batista-Navarro, 2019; Dubossarsky et al., 2017; Hamilton et al., 2016). We then compared word embedding vectors for the word of interest “circular economy” across the different time windows by calculating the cosine similarity between their embedding vectors calculated based on the two different periods. A lower cosine similarity between vectors is indicative of higher difference in the meaning, usage and context of a term.

#### 4.5 Validation of word embedding model using a control condition setup

We test the results obtained from word embeddings based on a control condition setup, given that Dubossarsky et al., (2017) identified some studies where semantic changes are largely spurious results of the word representation models on which they are based. Until we have sufficient knowledge about the interpretation of conceptual changes, inferences need to be drawn with care and verified through multiple methods (Sommerauer & Fokkens, 2019). Thus, we use a control condition setup to validate the results drawn from the word embeddings. Complementary to the genuine condition, a control condition is created where no change of meaning is expected. The underlying assumption is always that

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<sup>22</sup> <http://bibliometrix.org>

<sup>23</sup> <https://radimrehurek.com/gensim/models/word2vec.html>

within the same dataset, the “circular economy” concept did not change its meaning. Again, unlike in the genuine condition, any changes that are observed can be attributed only to “noise” that stems from random sampling, rather than any real change in the usage or context of the concept. Therefore, any observed change in a word’s meaning in the control condition can only stem from random “noise”, while changes in meaning in the genuine condition are attributed to “real” semantic change in addition to “noise”. In order to create a control condition we randomly sample the early dataset into two subsets (referred to as subsets A and B) and similarly created two random samples from the contemporary dataset (subsets X and Y). We then compute the mean cosine similarities between the word vectors of A and B and those of X and Y.

#### 4.6 Comparison of CE with respect to other concepts

Word embedding models are known to successfully capture complex relationships between concepts, as manifested in the well-known word analogies task (Mikolov et al., 2013), where a model aims to “solve” equations of the form “A is to B as C is to what?” A classic example that is often used in distributional models is capturing the relation between man and woman is same as king and queen (by adding and subtracting the corresponding word vectors). Thus, it is a natural development to investigate whether changes in semantic relationships across time can also be traced by looking at the diachronic development of different distributional models (Kutuzov et al., 2018). Drawing from this idea we proceed with detecting changes in the CE concept in relation to other concepts. We construct a database of academic abstracts on 20 concepts that have similar or overlapping conceptualisations with CE from the period 2005–2019. Firstly, one with all abstracts from the Scopus database using each of the 20 concepts and CE abstracts from the early period and second with all abstracts on the 20 concepts and CE abstracts from the contemporary period (identification of period based on [Section 4.2](#)). We again align the two models using orthogonal Procrustes and calculate the cosine distance of CE with the 20 other concepts in the early and contemporary period.

### 5. Experiments

In this section we present the results that we obtained following the pipeline that we proposed as the methodology.

#### 5.1. Change point detection

We summarise the results from the topic modelling in Figure 3.2. Based on the results of topic modelling (Mahanty et al., 2019) we identify two structurally different periods in the literature on CE. A structural change in the relative proportion of the identified topics was visually detected in the year 2015. In order to identify if the change in the year 2015 was significant we run a paired *t*-test based on the mean topic

proportions in the early and the contemporary dataset. In the paired  $t$ -test the null hypothesis is that the mean difference between the two sets of observations is 0. A statistically significant  $p$ -value at 0.042 leads us to reject the null hypothesis and is supportive of our decision to divide the corpus into two epochs.

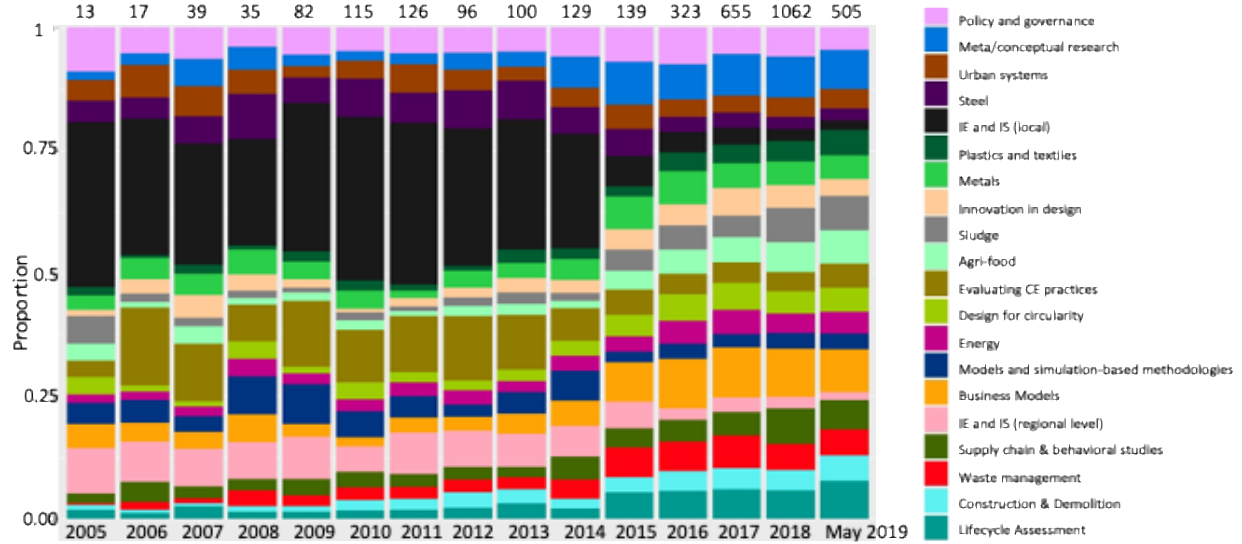


Figure 3.2: Evolution of the topic proportions over time with a change point 2014-2015

*\*numbers on top refer to the total number of articles in each year*

## 5.2. Co-occurrence networks

On developing keyword co-occurrence networks for each of the two datasets, i.e., early and contemporary, we observed certain differences between the structures. Contemporary CE literature was found to be more strongly linked to business models, supply chain, and product design. Meanwhile the focus of early CE literature was more on ecology, industrial economics and environmental management. These observations confirm that the concept of CE has undergone some change over the years that are reflected by a shift in focus in the context of its application. We note that despite this expansion, the core meaning of the concept has not changed over time (as evidenced by the nodes that are common between the two networks, for example, sustainable development, waste management, recycling).

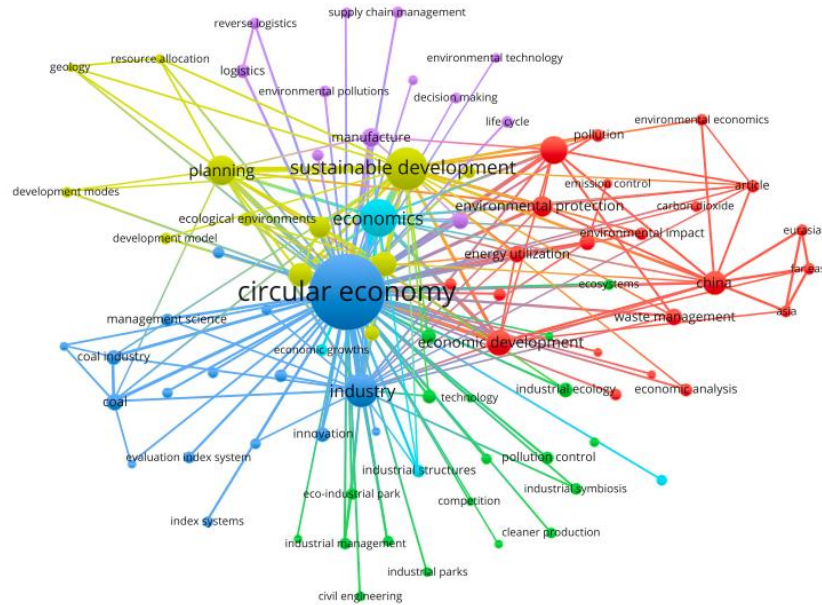


Figure 3.3: Co-occurrence network of the early dataset (2005–2014)

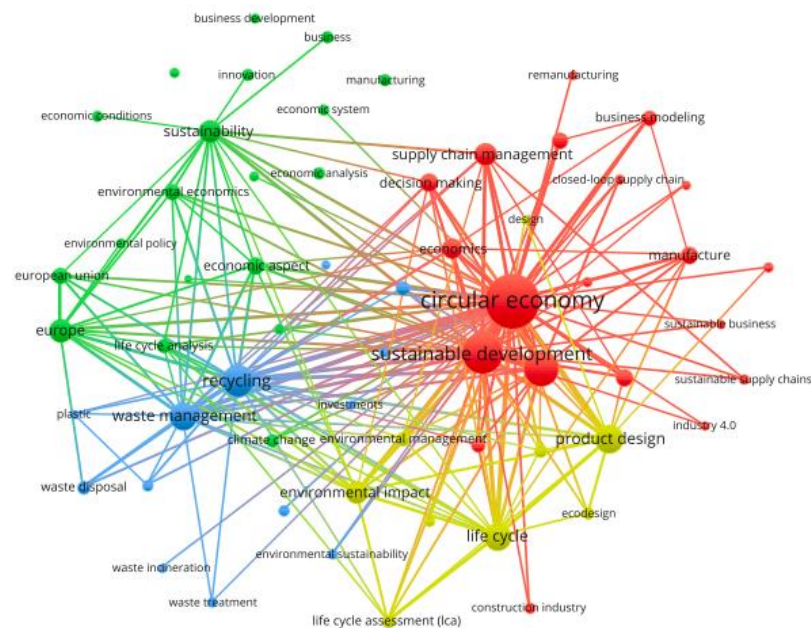


Figure 3.4: Co-occurrence network of the contemporary dataset (2015–2019)

### 5.3. Word embeddings

After training word embeddings on each of the two datasets and aligning them using orthogonal Procrustes transformation we examined the nearest neighbours of CE (i.e., words with highest similarity to CE). We see a shift from the environmental and industrial focus to a perspective which integrates innovation with a business focus and also incorporates the social dimension of CE. The results from the word embeddings are in agreement with the results from the co-occurrence networks. The early

literature primarily addressed macro-level themes in the context of environmental management and industries while the contemporary literature focuses on more micro-level interventions like business models, product design and supply chain. However, words such as sustainability and sustainable development consistently dominated the literature in both of the time periods, both of them being key to the conceptualisation of CE. The mean cosine similarity between word embedding vectors across the two time frames, i.e., early and contemporary, is only 0.195 which is quite low; this is not surprising, considering the extent of shift in the context of CE over time. We visualise the results from the word embeddings on a distributional space (Figure 3.5) using t-sne (van der Maaten & Hinton 2008) which visualises high-dimensional data by giving each datapoint a location in a two dimensional map.



Figure 3.5: t-sne visualisation of CE based on the vectors in the early and contemporary period

#### 5.4. Validation of results using a control condition setup

We observe the mean cosine similarity between the early and contemporary datasets is only 0.195. By using a control condition setup and creation of random subsets within the early and the contemporary period we find that the cosine similarity between the subsets drawn from the same time period was quite high, i.e., 0.62 and 0.743, for the early and the contemporary datasets, respectively. Thus, the low mean cosine similarity between early and contemporary datasets indeed indicates a change.

### 5.5. Comparison of CE with its overall semantic field

We compare CE with the overall semantic field and assess the relationships with the 20 concepts. In Figure 3.6 we present the semantic field in a distributional space using t-sne (van der Maaten & Hinton 2008). This is based on training word embeddings on a corpus of journal abstracts on the 20 concepts and CE. The total corpus consists of 61,444 abstracts. The individual dots represent the collocational words corresponding to each concept. The solid circles denote positions in the distributional space which are characterised by the unique contextualisation of the concepts whereas the dotted circle represents a space which constitutes an overlapping context between the concepts and depicts inter-relationships that exist between these concepts. It is interesting to note here that the “circular economy”

concept seems to have an overlapping conceptualisation with most concepts. The inter-related nature of the semantic field also points towards the fact that these concepts cannot be studied or analysed in silos and researchers in these areas need to have a holistic knowledge of the associated concepts.

For further analysis to detect any shift in the meaning of CE across the two time periods we divide the corpus into two parts as we did before and compute the cosine similarities between “circular economy” and each of the other concepts in the early and the contemporary period. The similarity between CE and each of the other concepts is mapped in Figure 3.7. We notice a shift in the CE concept with respect to the other concepts. Earlier the CE concept was more closely linked to eco-civilisation and low-carbon economy while in recent times it has a closer link to sharing economy, natural capital, and zero waste. However, no major shifts related to the competing concepts were found.

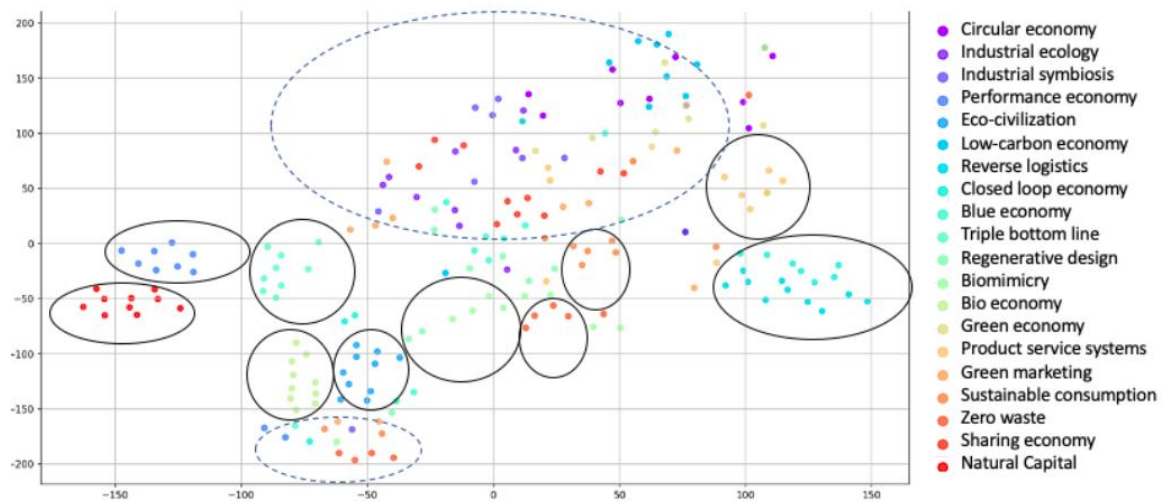


Figure 3.6: t-sne visualisation of the overall semantic field

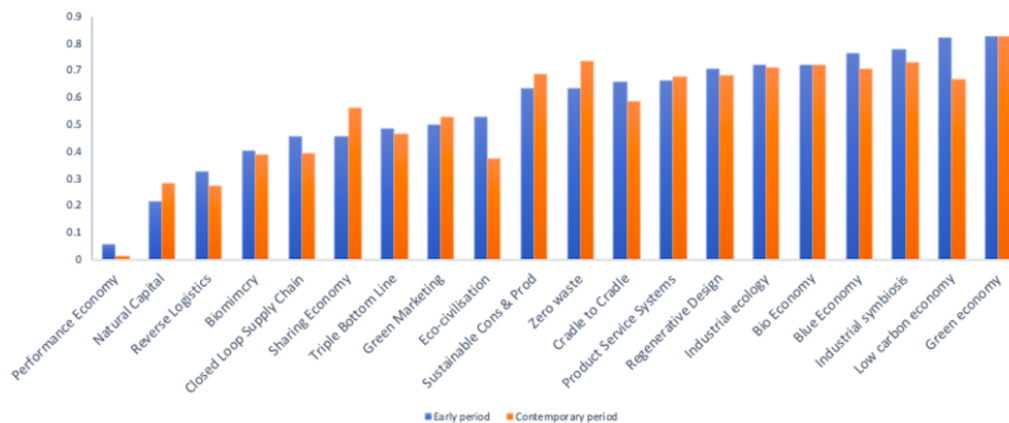


Figure 3.7: Cosine similarities of CE with other concepts in each of the two datasets



## 6. Discussion and Conclusion

In this chapter we presented a computational approach for analysing semantic change, which is underpinned by the automated discovery of topics within a corpus of 3,300 CE academic articles in English subdivided according to their year of publication. Applying an unsupervised topic modelling method based on Latent Dirichlet Allocation (LDA) on the entire corpus, a set of topics was identified for each of the years from 2005 to 2019. A significant structural change in the relative proportion of the identified topics was detected in the year 2015. Based on this observation the corpus was divided into two broad sets, i.e., 2005–2014 (early dataset) and 2015–2019 (contemporary dataset). To fulfil our first research objective and to detect changes in the CE concept, we compared the CE literature across these two time periods by applying on each of the data-sets two approaches – building of co-occurrence networks and training of word embeddings using “circular economy” as the primary term of interest. We then aligned the word embeddings using orthogonal Procrustes and analysed the nearest neighbours of CE and their cosine distances. In order to fulfil our second research objective to detect changes in the CE concept in relation to other concepts, we created a database of academic abstracts on 20 concepts that have similar or overlapping conceptualisations with CE from the period 2005–2019. The related concepts are based on literature and a Delphi study which we conducted with 66 academic researchers working on the CE concept. We created two datasets, firstly one with all abstracts on the 20 concepts and CE abstracts from the early period (30,762 abstracts) and second with all abstracts on the 20 concepts and CE abstracts from the contemporary period (30,682 abstracts). We again aligned the two models using orthogonal Procrustes and calculated the cosine distance of CE with the 20 other concepts in the early and contemporary period. We found that the results from co-occurrence networks and word embeddings are consistent with each other, both showing that the concept of “circular economy” has undergone semantic change. Semantic change could mean two things: either the evolution of the word usage to the point that the modern meaning is radically different or semantic change by words acquiring additional meanings rather than original meanings being outdated or being replaced. In this study we have observed the latter in the context of CE. Specifically, our results provide computational evidence – based on three different approaches – for two main findings. Firstly, the core meaning of the concept has remained the same; this is evidenced by some common nodes in the results from the co-occurrence networks and nearest neighbours of CE based on word embeddings, such as sustainable development, waste management. Secondly, the concept has undergone some significant expansion, where the contemporary literature on CE was more strongly linked to business models, supply chain and product design. In contrast, the focus of early literature was more on industrial ecology, industrial economics and environmental management. The results are aligned with the history of CE where the early dataset relates to its antecedent concepts such as industrial ecology while the contemporary dataset is related to micro-level interventions for sustainable development. A further detailed analysis of the evolution of



the CE concept and its relation to other concepts is beyond the scope of this paper. From a methodological perspective, this approach could be used in assessing the evolution of concepts in academic discourse which is characterised by a vast corpus. In previous works of detecting concept change using computational methods, there have been no studies which focussed on evolution of concepts in the process of scientific knowledge production. This allows researchers to analyse large amounts of data which cannot be analysed using manual inspection. The computational methods discussed through the case study of “circular economy” could be broadly applied across disciplines. It will allow researchers to get an overview of the concept. Secondly it enables researchers to observe any high-level changes in a concept and can identify certain research directions to pursue especially in the case of vast and expanding fields. We believe that this study will be helpful for both researchers already working on related topics as well as those new to the field, for example PhD candidates who wish to quickly grasp the recent advances and history of a field and pinpoint promising research opportunities and directions. Thirdly, more often than not there are multiple concepts that exist in a particular domain and a high level analysis of the overall semantic field provides the researcher with a fair understanding of the inter-relationships between the concepts. Along with that, from a conceptual perspective an evolutionary analysis could also aid in verifying hypotheses posited by linguists, anthropologists or other researchers in a field.

## Research Paper 3: An investigation of academic perspectives on the ‘Circular Economy’ using Text Mining and a Delphi study

*Mahanty, S., Boons, F., Handl, J. and Batista-Navarro, R.T., 2021. An investigation of academic perspectives on the ‘circular economy’ using text mining and a Delphi study. Journal of Cleaner Production, p.128574.*

### Highlights

- Assessing the evolution and positioning of Circular Economy (CE) in academic research
- A mixed methods approach combining text mining (topic modelling) and Delphi study
- Longitudinal analysis of the literature taking into account 3300 academic articles
- Opinion of 68 international experts to investigate the CE’s position and evolution
- Future research avenues are suggested based on the assessment of the experts

### Abstract

The Circular Economy (CE) concept has received immense traction among various stakeholders. This study aims to provide an assessment of its evolution and its positioning amidst “competing” concepts in the academic discourse. We do so by a mixed-methods approach combining text mining (topic modelling on CE literature) and Delphi study with 68 international scholars. In its evolution, we observe a structural change in the years 2014-2015 characterised by CE research undergoing immense proliferation, adopting a distinct line of inquiry from industrial ecology, becoming dispersed across topics and shifting from macro to micro-level interventions. This change is attributed to the use of CE to denote ideas and practices that existed before, increased interest from policymakers, adoption of CE terminology by businesses, and the research cycle of the concept itself shifting from being exploratory into different areas of practical implementation. In its positioning, we observe that scholars use several other “competing” concepts along with CE and do not consider it dominant despite the immense attention. The reason being, mainstream CE research is largely focussed on resource flows with limited attention to some of the long-term environmental challenges and it also overlooks the social dimension of sustainability, notwithstanding the efforts to make it inclusive. This study provides further impetus to academic knowledge on CE by a combination of quantitative analysis with a systematic, expert-based interpretive assessment of the literature. The enumeration of a wide range of concepts used by scholars provides an overview and a conceptual toolkit to researchers and newcomers to the field. This study also provides a set of informed future research avenues based on the expert assessment. The methodological contribution is of additional value to the research community.

**Keywords:** *circular economy, sustainability, concept evolution, mixed-methods. Delphi study, topic modelling*

## 1. Introduction

One of the focal points of the discussion on sustaining earth's life support systems (Rockström et al., 2009; WWF, 2016) and moving towards sustainable development (WCED, 1987a) is concerned with the management of waste and resources. After gaining traction in the 19th century it became a key environmental issue on the political agenda during the 1960s with the emergence of environmental protection as a driver (Wilson, 2007). To assess the issues and develop solutions to environmental issues concerning waste and resources, researchers, practitioners, and policymakers have used a broad range of concepts<sup>24</sup> such as waste prevention, industrial ecology (IE) (Erkman, 1997), performance economy (Stahel, 2016), bio-economy (BE) (McCormick & Kautto, 2013), sharing economy (SE) (Frenken & Schor, 2017), biomimicry (Benyus, 1997), degrowth (Charonis, 2012) and many more. Amongst these concepts, the concept of 'circular economy' (CE) has received immense traction in the waste and resource management discussions in recent years, providing a new cognitive unit and discursive space (Blomsma & Brennan, 2017).

As a relatively new and evolving concept that has quickly enjoyed a rapid uptake, the CE concept is characterised by ambiguities about its definition, scope, positioning amidst antecedent concepts, and more (Borrello et al., 2020). Such ambiguities and widespread use of the concept among various stakeholders can blur the concept and ultimately lead to its collapse (Kirchherr, Reike and Hekkert, 2017). Thus, in this paper, we aim to provide certain clarifications to improve the academic understanding of CE by focussing on three key issues.

First, a deeper interpretive understanding of the evolution of the CE concept based on a combination of qualitative and quantitative approaches is required. Previous studies have assessed the evolution of the CE concept either qualitatively or quantitatively. Blomsma and Brennan, 2017 use a qualitative narrative approach based on a limited set of references uncovering antecedents to CE. Reike, Vermeulen and Witjes (2018) use similar data to identify phases in the CE evolution, establishing that the CE in its dominant framing is not as new as often claimed. A recent study by Schöggl, Stumpf and Baumgartner, 2020 uses a suite of methods on a comprehensive set of articles to provide a longitudinal review. Such quantitative analysis is crucial, yet the interpretation is provided by the researchers conducting the quantitative study itself. Several other systematic literature reviews have been published on the CE which provide valuable information (Masi, Day and Godsell, 2017; Nobre and Tavares, 2017; Homrich, Galvao, *et al.*, 2018; Merli, Preziosi and Acampora, 2018; Centobelli *et al.*, 2020); however, the quantitative assessment of the literature and interpretation of the results are solely based on the opinion of the authors which could be subjected to researcher bias (Boell & Cezec-Kecmanovic, 2011). The first contribution of this paper is to add an interpretive understanding by combining a quantitative

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<sup>24</sup> The [Stanford Encyclopaedia of Philosophy](#) (Margolis et al., 2019) provides various understandings of a concept provided by philosophers. However, in this study, we draw from the definition of a concept put forward by (Fodor, 1975) and (Books, 1994). For parsimonious use of words, we define a concept as a linguistic label for an abstract idea.

approach (topic modelling on the CE literature from January 2005-May 2019) with a qualitative approach involving opinions of a group of scholars (Delphi study with 68 international scholars). Second, available comparisons of the CE concept with other resources and waste-related concepts are largely conceptual (Brueel et al., 2019; D'Amato et al., 2017; Geisendorf & Pietrulla, 2018; Henry et al., 2021) and they do not engage with the appreciation and actual use of 'competing' concepts by academics. Third, with the rapid uptake of the CE concept, it signals towards a perception that CE is 'dominating' the discourse (Borrello et al., 2020; Mah, 2021; Valenzuela & Böhm, 2017) and is often described with over-enthusiastic tones (Kirchherr & Piscicelli, 2019). The question about appreciation and actual use of the CE concept is especially relevant to understand the perception that CE is dominating the discourse given the large number of academic articles being published on CE<sup>25</sup>. Since concepts are building blocks of theory (Bacharach, 1989; Stinchcombe, 1968), an understanding of the different concepts being used by the scholars has the added benefit of providing an overview of the complex conceptual landscape to research students or 'newcomers' to the field as well as established researchers, providing them with the building blocks for a conceptual toolkit. In addressing the three issues discussed above, we draw from the assessment and opinion of the scholars. Although some of the processes associated with shaping concepts and related discourses are realised within the scientific community, the assessment and opinion of scholars are seldom subject to scientific inquiry (D'Amato et al., 2019). This also enables us to outline an informed future research agenda based on the assessment of an international group of experts.

The overall objective of the paper is to understand the evolution of the CE concept and its positioning viz-a-viz to related competing concepts. The research questions for this study are:

RQ1: How do scholars perceive the evolution of CE academic research?

RQ2: What other concepts are used by scholars in the expert panel prior to and along with the CE concept?

RQ3: Do scholars in the field consider CE as the dominant concept in addressing wider concerns pertaining to sustainability?

To answer these questions we use a text mining approach to inductively analyse the vast literature on CE. As inductive approaches like this may produce results that are obscure or difficult to interpret, we use a Delphi study, a qualitative approach using expert judgement, to validate and evaluate the text mining results along with providing an additional layer of contextual, expert-driven insight related to the CE concept. This study also provides a novel methodological contribution by combining topic modelling and a Delphi study which has not yet been done. Through this approach, we draw conclusions on how scholars perceive the evolution of the CE concept, the other concepts used by the scholars, and

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<sup>25</sup> Based on a [Scopus](#) search dated 14<sup>th</sup> August 2020 using the keyword 'circular economy' in the keyword, abstract, title over 1200 articles were published in the year 2018 alone compared to 100 articles published in 2013

CE's position amidst other concepts. We proceed by presenting the research method in Section 2 followed by the results in Section 3. In Section 4 we present the discussion and finally the conclusion and future research agenda in Section 5.

## 2. Research Method

Manual inspection of academic literature is resource-intensive and requires sufficient background knowledge to generate a coherent structure of the literature, its topics, and trends (Delen & Crossland, 2008). To overcome these limitations text mining can be employed (Yang et al., 2018). Text mining is a computational method that can structure vast amounts of previously unstructured data. It supports the exploration and review of large numbers of academic articles without any a priori selection of building blocks (topics) to be used as the foundations of the review (Guerreiro et al., 2016). The use of text mining, in particular topic modelling, in literature reviews is a popular approach that has been applied in various fields of study ranging from biomedical research to marketing (Bickel, 2019; Jiang et al., 2016; Moro et al., 2015; Sun & Yin, 2017; van Altena et al., 2016; Yang et al., 2018).

However, rigorous validation of the outputs from unsupervised text mining methods such as topic modelling requires consideration of issues of both statistical and practical significance -- the latter of these is particularly difficult to verify. With topic modelling being an explorative, unsupervised task, there exists no gold standard to compare results with directly (Chang, Boyd-Graber, Gerrish, et al., 2009). Instead, human judgement is often regarded as the gold standard in the evaluation of unsupervised methods (Dahdul et al., 2018). In this paper, we substitute the judgment of individuals conducting the quantitative study with that of a set of international experts.

Thus, we present a mixed-methods approach by combining two distinct strands, one quantitative and qualitative which are linked and each having its own rigorous data collection (Creswell & Tashakkori, 2007). In terms of typology of mixed methods, we follow a partially mixed sequential equal status design (Leech & Onwuegbuzie, 2009). This involves conducting a study with two phases that occur sequentially, and each phase having equal weight.

Our methodology is depicted in Figure 5 below:

- I. *Part A*: Text mining approach to draw insights from the vast CE literature
  - II. *Part B*: Delphi study with a group of international scholars by providing them with the results from the text mining, combined with other questions aimed at harvesting their knowledge on the CE concept.
- Together Part A and B generate insights regarding the development of the CE concept in the academic context and how scholars perceive its evolution and positioning relative to competing concepts.

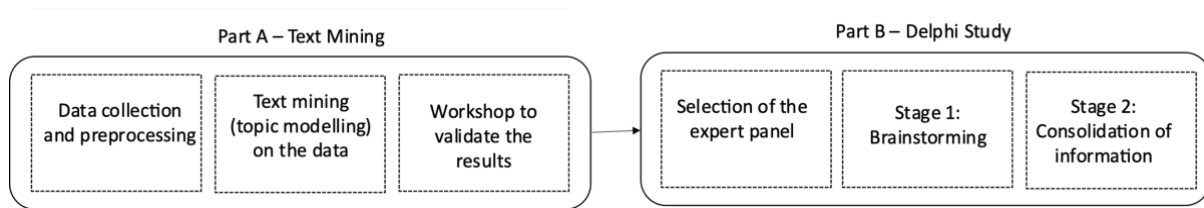


Figure 1: Overview of the research methodology

## 2.1. Data collection and pre-processing

Data was collected from the Scopus database from January 2005 to May 2019, i.e., after which we executed Part A of the methodology. The results from Part A of the methodology serve as an input for Part B. The Scopus database was selected as our data source as it is considered to be one of the largest databases containing peer-reviewed literature, including scientific journals, books, and conference proceedings (Nobre & Tavares, 2017). In our choice of keywords, we draw on the idea of a central subject put forward by (Hull, 1975). To define or understand a process a central subject needs to be identified which can be any kind of entity such as an individual actor, group of actants, linguistic object, social movement, or a machine. As we seek to understand the evolution and position of the ‘circular economy’ concept, the central subject of this study is the linguistic object ‘circular economy’. We thus select literature which uses this central subject in its title, keywords, or abstract as documented in Scopus. We included peer-reviewed journal articles, books, conference proceedings, editorials published in English in the search, to ensure maximum coverage. Such a choice in documents enables us to capture the broadest range of scientific activity relating to CE, with the advantage that it covers additional information about emerging CE activities that lesser-known journals and conference publications may contain (Geissdoerfer et al., 2017b; Türkeli et al., 2018). From the 3437 results, 3300 were retained after omitting 137 which contained empty abstracts. Abstracts were considered as our data source for part A, as they normally contain sufficient keywords about the research themes (Griffiths & Steyvers, 2004; Sun & Yin, 2017a). The data (3300 abstracts in CSV format) was loaded using the ‘tm’ package in R and standard text mining pre-processing steps i.e., lowercasing, removal of stopwords, punctuation, stemming were applied to the entire corpus.

## 2.2. Topic Modelling

To determine key trends in the CE literature we employ topic modelling—a statistical approach wherein non-exclusive groups of words are automatically induced based on their distribution in a corpus (Nikolenko et al., 2017b). Using this methodology we can divide the corpus into topics and then further visualise the representation of each topic longitudinally over time. Topic modelling has been used as a popular tool for systematic literature reviews in a wide range of studies ranging from education to ecology and evolution (Dayeen et al., 2020; Hall et al., 2008; Kunc et al., 2018; Nunez-Mir et al., 2016;

Wang et al., 2017). In recent years, topic modelling has been used to analyse different aspects of the CE concept, from an overview of the entire CE literature to specific investigations regarding the lack of congruence between European citizen perspectives and policies on CE (D'Amato et al., 2017; Anttonen et al., 2018; Repo et al., 2018; Ginga et al., 2020; Schöggel, Stumpf and Baumgartner, 2020). In the application of topic modelling in this study, we use similar approaches as previous studies. However, our application of topic modelling is different from previous studies in that we identify the number of topics and, importantly, examine how each topic evolves.

In the application of topic modelling to our data, every document  $d$  (the abstract) is considered to consist of a mixture of several topics  $k$ . A well-known algorithm for topic modelling is Latent Dirichlet Allocation (LDA) (Blei et al., 2003a), which we applied over the entire corpus using the *lda* (Chang, 2015) and topic models (Grün & Hornik, 2011) R packages. For each document  $d$  in the corpus, LDA computes the probability that  $d$  belongs to topic  $t$ , where  $t$  is any of the  $k$  topics automatically identified. The probabilities for each topic are then summed for each year based on the year of publication of each document. The sums are then visualised graphically in a stacked plot to assess the trend in the prevalence of different topics over the years.

### *Selection of number of topics*

One of the most important variables to be pre-determined in a topic model is the number of topics ( $k$ ) since it can significantly impact the interpretability of the model. Whilst a lower number of topics can divide the corpus into very generic semantic contexts, not capturing the corpus adequately, a higher number of topics can generate topics that are overlapping and uninterpretable (Zhao et al., 2015). A combination of scientific methods and human judgement is available to choose the number of topics (Shin et al., 2018). We compute topic coherence scores using the UCI metric<sup>26</sup>. We mapped the topic coherence scores from  $k = 1$  to 30. Based on the coherence scores the optimal number of topics is determined as  $k = 20$ . We further validate the suggested number of topics through the workshop discussed in the next section. We refer the reader to Appendix A for additional technical details on the determination of the number of topics

### **2.3.A Pilot Study (Workshop)**

One of the risks posed by unsupervised methods like topic modelling is that there exist no gold standards to evaluate the results. There is a possibility that results that appear statistically meaningful have no practical interpretation. To ensure that the results would provide meaningful input to part B of the study

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<sup>26</sup> There are a number of methods to compute topic coherence scores such as UMass metric, any-any, one-any metrics. We choose the UCI metric because it has shown higher correlation with human judgement when compared to UMass metric. While other metrics such as any-any and one-any slightly outperform the UCI metric they pose challenges like exponential running time and difficulty in practical application.



(the Delphi), we conducted a pilot workshop with 7 scholars, all members of the Circular Economy group hosted by the Sustainable Consumption Institute, University of Manchester. Members of this group come from diverse departments such as chemical engineering, social sciences, civil engineering and work on different aspects of the CE. This pilot study aimed to test if scholars in the field could engage with the results of the topic modelling and would find it meaningful, before scaling it up to a larger audience; results from this stage did not feed into the Delphi study. The workshop was structured around the following questions: (1) Is there semantic coherence in the topics generated by the model? This question is aimed to assess if the topics can be meaningfully interpreted using human judgment. (2) Are all aspects of the CE literature covered in the topic model results? This question is aimed to assess if the set of topics adequately covers the literature on the CE.

Additionally, from the pilot study, we also provide labels to each of the topics and organise them into coherent themes, however, we only use the topics for further analysis in the Delphi study and not the themes.

## 2.4. Section of qualitative methodology

Part B (see Figure 1) aims to collect expert opinions on the results obtained from topic modelling. Qualitative research uses a range of methods to scientifically establish the interpretive meaning of social phenomena: interviews, focus groups (Gill et al., 2008), analysis of written material, group discussions, observation studies (Carter and Henderson, 2005), and Delphi studies (Okoli & Pawlowski, 2004). To select the appropriate method for soliciting expert opinions we followed the three criteria proposed by (Harrell & Bradley, 2009):

- I. Does the selected method allow for obtaining in-depth information from the respondents?

The aim is to harvest the opinion of the experts with no limitation in the style and length of the answers, to solicit as much information as possible from experts.

- II. Does the selected method enable resolving conflicting opinions of the experts?

The concept of CE has theoretical underpinnings stemming from a variety of fields. Hence we anticipate that in a group of experts coming from diverse backgrounds conflicting interpretive understandings may exist regarding our research questions. We actively seek for consensus of interpretations among experts where possible.

- III. Does the method enable the correlation of judgements of the respondents in different stages to achieve consensus?

The methodology should enable us to make correlations between the judgments of the respondents at every stage of the data collection thereby allowing meaningful content analysis covering all aspects of the concept.

Using these criteria we compared five qualitative data collection techniques i.e., surveys, interviews, focus groups, Delphi study, and workshops. Three methods i.e., focus groups, Delphi

studies, and workshops fulfilled our criteria. Logistical issues associated with gathering international experts prevented us from using workshops. After comparing focus groups and Delphi studies we found that focus groups are more strongly affected by group dynamics and the opinion of some members of the group might overpower others (Gill et al., 2008). In contrast, Delphi studies take advantage of complementary knowledge, opinions, and expectations of high-level experts, avoiding dominance by a single member (Osborne et al., 2003). Hence, we adopted the use of the Delphi study over focus groups, to solicit expert opinion in our study.

## 2.5. Delphi study

The Delphi study is a group process used to survey and collect expert opinions on a particular subject (Yousuf, 2007). It is especially helpful in the exploration of information in cases where there is insufficient historical data, knowledge, or agreement in the field (Okoli & Pawlowski, 2004). The Delphi method has been popularly applied in a wide range of studies ranging from nursing to information technology (Garrod and Fyall, 2000; Schmidt *et al.*, 2001; Seuring and Müller, 2008; Boulkedid *et al.*, 2011; Davis, Taylor, and Reyes, 2014). There are different types of Delphi studies such as classical Delphi, policy Delphi, decision Delphi, group Delphi/expert workshop (Van Zolingen & Klaassen, 2003). For this study, we proceed with the Classical Delphi.

There are various studies in different application areas of CE where expert opinion in different forms such as semi-structured interviews, surveys, Delphi studies, and workshops have been used (de Jesus et al., 2019; Garza-Reyes et al., 2019; Mahpour, 2018; Rincón-Moreno et al., 2020; Singh et al., 2020; Sørensen et al., 2019; Urbinati et al., 2017). While the use of expert opinion is popular in the CE literature, our application in this paper is novel in the way we utilize quantitative results as a core instrument to elicit qualitative views in the Delphi study.

## 2.6. Selection of expert panel

Delphi studies are often seen as vulnerable to researcher and subject bias (Keeney, Hasson and McKenna, 2001). To address this, it is imperative to design the panel such that its composition minimises bias to the extent possible (Okoli and Pawlowski, 2004). In this study, we considered two important aspects in the selection of the expert panel.

- I. First is the geographical composition of the panel, to achieve variation in terms of respondents' background and cultural environment. This also includes diverse affiliations of the respondents ensuring distinctive ideas and insights.
- II. CE-relevant expertise spans a wide range of disciplines. Therefore, to ensure a representative, all-around perspective we sought to select participants with a diverse range of expertise and interests. As our data-driven analysis had identified 20 topics in the CE literature, we aimed to ensure the presence of experts from all topics.

To systematically identify the experts and fulfil the above criteria we adopted the following steps:

- I. Based on the keyword search “circular economy” (matched against abstracts, keywords, and titles) in Scopus, we listed the countries that have produced over 50 articles. We identified 26 such countries, aiming to include experts from each of these countries.
- II. Across the 26 countries, we identified 54 universities/research institutes that are associated with over 30 articles published on CE.
- III. In the first stage, we identified 2-3 experts in each of these universities and invited them to participate in the study. A total of 112 email invitations were sent in this first round. we received 29 responses (~26% response rate).
- IV. We identified a new set of 2-3 experts from each of the 54 universities/research organisations. We then sent 136 emails in the next stage and received 39 responses, (~29% response rate).

Our final expert panel was composed of 68 experts spread across 16 countries and 42 universities and research institutes (Refer to Appendix D for profile of the expert panel).

### 2.7. Design of the Delphi study

Practical implementations of a Delphi study are usually designed in two to three stages (Okoli & Pawlowski, 2004; Seuring & Müller, 2008). Our study was designed to have two stages i.e., brainstorming and consolidation. For the detailed questionnaire design, we refer the reader to Appendix B.

- I. Stage 1: Brainstorming : In the first stage, questionnaires were administered through an online survey platform i.e., SmartSurvey<sup>27</sup>, which included both closed and open-ended questions. The panellists evaluated several given statements on a Likert scale. The open-ended questions allowed the panellists to comment relatively freely on the CE concept. They were thus encouraged to provide arguments supporting their views and opinions. The questions have been discussed in detail in sections 3.2, 3.3, and 3.4. This stage lasted for two and a half months wherein 68 experts participated.
- II. Stage 2: Consolidation: The second stage was focused on the consolidation of the results from the brainstorming phase. Once the first stage was complete, we collated all of the responses received. The resulting document contained summary statements together with anonymised quotes supporting each statement. This document was shared with the entire panel of 68 experts and they were asked to indicate their agreement with each summary statement on a Likert scale. This stage lasted for three weeks and there were 45 experts (~67%) who participated.

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<sup>27</sup> <https://www.smartsurvey.co.uk>

### 3. Results

#### 3.1. Text Mining using Topic Modelling

By combining scientific methods and human judgement we determine the optimal number of topics in the CE literature corpus to be 20. We use the LDA topic modelling algorithm and extract 20 topics from the literature corpus. Refer to Appendix C for details on each of the 20 topics. We also find the relative proportion of each topic in each year which is mapped on a stacked graph. This allows us to visualise the evolution of the CE literature over the years starting from January 2005 to May 2019. Figure 2 is a representation of the evolution of topic proportions over time. Each stacked bar is representative of the relative topic proportion in each year. Apart from the relative proportion of each topic, it is also important to appreciate the clear increase in the absolute number of articles that are published each year as indicated by the counts on top of each stack. We notice a clear change in the pattern of the topic proportions that are further explored in the Delphi study.

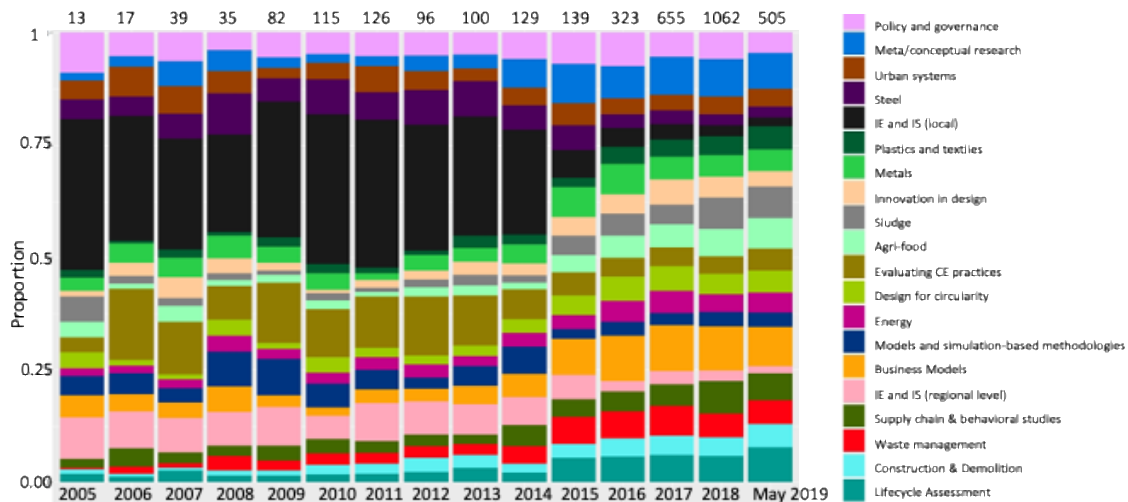


Figure 2: Evolution of the topic proportions over time with a clear change in pattern in 2014-2015 \*numbers on top refer to the total number of articles in each year

#### 3.2. Scholars perspectives on the evolution of the CE concept

In this section, we present the results from the Delphi study, as underpinned by our topic modelling results (Figure 2). We solicit expert opinion on the following questions:

- i. What do you observe in the graphical representation?
- ii. In your opinion, what happened in the year 2014-2015?
- iii. Is there any anomaly in the results of the text mining analysis?

While question (i) is aimed at collating observations of the experts, question (ii) is aimed at understanding the reasons for the same. Together, they enable us to identify the observations and reasons in Table 1 and 2 respectively. Sections 3.1 and 3.2 combined enable us to answer RQ1.

### Observations made by experts based on the text mining results

The experts provided various observations based on the graphical representation. The responses were first listed and all duplicates were removed manually. Five summary statements were generated based on the list of all the observations provided by the 68 experts manually. The five observations, along with typical statements in support of each observation, were provided to the experts in Round 2. In this round, the experts were asked to rate their agreement with the observations on a Likert scale. To define the acceptance criterion in the Delphi study we used the criteria provided by McKenna., (1994) drawing on Loughlin and Moore., (1979) suggesting that a consensus should be equated with 51% agreement amongst respondents. Table 1 provides the five observations along with the details of the agreement for each observation. There is one observation where agreement has not been reached about the CE literature becoming less evaluative.

Table 1: List of observations made by the experts based on the results of the text mining presented in Figure 2

Observations	Disagree	Neutral	Agree	Agreement Status
There has been an immense increase in the number of articles produced since 2015.	0%	0%	100%	achieved
There has been a significant structural change where CE literature has developed a distinct line of enquiry distinguishing itself from IE in the year 2014-2015.	6%	17%	77%	achieved
CE has evolved to include multidisciplinary trends making the concept more dispersed across topics.	3%	23%	74%	achieved
With a strong focus on businesses, CE literature moved away from macro-level industrial focus to micro-level interventions such as business models, product design etc leading to a significant structural change in research trends in the year 2014-2015.	6%	20%	74%	achieved
Over time CE literature is becoming less evaluative.	31%	31%	37%	not achieved

### Reasons for the observations provided by the experts

Based on the observations listed in Table 1 we also seek to investigate specific reasons that have led to the recent evolution of the CE concept. We follow the same method as we did for the observations above i.e., listing down all the reasons provided by the experts, then removing duplicates and summarizing. Further, asking the experts to rate the reasons on a Likert scale. There were a total of nine reasons that were deduced out of which agreement was achieved on six, as presented in Table 2.

Table 2: Reasons for observations made by the experts based on results of the text mining presented in Figure 2

Reasons	Disagree	Neutral	Agree	Agreement Status
It was a change in terminology used by the academic community i.e., different labelling moving away from antecedents such as IE and IS to align with funding calls and the popularity of the CE concept.	26%	11%	63%	achieved

The extensive work done by the EMF in promoting CE had an impact in promoting CE around the year 2014-2015 leading to a change in the research trends.	6%	3%	91%	achieved
EU joining the CE debate with the EU CE package, CE Action Plan and EC Horizon 2020 had a significant role in the structural change in the CE research trends in 2014-2015.	6%	6%	89%	achieved
The way the CE concept was defined was much easier to link to business strategy and communications and that led to a specific structural change in research trends specifically in the year 2014-2015.	9%	11%	80%	achieved
Big businesses were actively involved in popularising the CE concept, this trend also impacted the evolution of CE in the academic community.	11%	0%	89%	achieved
The structural change in CE literature over time was attributed to the research cycle which concepts undergo wherein initial research is more exploratory and over time it evolves into more practical applications.	17%	23%	60%	achieved
State of the world economy becoming more vulnerable led to the rise of the CE as an economically viable solution aiming towards continued sustainable economic growth.	37%	29%	34%	not achieved
Chinese policy has impacted the evolution of the CE Literature over time and has had a significant impact in 2014-2015.	17%	46%	37%	not achieved
Regulatory requirements led to increased traction that CE received over time since topics such as LCA were embedded in regulations.	23%	37%	40%	not achieved

### Anomaly in the results from text mining

We asked the experts if they found any anomalies in the results from the text mining. This question aimed to distinguish if the results from the study are indicative of any specific change in the system or are just artefacts of data collection and sampling (Bower, 2019). The responses are summarised in Table 3 below. Out of 68 experts, 66 experts have not observed an anomaly in the results of text mining. In Table 6 below, we (the authors) address the comments from the experts.

Table 3: Anomalies in the results from the text mining as detected by the experts

	No. of experts	Authors' reasoning
No anomaly	62	
Not convinced with the structural change in 2014-2015.	2	
Expected the topic on Policy and Governance to increase more rapidly in the graphical representation	2	There is a considerable increase in the absolute number of articles published on Policy and Governance (~15% increase in articles every year) although its presence relative to other topics is less.
There is an expanding body of grey literature that has not been represented in the graphical representation.	1	The scope of this research is only limited to academic research articles. However, we do acknowledge the vast

An issue with the topic name- not clear what evaluating CE refers to.	1	body of grey literature that has valuable information on CE. Changed topic name to Evaluating CE practices
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### 3.3. Concepts used by scholars in the field

In this section, we present results based on soliciting expert opinion on the following question which enables us to answer RQ2:

*What other concepts have the scholars used in their work prior to and along with the CE to address the wider discussion on sustainability?*

In addressing the question above only 7 out of 68 i.e., ~10% of the experts in the panel have stated that they did use other concepts in their research earlier but currently *only* use CE. The remaining 90% of the experts in the panel have stated that they have used and continue to use other concepts apart from the CE. In Table 4 we represent a list of all concepts that the experts have used and continue to use in their research work. The wide range of concepts that have been presented is reflective of the diverse and rich discussion on managing sustainability issues about waste and resources. The list of concepts has been semantically grouped and are indicative of the conceptual toolkit that is available to researchers in advancing the discussion on sustainability issues about waste and resources. Further, we zero down on the most common concepts based on the count of the number of experts in the panel who use them. Out of the long list of concepts that the experts in the panel provide, the most commonly used concepts along with ‘CE’ are *IE, SE, C2C, IS, green economy, regenerative design, performance economy, biomimicry, reverse logistics, blue economy, natural capital*. Figure 3 is a representation of the count of experts using these concepts prior to and along with CE. On further analysing the results from Figure 3, we observe that individual experts use a diverse set of concepts with CE than they did before. For example, the number of experts using concepts such as *blue economy, biomimicry, performance economy, regenerative design, green economy, SE* along with CE has substantially increased. Furthermore, it is interesting to note here that a number of concepts which are commonly used by scholars in Figure 3 are the predecessor concepts from which the concept of CE is often said to have emerged or reincarnated such as *IE, C2C, biomimicry, blue economy, regenerative design, natural capital, IS* (Geissdoerfer et al., 2017; Lewandowski, 2016; Merli et al., 2018; Reike et al., 2018) and these predecessor concepts are often regarded as the schools of thought of the CE conceptualisation (Homrich, Galvão, et al., 2018). Thus, CE has not replaced any of the predecessor concepts rather scholars continue to use the older concepts which could potentially indicate that owing to the conceptual ambiguities researchers continue to rely on other concepts or use them in combination with the CE.

Table 4: List of all concepts used by researchers prior to and along with the CE



Concepts used prior to using 'circular economy'	Concepts used along with using 'circular economy'	
	Same as concepts used earlier	Additional concepts used
Collaborative consumption Responsible consumption	Collaborative consumption Responsible consumption Systems of sustainable consumption and production	Circular consumption
Product Service systems Eco Product-Service Systems Functional economy Servitization Sustainable servitization Performance economy Sharing economy Inverse manufacturing	Product Service systems Eco Product-Service Systems Functional economy Servitization Sustainable servitization Performance economy Sharing economy	Eco-system services
Eco-services Eco-innovations Eco-design Eco-efficiency Eco-physics	Eco-services Eco-innovations Eco-design Eco-efficiency	Eco-civilization Eco-industrial development
Sustainability Sustainable development Sustainable business models Sustainable production and consumption Sustainable Marketing Sustainable-based processing	Sustainability Sustainable development Sustainable business models Sustainable production and consumption	Sustainable circular eco-systems Sustainable consumption Sustainable circular economy Sustainable Economy
Green economy Green growth Green marketing Green products Cleaner production Integrated Product policy Post-mass production paradigm Waste to Product Zero-Waste Waste minimization	Green economy Green growth Green marketing  Cleaner production Integrated Product policy  Waste to Product Zero-Waste	       Waste to Resource E-waste End-of-Waste
Life cycle thinking Life cycle management	Life cycle thinking Life cycle management	Material flow systems
Sustainable supply chain management Closed-loop supply chain Reverse logistics	Sustainable supply chain management Closed-loop supply chain Reverse logistics	
Resource efficiency Resource recovery	Resource efficiency Resource recovery	Resource effectiveness
Regeneration of drosscapes Urban / regional metabolism Industrial ecology Industrial symbiosis Eco-industrial parks	Regeneration of drosscapes Urban / regional metabolism Industrial ecology Industrial symbiosis Eco-industrial parks	Regeneration of waterscapes circular metabolism
Biobased Economy Biomimicry Biomass recycling	Biobased Economy Biomimicry	Bioeconomy
Regenerative agriculture Regenerative design Recycling Reuse	Regenerative agriculture Regenerative design Recycling Reuse	Regenerative economy
Natural capital Blue Economy Cradle to Cradle Decoupling Kretsloppssamhället <sup>28</sup> Pollution prevention	Natural capital Blue Economy Cradle to Cradle Decoupling	Triple bottom line Low carbon economy Circularity Criticality Environmental accounting Solidarity Economy Environmental security

<sup>28</sup> Swedish term for 'circular economy'

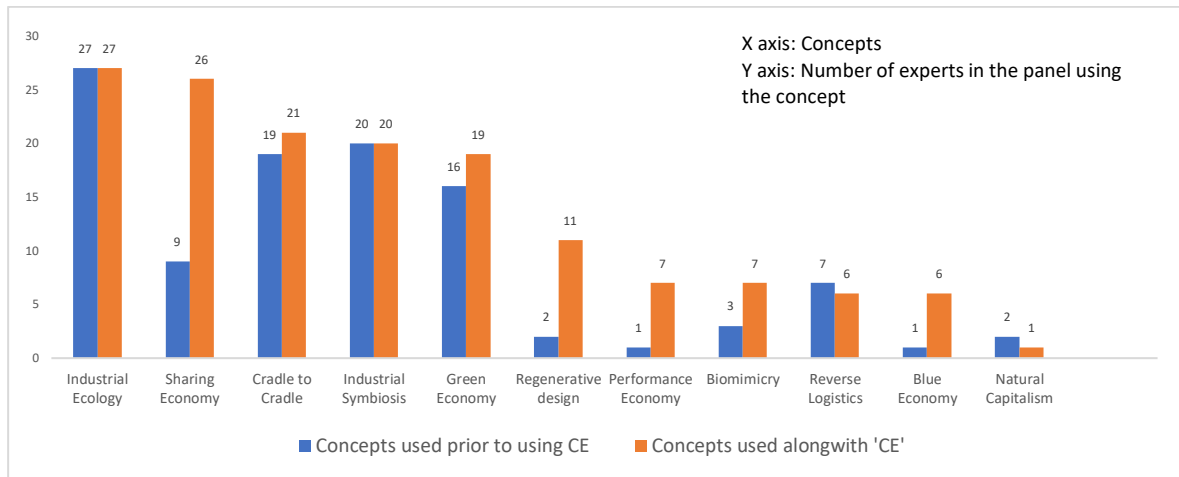


Figure 3: Most commonly used concepts prior to and along with CE based on the count of the experts

### ***Scientific production on different concepts***

To further empirically investigate and elaborate on the findings from Figure 3 we assessed the number of academic articles produced annually using the 11 commonly used concepts represented in Figure 3. Count of scientific production in the form of articles, books, conference proceedings are particularly useful in constructing time series data and when researchers are trying to understand trends (Abrahamson, 1996). This enabled us to put into perspective the volume of academic articles produced on each of these concepts. Figure 4 is a representation of the number of academic articles produced on each of the popularly used concepts apart from CE. We observe that the increased traction of the CE concept in academic discourse cannot be overlooked. However, the other concepts have also witnessed a consistently increasing trend in the number of academic articles produced. Especially the concepts of 'IE', 'SE', 'green economy' have also witnessed a significant increase in the number of academic articles over the years. Thus, indicating towards the rich and diverse discussion on managing sustainability issues about waste and resources.

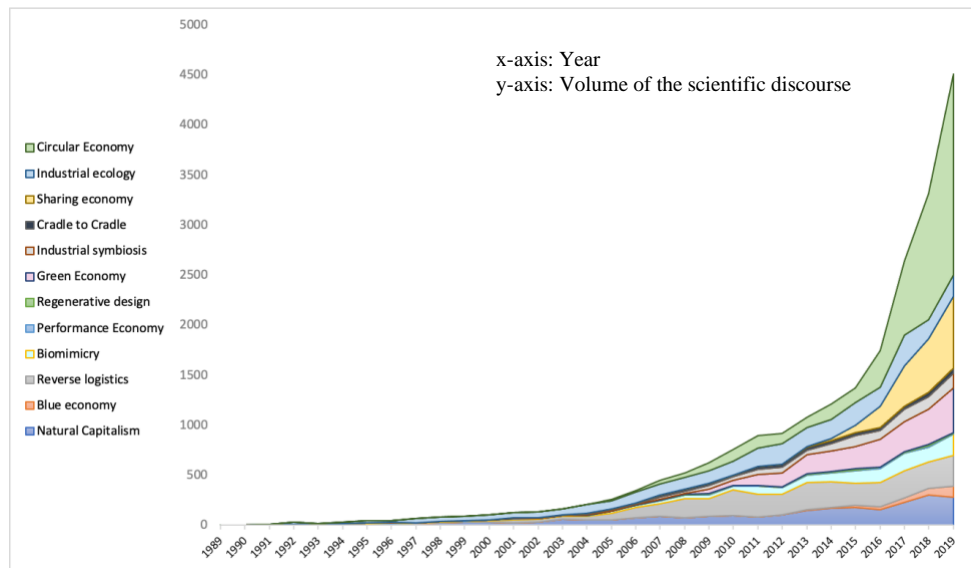


Figure 4: Annual academic production on CE and other competing concepts based on a Scopus search performed on 14<sup>th</sup> August 2020 searching for “circular economy” verbatim in titles, abstracts, keywords

### 3.4. The dominance of CE in addressing questions pertaining to sustainability

There is an increasing perception that CE is a dominant narrative in CE discussions (Borrello et al., 2020; Mah, 2021; Valenzuela & Böhm, 2017). It has also been established as a key framing device for sustainability issues regarding waste and resource management (Blomsma & Brennan, 2017). However, there is no adequate enquiry that seeks consensus on how scholars in the field perceive the position of CE in discussing sustainability issues. Given the diversity of the field which we reflected upon in Section 3.3, we set out to uncover if scholars perceive CE to be a dominant concept in these discussions. The word *dominant* is often used in various settings, in academic literature such as dominance in genes (Wilkie, 1994); dominance in animal behaviour (Drews, 1993), social dominance (Hawley, 1999), market dominance (Cabral & Riordan, 1994). In these settings the word dominant is typically meant to designate something (e.g., genes, humans, market forces) that has power or influence over others and has an authoritative position. In this article, we define a *dominant concept* as one which can replace other competing concepts to claim an authoritative position as an uncontested denotation of a phenomenon. In previous studies so far no definition is provided when discussing the position of CE as dominant or as a key framing. Whilst the increasing number of academic articles reflect the increased traction in the academic context, to understand its dominance it is imperative to assess the use of the CE concept in relation to other competing concepts (as we have done in the previous section) and to understand scholar’s opinion of the dominance i.e., if it is dominant or not and why so. To this end, we solicited expert opinion on the following question which enables us to answer RQ3:

*Is CE a dominant concept in addressing questions pertaining to sustainability?*

In the first round of the Delphi study, experts were asked to provide their opinion to the statement and to provide an explanation/motivation for their opinion.

In the first round, only 20 % of the experts agreed to the statement, implying that most scholars did not agree with the statement. We provide the same question in the second round with example statements showcasing support, contradiction and neutrality. The number of experts agreeing to the statement in the second round went down to 18% whilst the neutral opinion went up to 34% from 32%. To assess if there is any significant difference in the results of the two rounds we computed the coefficient of variation (CV)<sup>29</sup> of the scores provided by the experts in the two rounds which is only 0.04; this is considered a minor difference in line with previous studies and we conclude that two rounds were sufficient to terminate the study and draw conclusions on this statement (Yang, 2003).

In Table 5 below we present a summary of the expert opinions. Based on the expert elicitation the opinion of the experts is divided with respect to its dominance, with the majority of experts not perceiving CE as a dominant concept in addressing issues about sustainability. However, there were also a considerable number of experts who provided a neutral response to the statement.

In considering why experts held the view that CE is not a dominant concept in sustainability discussions, we were able to narrow this down to two main reasons. First, CE does not tackle certain issues such as climate change, biodiversity loss, emissions, desertification, land use, transport emissions and more arising from anthropogenic activities. Second is the critique that CE is characterised by a missing social dimension. While CE's dominance in managing sustainability issues pertaining to waste and resources is agreed unanimously by the experts they do not agree to its dominance in addressing broader issues pertaining to sustainability.

### ***Perspectives of experts based on geographical affiliation***

In recent years, CE has emerged as a policy agenda at the European community level, as a result of the enactment of the CE Package, which is considered the next political economy policy for Europe (Lazarevic & Valve, 2017). Recent studies have compared the European conceptualisation and implementation of CE with other regions such as China (McDowall et al., 2017; Ranta, Aarikka-Stenroos, & Mäkinen, 2018), Latin America (Morales & Sossa, 2020), South Africa (Mativenga et al., 2017), United States (Ranta, Aarikka-Stenroos, & Mäkinen, 2018). Drawing on this work, we are interested to further investigate the perception of the dominance of the CE concept, and how this differs from the geographical affiliation of the experts. In the comparison of perspectives listed earlier, the European perspective is the common link owing to the popularity of the concept in Europe, hence we create two groups from our expert panel. One group comprises experts from Europe and the other group consists of experts from the rest of the world. We conduct a paired *t*-test<sup>30</sup> to determine whether there is a significant difference in the opinion of the experts in Europe and the rest of the world regarding the

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<sup>29</sup> The **coefficient of variation** (CV) is the ratio of the standard deviation to the mean. Higher the CV, greater the level of dispersion around the mean. The difference in CV in the two rounds enables to understand the variability in the responses. A lower difference means lower variability.

<sup>30</sup> A paired *t*-test is a statistical procedure used to determine if the mean difference between two sets of observations is 0.

perception of the dominance of the CE concept. At 95% confidence interval we find the  $p$ -value to be 0.5<sup>31</sup> concluding that there is no significant difference in the perception amongst experts from Europe and the rest of the world.

Table 5: Opinion of the experts pertaining to the dominance of the CE concept

	Round	Disagree	Neutral	Agree	CV	Agreement status
CE has become a dominant concept in addressing questions pertaining to sustainability.	1	48%	32%	20%	0.31	not achieved
<b>Example statements from experts in contradiction:</b>						
<i>“The global emphasis and discourse on decarbonisation and net-zero largely overlooks CE, and is clearly dominant in terms of sustainability conversations.”</i>						
<i>“There are many other aspects of sustainability that are not covered in this term, e.g. land use, water use, transport emissions, social sustainability etc.”</i>						
<i>“CE addresses only some questions pertaining to sustainability, closely related to resources preservation and economic development. However, the whole spectrum of social issues and many environmental topics (e.g. CO<sub>2</sub> or ozone emissions), are not core of CE discussions.”</i>						
<i>“...it has not yet displaced topics such as climate change and biodiversity conservation which I believe it should not, as the CE focuses on material flows and resource use, despite efforts to make it more comprehensive.”</i>						
<b>Example statements from experts in support:</b>						
<i>“CE allows to address problems related to sustainability from different perspectives, not just from the environmental point of view but considering also economic and social issues.”</i>						
<i>“the CE is still in the spotlight of sustainability, mainly because of the favour of several developed countries to base their environmental policies on the principles of the circular economy and developing countries in some way, try to follow the trend.”</i>						
<i>“Yes, it is part of the sustainability agenda because of the dissemination of a multitude of models in every area of interest: from industry to city.”</i>						
<b>Example neutral statements from experts:</b>						
<i>It is true that CE has been popularised in recent years by for example by the EMF and is becoming a more and more familiar term but I do not agree that it is dominant in addressing most questions about sustainability as sustainability contains both aspects of social, economic and environmental sustainability of which CE is questionable as it is mostly associated with the environmental and economic aspects.</i>						
<i>The concept surely became dominant in the context of resource-use, but it has not yet achieved this status in relation to climate policy.</i>						
<i>What does “dominant” mean? There has been an evolution in terms, but also the awareness of society. I think that there has been more funding, more support from the institutions, etc. that coincide in time with the concept of the circular economy.</i>						

<sup>31</sup> At 95% level of significance if the  $p$ -value is less than 0.05, we reject the null hypothesis concluding there is a significant difference and if  $p$ -value is greater than 0.05, we accept the null hypothesis concluding there is no significant difference

## 4. Discussion

In this section, we discuss the main findings and implications of the three research questions.

*RQ1: How do scholars perceive the evolution of CE academic research?*

We longitudinally assess the CE literature to generate interpretive conclusions regarding its evolution and maturation in recent years. Our analysis of RQ1 is an extension of previous studies which focus on the historical evolution of the concept such as Reike, Vermeulen and Witjes, (2018) and Blomsma and Brennan, (2017). Both these studies present stages in the historical evolution of CE drawing on a different timeline, database and methods as compared to ours thereby labelling the contemporary stage of CE research as CE3.0 and validity challenge period respectively. However, these studies are not geared towards analysing the contemporary stage of CE research in detail when over 90% of the CE literature has been produced.

In our analysis, we detect 20 underlying topics in the CE literature using topic modelling and map the topic proportions over time to visualise their evolution. Building on the expert assessment of the text mining results, a structural change in the evolution of CE research is observed in the year 2014-2015 (see Figure 2). The structural change (2014-2015) detected in this study is comparable to some extent to the time slices used by Schögggl, Stumpf and Baumgartner, (2020) who split their data from 2000-2019 into 4 time slices. However, the time slices in their study are pre-determined based on the authors' judgement, underpinned by some of the key events in the CE discussion. On the other hand, the structural change observed in our study is informed by the text mining and Delphi study results thus providing a strong validation for the changes that we observe. In further analysing the structural change we detect the following features:

- There has been an immense proliferation in the number of academic articles using the CE concept in the period following the structural change. The proliferation in articles is a common observation discussed frequently in publications. In further investigating this trend and concept lifecycle we observe an extended period of dormancy where the idea of CE existed for a long time (Murray et al., 2017). However, there were only a few verbatim mentions in the 1990s for instance by Cooper, (1994, 1999). The concept started gaining traction in the early 2000s with the first Scopus record dated 2004, followed by the current period of rapid uptake and diffusion. Ostensibly, the lifecycle of the CE concept so far can be compared to a lifecycle (Abrahamson & Fairchild, 1999) where concepts undergo an extended period of dormancy followed by rapid uptake and diffusion and then a period of decline. The risk of this rapid diffusion of CE without conceptual clarity is that it could lead to a conceptual collapse (Kirchherr, Reike and Hekkert, 2017) hence witness the period of decline similar to management fashions or else like other concepts may be subject to a re-examination and redefinition that may then act as a trigger for a new wave of popularity (Grant, 2015). Further exploration of potential outcomes such as

conceptual collapse or re-examination and redefinition in detail is beyond the scope of this paper.

- There is a considerable conceptual affinity between the concepts of IE and CE due to CE's theoretical origins embedded in IE. (Bruel et al., 2019; Saavedra et al., 2018; Saidani et al., 2019). Previous studies have put forth a direction of research where IE could contribute to the theoretical development and implementation of CE (Blomsma & Brennan, 2017). However, the recent trend has been a "mission drift" wherein implementing CE no longer conforms to its theoretical origins (Henry et al., 2021). We observe that the key to the structural change is the literature on CE developing as an increasingly distinct line of inquiry from IE. Thus, rather than drawing from IE, CE research is developing independently from it. Interestingly, the number of articles using the concept of IE did not diminish. So, both the IE and the CE concept show growth in the period after the structural change.
- There have been previous assessments of the literature that have aimed to organise and cluster CE research. For instance, Homrich, Galvao, et al., 2018 organise CE literature into (1) IE and IS in a Chinese context and (2) supply chains, material closed loops and business models. Winans, Kendall and Deng, (2017) cluster CE research into (1) policy instruments and approaches; (2) value chains, material flows, and product-specific applications; and (3) technological, organizational, and social innovation. Merli, Preziosi and Acampora, (2018) use a range of dimensions to organise CE research. Whilst such organisations form a broad organisation of the literature on CE, our analysis detects 20 topics in CE research through topic modelling of 3300 abstracts. One of the key topics before the structural change was IE and IS in a Chinese context as identified by Homrich, Galvao, et al., (2018). Following from the previous point, as CE research is developing a distinct line of inquiry from IE, the diversity of the topics in CE research is developing further. For instance notice in Figure 2, before the structural change IE and IS hold the highest proportion. However, in recent years the literature on CE has evolved in a way that the attention is almost equally divided across different interdisciplinary topics. In the period after the structural change, the proportion of topics has been stable.
- The literature on CE in recent years has shifted away from macro to more micro-level interventions for sustainable development such as business models, product design and supply chain studies. Merli, Preziosi and Acampora, (2018) in their study identified a higher proportion of CE research geared towards macro-level interventions however this is based on only 565 articles. Drawing from the text mining results and expert assessment we determine a shift from macro to micro-level interventions in recent years. This also entails CE research adopting a language that is much easier to link to business strategy and communications.



Further analysis of the structural change through the opinion of the experts in the Delphi study revealed the following reasons for the above changes:

- The use of the concept of CE is often a new label used to denote ideas, topics and discussions that have existed before. To add to that, many researchers use terms such as CE, cradle-to-cradle, industrial engineering or closed-loop supply chains almost interchangeably (Geisendorf & Pietrulla, 2018). The drivers of such trends could be the bandwagon effect (Abrahamson & Rosenkopf, 1993), the need to align with funding calls and grants (Boyack & Börner, 2003) or with a particular policy agenda. A full exploration of these drivers and mechanisms is beyond the scope of this paper and we discuss this further in the future research agenda. Also, this points towards the fact that in a world dominated by buzzwords and dissonant meanings, there is an urgent call to use clarity in language and consistent definitions to avoid misinterpretations (Morseletto, 2020).
- In recent years the importance of the CE has been reflected by the commitment of the EU in transitioning towards a CE (European Commission, 2020; 2019; 2018; 2016). Indeed, since 2013 the Europe-centric interest in the topic has matched the Chinese interest in the early 2000 period. The work of organisations like the EMF in conjunction with the British Government have resulted in the increased traction of the concept in Europe and especially in the UK (Masi, Day and Godsell, 2017). The timing of the European interest is strongly linked to the structural change in the CE literature, as evidenced by both our text-mining results and expert opinion. This hints towards an interesting direction in the organisation of the science-policy interface (Watson, 2005) in the CE concept, i.e., if science informs policy or policy pushes science. The coercive impact in driving the structural change in CE academic research is evident.
- Major consulting companies such as McKinsey & Company, Accenture, Deloitte, Ernst and Young, KPMG have all published reports on CE showcasing the popularity and acceptance of the CE concept in the business domain and indicating their active role in further popularizing the concept. Initiatives by various practitioners such as Nike, H&M, Puma, BMW, Cisco Systems has been discussed in these reports (Accenture, 2014; Deloitte, 2016; Ernst & Young Accountants LLP., 2015; KPMG, 2019; McKinsey, 2016). Thus, we see immense acceptance of CE in the private sectors where the sentiments and CE discourse are very positive (Kirchherr & Piscicelli, 2019). This also leads to one of the critiques of CE that the private sector and actants in the government are producing a discourse with specific political and economic agendas, often using CE as a narrative device for greenwashing (Calisto Friant et al., 2020). The adoption of language in academic research is also in a way that matches the language of business strategy and communications. This also entails a lack of critical approach towards CE in the mainstream literature in line with the practitioner and policy maker sentiments.

- Lastly, expert consensus also attributes this change towards the research cycle that concepts undergo where the initial stages of research are more exploratory and over time research expands to different areas of practical implementation. This aspect is also linked to the fact that CE is now developing a distinct line of inquiry from IE and developing towards more interdisciplinary topics. As the research field is growing the practical areas of implementation are being explored further. For instance, in the early years topics such as plastics and textiles, construction and demolition were not explored to that extent while recently there is a significant body of knowledge that is being produced on these topics.

*RQ2: What other concepts are used by scholars in the field prior to and along with the CE concept?*

We specifically asked the scholars in the expert panel about the other concepts that they used prior to and along with CE. The expert elicitation shows that there is a wide range of concepts that experts used and continue to use in their research (see Table 4). The different concepts have been semantically grouped in Table 4 and can be used by newcomers or researchers in the field as a conceptual toolkit to address sustainability issues concerning waste and resources. While the language used by scholars is continuously evolving, they select variations of a concept and define those concepts in a way that fits their research questions (Boons et al., 2017). In the case of the concept of CE, it is often said to have emerged or reincarnated from predecessor concepts such as IE, C2C, biomimicry, blue economy, regenerative design, natural capital, IS (Lewandowski, 2016; Geissdoerfer *et al.*, 2017; Homrich *et al.*, 2018; Reike, Vermeulen and Witjes, 2018). However, information from the expert panel shows that the CE concept has not replaced the usage of any of these concepts in academic research, and scholars continue to use these predecessor concepts. While the increased attention to the CE concept is evident from the scale of scientific production in recent years, it also cannot be overlooked that other concepts continue to receive, or even grow in, attention in academic discussions. Thus, we could say that scholars equip themselves with an increasingly wide range of concepts to address wider concerns regarding sustainability issues about resources, one of which is the CE. This could be attributed to the fact that other competing (adjoining) concepts provide useful specifications or additional aspects that CE does not (Geisendorf and Pietrulla, 2018). Also, CE is a concept that is still evolving, scholars are continuously seeking other concepts such as IE (Blomsma & Brennan, 2017), social or solidarity economy (Moreau, Sahakian, Griethuysen, et al., 2017) which can contribute to the theoretical development of CE. Thus, there is the continued use of other concepts along with CE.

Further analysis of the type of concepts used by the experts reveals that they are mostly technical or suiting business requirements rather than transformative socio-cultural approaches. The choice of concepts by experts to some extent reflects economically and politically framed responses to mounting environmental pressures. Hence, the usage expressed by experts contradicts the resonance that has been proposed between CE and alternative discourses such as degrowth, and steady state economics (Calisto

Friant et al., 2020b; Charonis, 2012). These results are also divergent from a study by D'amato et al., (2019) who found that the set of experts who participated in their study were much more inclined to post-growth and degrowth perspectives. The reason for this could be in the choice of the expert panel itself. D'amato et al., (2019) systematically chose the experts dealing with more than one concept (CE, GE and BE) ensuring a balance between these three concepts. They also had a preference to include experts with a broader view of sustainability (including pro/degrowth ideas).

*RQ3: Do scholars in the field consider CE as a dominant concept in addressing wider concerns pertaining to sustainability?*

We further investigated if, amidst the other concepts in the discussions about sustainability, CE is a dominant concept. We understand 'dominant' (which is used without definition in the context of CE) to denote a concept that (1) has replaced other concepts, and (2) has an authoritative position as an uncontested denotation of a phenomenon. Based on the expert elicitation we conclude that mainstream interpretations of CE are majorly focussed on resource flows and does not completely tackle certain long term environmental challenges like climate change, biodiversity loss, decarbonisation, land use, transport emissions along with a missing social dimension (which is integral to sustainable development) despite efforts to make it more inclusive. As one of the experts in the panel quoted: *"The concept might have become dominant in the context of resource-use, but it has not yet achieved this status in relation to climate policy and biodiversity which is an integral part of sustainability."*

There has been limited attention on the relationship between CE and biodiversity wherein biodiversity protection is rarely mentioned in mainstream CE literature. Some of the ideas that CE advocates such as biomimicry, BE, renewable energy have their own set of conflicts with biodiversity and make the relationship between CE and biodiversity problematic in some ways (Buchmann-Duck & Beazley, 2020). However, some studies aim to address this gap by analysing trade-offs between materials, energy and biodiversity in a CE (Bauwens et al., 2020; Calisto Friant et al., 2020). Ali et al., (2018) in their study also explore prospects for market-based biodiversity offsets to address the current shortcoming in the existing CE policies in China.

Coming to the social dimension, CE has often been criticised for neglecting social and ethical issues and focussing on the environmental and economic aspects of sustainability (D'amato et al., 2019; Hobson & Lynch, 2016; Merli et al., 2018). There are studies that have aimed to strengthen the CE concept by integrating the social dimension. For instance, Inigo and Blok, 2019 draw from responsible research innovation to strengthen the socio-ethical foundations of the CE. Campbell-Johnston et al., 2020 propose a new framework that integrates cascading with the CE-R imperatives whilst accounting for the social complexities of the decision-making process. Jaeger-Erben et al., (2021) and Calisto Friant, Vermeulen and Salomone, (2020) reiterate the importance of a circular society to achieve the radical transformation that CE requires. Genovese and Pansera, (2020) propose a countervailing

discourse of CE based on the idea of convivial technology. However, it is important to appreciate that CE is an evolving concept which means different things to different people, and there remain mainstream interpretations and frameworks of CE implementation that do not consider a dimension of social justice both at the geographic and intergenerational levels (Murray et al., 2017). Therefore, the perception about the missing social dimension remains, despite recent efforts to make the CE concept more inclusive (Nogueira et al., 2019; Schröder, Lemille, et al., 2020).

In the elicitation of response about the dominance of the CE concept (~20%) of the panel noted the need to develop the social dimension of the CE concept. As one of the experts put it: *I agree to CE's dominance in environmental and economic sustainability, however not in relation to social sustainability.*

In fact, only 18% of the panel agreed to CE being a dominant concept, particularly because it covers different areas of interest and hence is applied to different action areas. 34% of the panel provided a neutral response to this statement. Neutral respondents expressed that CE is dominant in the discourse of managing waste and resource flows, but sustainability covers a variety of issues that CE does not address. As one of the experts who rated the statement neutral in both rounds summarise:

*I think that businesses are particularly interested in this concept. .... there is a strong focus on "economy". Of course, policy refers to resource scarcity and the need for more efficient use of resources, but oftentimes CE is "sold" as a business opportunity. Take the EU Action Plan for CE: the big headlines are thousands of new jobs and economic growth is still attached to the idea of sustainability in this case..... cities use CE to label some strategies that were previously related to sustainability in general. .... I must say that the problem with a dominant discourse around CE and sustainability is that people mostly associate CE with "good for the environment". For example, I questioned my MSc students during my lectures and they instantly agree with the idea of a CE being always good for the environment. I think we are still not sufficiently aware of the trade-offs arising from certain strategies. Thus, I rate this statement as neutral.*

To further investigate the perspective of the dominance of the CE concept we assessed the geographical diffusion of the concept. On comparing the opinions of the experts in Europe and the rest of the regions, we find no significant difference. Thus, even in Europe where CE enjoys wide currency the perspective of scholars is that the other related competing concepts continue to thrive. Based on our analysis we conclude that CE is an important concept in environmental sustainability issues about waste and resources, however, it does not address several concerns about the wider discussions on sustainability, in particular, the social dimension and long-term environmental impacts.

## 5. Conclusion

The objective of this study was to uncover and interpretively understand the evolution and positioning of the CE concept in academic discussions through the assessment of an expert panel. To this end, we

adopted a mixed-methods approach using topic modelling and a Delphi study with a set of 68 global scholars. In analysing the CE concept evolution in the last 15 years of it being used verbatim in academic discussions we note a significant structural change in research trends in the year 2014-2015. The structural change in the years 2014-2015 is characterised by CE research undergoing immense proliferation, adopting a distinct line of inquiry from industrial ecology, becoming dispersed across topics and shifting from macro to micro-level interventions. This change is mainly attributed to the fact that. This change is mainly attributed to the use of CE to denote ideas and practices that existed before, increased interest from policymakers, adoption of CE terminology by businesses, and the research cycle of the concept itself shifting from being exploratory into different areas of practical implementation.

In analysing the concept's positioning we find that CE has not replaced any of the predecessor concepts. The evolving nature of the CE concept and its theoretical underdevelopment causes scholars to use other concepts in conjunction to fulfil their research objectives. . The choice of concepts by an interdisciplinary panel of 68 expert scholars, reveal a pattern of adopting concepts that are technical or business-led and not transformative socio-cultural approaches. Further, analysing the perception of the dominance of CE amongst scholars, the opinion is that the dominance of CE is limited to managing waste and resource flows because the concept is underdeveloped in terms of addressing some key issues like the social dimension of sustainability and some long-term environmental impacts.

The presence of several ideas and concepts in discussions about waste and resources creates a complex conceptual landscape. This study builds on the assessment of scholars to uncover the recent developments relating to the CE concept and its position amidst other related competing concepts in the complex conceptual landscape which has not yet been done. The developments of the CE concept have been subjected to scientific inquiry through reviews and bibliometric studies, where quantitative results are interpreted by the researchers who conduct the analysis itself. However, this is the first study that systematically combines quantitative results with the expert assessment and opinion of scholars. Through this study, we aim to provide further impetus to academic knowledge on the CE concept. We provide an overview of the complex landscape to students or 'newcomers' to the field as well as established researchers. The study is also relevant in understanding that the increased traction of the CE concept is not to be taken at face value and several other concepts continue to thrive in the field. It is also important to appreciate the limitations of the concept in addressing all aspects of sustainability and other long-term environmental concerns. This paves a way for informed future research avenues that could further strengthen this discussion on CE. Additionally, a novel methodological approach to systematically assess scientific inquiry is of value to the research community.

### 5.1. Further Research Avenues

In this section, we present the future research avenues based on the results from this study. In proposing future research avenues we take inspiration from Weintraub, (2002) who distinguishes between first

and second-order questions. First-order questions are concerned with the subject matter of the discipline, while second-order questions are concerned with the philosophy, history, or sociology related to the discipline. Through our analysis, we also propose two strands of future research avenues where the first strand (comparable to first-order questions) is concerned with the subject matter of the CE concept while the second strand (comparable to second-order questions) is concerned with our sociological understanding of the concept.

### *First-order questions*

One of the points of contention about the CE concept is how it addresses the social dimension of sustainability. While there are studies that have integrated social and ethical dimensions in CE frameworks, this area remains underdeveloped which we have noted in the discussion of RQ3. The guiding question in this direction is:

*How can the social and ethical dimensions be integrated into the CE concept?*

Currently, mainstream CE literature is framed in a way that aligns with business strategy and communications. To allow a more inclusive and comprehensive discussion on the CE enabling the transitioning to a more sustainable society, there is a need to align CE with transformative socio-cultural approaches which mostly exist in silos. Notwithstanding some studies which have aimed to address this issue, and which we have noted in the discussion of RQ2, there is still a gap in terms of understanding how CE aligns with transformative socio-cultural approaches such as degrowth, steady-state economics etc. The guiding question in this direction is:

*How can CE be aligned with transformative socio-cultural approaches to advance strong sustainability efforts?*

From our expert elicitation we also find that despite making efforts to make CE more inclusive and bring about conceptual clarity, there are still certain concerns as to how CE addresses some wider sustainability concerns about climate change and biodiversity conservation which we have noted in the discussion of RQ3. The guiding questions in this direction are:

*How can CE transition tackle issues such as climate change and biodiversity loss?*

### *Second-order questions*

In analysing the evolution of the CE concept it is also important to appreciate the motives of academic scholars who work on the CE concept. To put things into perspective there are over 7000 academic researchers using the CE concept as of October 2020 compared to only ~450 researchers in 2015<sup>32</sup>. In further investigating the evolution of the CE concept it is important to understand the motives of the

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<sup>32</sup> Based on a Scopus search dated 1<sup>st</sup> October 2020 using the keyword “Circular Economy” in titles, abstracts and keywords. The count of researchers is based on the unique author ID assigned by Scopus for each author. All authors listed in any CE publication were counted irrespective of the authorship sequence. All duplicate IDs were removed

scientists who are central subjects in the process of scientific knowledge production (Hull, 1975). Thus, the guiding question that we propose in this direction is:

*How do the individual motives of scientists impact the overall emergence and development of CE?*

In analysing the evolution of CE in RQ 1, the structural change in 2014-2015 marks the active presence of some key actants like the EU, EMF, private sector companies, etc. Thus, a further research direction would be analysing the roles of the key actants in propelling the CE discussion forward. The guiding question in this direction is:

*What roles are some of the key actants playing in multiple levels of governance to propel the CE discussion forward?*

This order of questioning is important because there have been calls to not only account for the progress in scientific knowledge but also acknowledge the social dimensions of scientific inquiry (Kitcher, 1998; Wray, 2002). Such questions provide a deeper understanding of the social pressures that affect scientific research, the impact of science on policy and vice-versa, which serve as the foundations to construct a more rational science policy.

## 5.2. Limitations

This study is the first systematic expert assessment of the CE literature. However, inevitably, there are limitations in the study. First, we collected data upto May 2019 for the topic modelling and then conducted the Delphi study therefore the data collected for 2019 is not for the complete calendar year. However, our literature corpus of 2019 has 505 articles which we believe provides a good representation of the academic inquiry in that year. Second, to minimise the limitations of the study, we have carefully conducted an empirical study combining text mining and a Delphi study with a global set of 68 scholars. We aimed to have a geographically diverse expert panel which we achieved to a great extent by covering 17 countries. However, we did not completely match the geographic distribution of the panel and the literature (Refer to Appendix D for the profile of the experts). Nevertheless, overall we have a very rich and knowledgeable expert panel with an average research experience of 13 years. Lastly, there is a continued upsurge in the production of academic articles on CE; by the time any peer-reviewed article passes the publication stage, there is more literature that becomes available. This is a limitation that most publications on CE including ours have to acknowledge given the pace of growth the concept is witnessing.



## Appendix

### Appendix for Research Paper 2

#### **Appendix A: Related concepts and definitions**

1. industrial ecology: Systems view which seeks to optimise the total materials cycle, from virgin materials, to finished material, to component, to product, to obsolete product, & to ultimate disposal.  
industrial symbiosis: Engaging traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products.
2. performance economy: Represents a full shift to servitization, with revenue obtained from providing services rather than selling goods.
3. eco-civilisation: Inclusion of environmental protection in the nation's economic, social, cultural, & political systems.
4. reverse logistics: Process in which a manufacturer systematically accepts previously shipped products or parts from the point for consumption for possible recycling, re-manufacturing, or disposal.
5. cradle to cradle: Minimizing environmental damage through sustainable production, distribution, disposal practices, & socially responsible products.
6. blue economy: Optimization of natural marine resources within ecological limits, & the decoupling of environment and economy.
7. triple bottom line: An accounting framework that incorporates three performance dimensions: social, environmental & financial.
8. regenerative design: Principle that calls for products or services to contribute to systems that renew or replenish themselves.
9. biomimicry: Studies nature's best ideas and then imitates the designs & process to solve human problems.
10. bio economy: Includes all economic activities that are linked to the development & the use of biological products and processes.
11. green economy: System aimed at improved "well-being & social equity, while significantly reducing environmental risks & ecological scarcities".
12. product service systems: Combination of products & services in a system that provides functionality for consumers & reduces environmental impact.
13. green marketing: Activities designed to generate and facilitate exchanges intended to satisfy human needs or wants, such needs and wants are satisfied without environmental impact.
14. sustainable consumption and production: Use of services & products, which fulfil basic needs, bring about a better quality of life while minimizing natural resource use, toxic materials & reduce emissions thereby not jeopardising future generations.

15. zero waste: An aspirational end point where all waste is reused or recycled as a resource without the need for any landfill or energy recovery.

sharing economy: Forms of exchange facilitated through online platforms, aimed at open access to under-utilised resources through what is termed “sharing”.

natural capital: An approach for protecting the biosphere & for improving profits and competitiveness that benefits the current and future generations.

low-carbon economy: Economy based on low energy consumption & low pollution.

closed loop economy: Used synonymously with the “circular economy”.

### [Appendix for Research Paper 3](#)

#### **Appendix A- Scientific selection of the number of topics**

Topic coherence measures score a single topic by measuring the degree of semantic similarity between high scoring words in the topic thereby distinguishing between semantically interpretable topics and topics that are artefacts of statistical inference. The two coherence measures, which are designed for LDA, matching well with human judgements of topic quality are: (a) the UCI measures, which are calculated over an external corpus such as Wikipedia. This metric is an external comparison to known semantic valuations (b) the UMass measure, which is an intrinsic score that computes coherence scores over the original corpus that has been used to train the models.

We compute UCI coherence scores for topics (k) ranging from 1 to 30 and plot it on a graph. The coherence score is highest until  $k = 4$  before declining. The coherence scores fluctuate until  $k = 18-21$  where it stagnates before dropping again. Coherence scores at  $k = 18-21$  plateau with the coherence scores at  $k = 7-8$ . Our rationale for not selecting  $k$  as 4, which has the highest coherence value, is that it poses a risk of generating few generic topics and not capturing the wide range of application areas of the CE literature. Along similar lines, we do not select  $k$  as 7 or 8 and rather select  $k$  as 20 which almost has the same coherence score as  $k = 7-8$  and will possibly help in generating more meaningful topics. We determine the optimal number of topics to be 20 based on coherence scoring. Figure A.1 is the representation of the topic coherence scores for different number of topics.

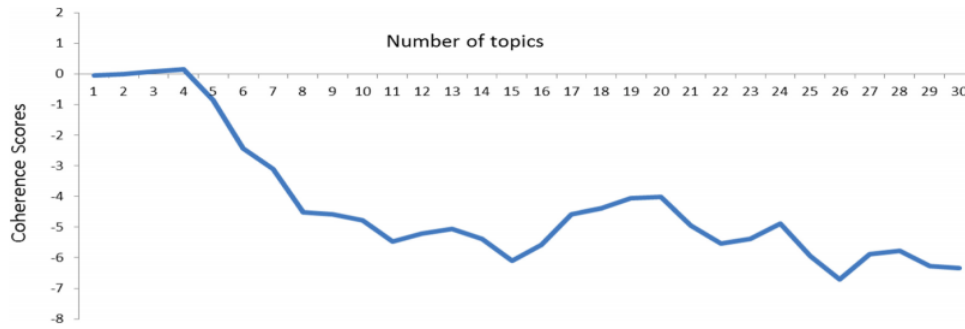


Figure A.1: Topic coherence measures for a number of topics

## Appendix B- Delphi study questionnaire

The Delphi study questions can be grouped into three sections.

The first section aims to collect the following demographic information about the participants:

- i. Name
- ii. Country of affiliation
- iii. When did your research career start?
- iv. When did you start using the CE concept?
- v. What is your area of expertise in CE-related research?

The second section aims to elicit scholar's responses to the text mining results to understand how they perceive the evolution of the CE concept in academic literature. The participants were asked not to feel limited in the style or length of their answers.

- i. What do you observe in the graphical representation?
- ii. In your opinion, what happened in the year 2014-2015?
- iii. Is there any anomaly in the results of the text mining analysis?

The third section aims to elicit the scholars' response in terms of what concepts they use in their work prior to and along with CE to address issues about CE. It also aims to assess the scholars' perception of the dominance of the CE.

- i. What other concepts have you used in your research work prior to and along with the CE concept?
- ii. Is CE a dominant concept in addressing questions pertaining to sustainability?

## Appendix C- Details of different topics from topic modelling on the CE literature

The results of the topic modelling algorithm provide the top 10 terms in each topic, we utilise the workshop participants to provide names to the topics rather than doing it ourselves. We provided the top 10 terms for each topic to the experts where they provided topic names individually. Then the participants would come together as a group to discuss the topic names and we finally assigned the topic

names. While the topics seemed acceptable and coherent from a computational perspective, we acknowledge that anyone with knowledge of the CE academic literature will not consider it as the most ideal organisation of the literature. Thus, taking an additional step to arrive at a coherent organisation of the literature, we enlisted the help of the workshop participants who grouped the twenty topics into the following seven themes:

- (i) Resources for a CE
- (ii) Industrial Ecology and Industrial Symbiosis (IE and IS)
- (iii) CE Assessment Models
- (iv) Firms, Businesses, and Consumers
- (v) Design for circularity
- (vi) Meta/conceptual research
- (vii) Policy and governance

Table B.1 is a summary of the topic modelling results. It lists the different topics grouped into themes along with a brief description of each theme, examples of some typical articles in the theme, and the specific journals which produce most of the articles. The results are reflective of the dispersed range of topics addressing different aspects of the CE.

Table C.1: Summary of topic modelling and initial workshop that provided the foundation for the Delphi study

Themes	Top 10 terms in each topic	Topic Name	Proportion	Brief description	Example articles	Journals
Resources for a CE	<i>wast,manag,recycl, landfill,collect,recover i,solid,municip, generat,dispos</i>	Waste management	5.03%	The CE concept has been cited as a concept that would transform the function of 'resources' in the economy. The resource theme has the highest share and includes resource flows such as waste, metals, food, energy, steel, construction material, plastics.	(Giurco et al., 2014; Jackson et al., 2014; Kaur et al., 2018; Leslie et al., 2016; Malinauskaite et al., 2017; Moorhouse & Moorhouse, 2017; Paletta et al., 2019; Smol et al., 2015; Toop et al., 2017)	(i) Journal of Cleaner Production
	<i>wastewat,treatment,metal,recoveri,sludg,extract,acid,concentr,remov,water</i>	Sludge	4.86%			(ii) Sustainability Switzerland
	<i>materi,recycl,flow,resourc,metal,raw,mine,product,stock,secondari</i>	Metals	4.78%			(iii) Resources, Conservation & Recycling
	<i>food,product,digest,agricultur,nutrient,soil,farm,organ,biomass,wast</i>	Agri-food	4.69%			(iv) Waste Management Research
	<i>energi,plant,fuel,renew,electr,power,gas,technolog,carbon,bioga</i>	Energy	3.91%			(v) Minerals, Metals & Materials Series
	<i>energ,emiss,consumpt,steel,carbon,china,reduc,reduct,industri,resource</i>	Steel	3.78%			(vi) Advanced Materials Research

	<i>ash,property,cement,materi,concret,test,slag,composit,result,raw</i>	Construction & Demolition	3.70%			
	<i>recycl,plastic,packag,materi,wast,chemic,weee,textil,polym,product</i>	Plastics and textiles	3.47%			
Industrial Ecology & Industrial Symbiosis	<i>develop,economi,circular,china,coal,resourc,enterpris,ecology,industri,mode</i>	IE and IS (regional+national level)	9.07%	The study of resource flows in terms of an IE gained momentum in the 1990s, this perspective has influenced the conceptualisation of CE.	(Fang et al., 2017; Geng & Doberstein, 2008; Jiang, 2011; Martín Gómez et al., 2018; Prendeville et al., 2018)	(i)Journal of Industrial Ecology (ii)Journal of Cleaner Production (iii)Resources, Conservation & Recycling
	<i>water,urban,citi,region,land,area,system,environment,resourc,ecology</i>	Urban systems	3.89%			
	<i>industri,park,symbiosi,eco,ecolog,china,chain,develop,chemic,eip</i>	IE and IS (local level)	3.67%			
CE Assessment Models	<i>evalu,system,indic,method,effici,circular,economi,index,model,eco</i>	Evaluating CE practices	5.72%	This theme comprises models that provide a systematic assessment of specific applications of the CE concept comprising CE indicators monitoring the CE transition and measuring the effects of its adoption, including simulation-based models and lifecycle assessment studies	(Geng et al., 2012; Huysman et al., 2017; Moraga et al., 2019; Saidani et al., 2019; Smol et al., 2017)	(i)Journal of Cleaner Production (ii)Resources, Conservation & Recycling (iii)Sustainability Switzerland
	<i>environment,impact,life,assess,cycl,product,lca,scenario,result,use</i>	Lifecycle Assessment	5.13%			
	<i>system,model,research,design,network,base,optim,data,analysis,simul</i>	Models & simulation-based methodologies	3.51%			
Firms, businesses and consumers	<i>model,busi,circular,economi,valu,system,product,sustain,transit,resource</i>	Business Models	8.24%	This theme comprises literature focussed on CE business models.	(Bocken et al., 2016; Borrello et al., 2017; Lakatos et al., 2016; Tunn et al., 2019; Wastling et al., 2018)	(i) Journal of Cleaner Production (ii)Resources, Conservation & Recycling (iii)Sustainability Switzerland (iv)Business Strategy & the Environment
	<i>Suppli,chain,company,study,barrier,practic,fund,firm,consum,behaviour</i>	Supply chain + behavioural studies	5.28%	This theme also includes studies about consumer behaviour and firm behaviour.		
Design for circularity	<i>product,remanufactur,design,reus,manufacturer,compon,consum,dissassembl,eol,electron</i>	Product design	4.34%	This theme comprises literature on CE which covers social and technical innovations about CE. It includes literature on micro-level interventions such as circular product design for sustainable development.	(den Hollander et al., 2017; Mendoza et al., 2017; Saidani et al., 2019; Van den Berg & Bakker, 2015; Wastling et al., 2018)	(i) Journal of Cleaner Production (ii)Resources, Conservation & Recycling (iii) Sustainability Switzerland (iv)Business Strategy and Environment
	<i>innov,design,project,build,sustain,educ,solut,enhin,develop,new</i>	Innovation in design	4.13%			

Meta and conceptual research	<i>research,concept,review,literatur,practic,econom,sustain,framework, discuss</i>	Meta & conceptual research	7.11%	This theme comprises research that provides conceptual frameworks and reviews of the existing literature. Given the popularity of the concept of CE and its rapid evolution, a large number of studies review the vast and expanding literature.	(Ghisellini et al., 2016; Kirchherr et al., 2017; Lewandowski, 2016; Merli et al., 2018; Nobre & Tavares, 2017; Tukker, 2015)	(i) Journal of Cleaner Production (ii)Resources, Conservation & Recycling (iii)Sustainability Switzerland (iv) Journal of Industrial Ecology (v)Ecological Economics
Policy and governance	<i>Polici,govern,european,public,social,regul,countri,econom,development,environment</i>	Policy & governance	5.69%	This theme captures literature on various policy, regulatory and economic instruments that can support the implementation of the CE concept.		(i)Journal of Cleaner Production (ii)Resources, Conservation & Recycling (iii)Sustainability Switzerland (iv) Journal of Industrial Ecology

#### Appendix D: Profile of the Delphi study expert panel

Figure D.1- Visual representation of when the experts started their research career and when they started to use the CE concept. The average number of years of research experience and the average number of years the expert panel is using the CE concept is 13 and 6 years respectively.

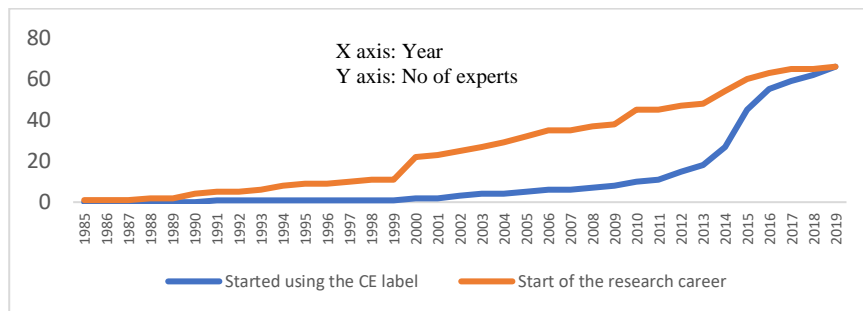


Figure D.1: At each year, the number of experts who started their research career and the number of experts who started to use the CE concept

Topics	Distribution of experts in the expert panel	Distribution of topics in the overall literature
Business Models	9%	7%
Construction and Demolition	2%	1%
Design for circularity	11%	8%
Energy	5%	7%
European Policy and Governance	5%	7%
Evaluating CE practices	8%	6%
Food and Agriculture	4%	6%
IE and IS (local level)	4%	3%
IE and IS (regional+national level)	6%	7%
Innovation in design	4%	6%
Lifecycle Assessment	8%	5%
Meta/Conceptual research	5%	6%
Metals	3%	5%
Models and simulation based methodologies	4%	2%
Plastics	3%	5%
Sludge	1%	2%
Steel	2%	2%
Supply chain and behavioural studies	4%	5%
Urban systems	1%	2%
Waste Management	11%	9%

Table D.1- Comparison of the distribution of the experts in the panel versus the literature based on the topics identified through topic modelling.

Countries	Representation in the Delphi panel	Representation in the literature
Belgium	3%	2%
Brazil	7%	4%
Canada	1%	1%
China	3%	16%
Denmark	4%	3%
Finland	4%	4%
France	1%	5%
Germany	6%	7%
Italy	10%	13%
Mexico	1%	1%
Norway	4%	1%
Spain	7%	10%
Sweden	13%	6%
The Netherlands	9%	7%
United Kingdom	18%	15%
United States of America	6%	5%

Table D.2- Comparison of the distribution of the experts in the panel versus the literature based on the country of affiliation



## References

- Abbott, A. (2005). Linked ecologies: States and universities as environments for professions. *Sociological Theory*, 23(3), 245–274.
- Abbott, A. (2010). Chaos of Disciplines. In *Chaos of Disciplines*. University of Chicago Press.  
<https://www.degruyter.com/document/doi/10.7208/9780226001050/html>
- Abbott, A. (2016). Processual Sociology. In *Processual Sociology*. University of Chicago Press.  
<https://www.degruyter.com/document/doi/10.7208/9780226336763/html>
- Abbott, A. (1990). Positivism and interpretation in sociology: Lessons for sociologists from the history of stress research. *Sociological Forum*, 5(3), 435–458.
- Abercrombie, G., & Batista-Navarro, R. T. (2019). Semantic Change in the Language of UK Parliamentary Debates. *Proceedings of the 1st International Workshop on Computational Approaches to Historical Language Change*, 210–215.
- Abrahamson, E. (1996a). Management Fashion. *The Academy of Management Review*, 21(1), 254–285. <https://doi.org/10.2307/258636>
- Abrahamson, E. (1996b). Management fashion. *Academy of Management Review*, 21(1), 254–285.
- Abrahamson, E. (2006). Review of Global Ideas: How Ideas, Objects, and Practices Travel in the Global Economy [Review of *Review of Global Ideas: How Ideas, Objects, and Practices Travel in the Global Economy*, by B. Czarniawska & G. Sevón]. *Administrative Science Quarterly*, 51(3), 512–514. <http://www.jstor.org/stable/25426920>
- Abrahamson, E., & Fairchild, G. (1999). Management Fashion: Lifecycles, Triggers, and Collective Learning Processes. *Administrative Science Quarterly*, 44(4), 708–740.  
<https://doi.org/10.2307/2667053>
- Abrahamson, E., & Rosenkopf, L. (1993). INSTITUTIONAL AND COMPETITIVE BANDWAGONS: USING MATHEMATICAL MODELING AS A TOOL TO EXPLORE

INNOVATION DIFFUSION. *Academy of Management Review*.

<https://doi.org/10.5465/amr.1993.9309035148>

Accenture. (2014). Circular Advantage. In *Accenture Strategy*.

Adams, T.M. and Winkelman, B. (2016) 'Statistical analysis for assessing highway maintenance level of service', *Transportation Research Record*, 2551(1), pp. 73–81.

Adler, E. (1992). The Emergence of Cooperation: National Epistemic Communities and the International Evolution of the Idea of Nuclear Arms Control. *International Organization*, 46(1), 101–145. <https://www.jstor.org/stable/2706953>

Alcouffe, S., & HEC, G. (2002). Discourse and diffusion lifecycles of management fashions: An empirical study. *Beitrag Im Rahmen Des Second Annual Congress of the European Academy of Management, Stockholm*.

Aldrich, H. E. (2012). The emergence of entrepreneurship as an academic field: A personal essay on institutional entrepreneurship. *Research Policy*, 41(7), 1240–1248.  
<https://doi.org/10.1016/j.respol.2012.03.013>

Alhonnoro, L. (2014). Practice as a patterned network of heterogeneous materials-an actor-network approach to practice theory. *Kulutustutkimus. Nyt*, 8(2), 16–28.

Ali, M., Kennedy, C. M., Kiesecker, J., & Geng, Y. (2018). Integrating biodiversity offsets within Circular Economy policy in China. *Journal of Cleaner Production*, 185, 32–43.  
<https://doi.org/10.1016/j.jclepro.2018.03.027>

Alonso-Almeida, M. del M., Rodriguez-Anton, J. M., Bagur-Femenías, L., & Perramon, J. (2021). Institutional entrepreneurship enablers to promote circular economy in the European Union: Impacts on transition towards a more circular economy. *Journal of Cleaner Production*, 281, 124841. <https://doi.org/10.1016/j.jclepro.2020.124841>

Aminikhanghahi, S., & Cook, D. J. (2017). A survey of methods for time series change point detection. *Knowledge and Information Systems*, 51(2), 339–367.

- Anttonen, M., Lammi, M., Mykkänen, J., & Repo, P. (2018). Circular economy in the triple helix of innovation systems. *Sustainability*, *10*(8), 2646.
- Bacharach, S. B. (1989). Organizational Theories: Some Criteria for Evaluation. *The Academy of Management Review*, *14*(4), 496–515. <https://doi.org/10.2307/258555>
- BALL, C. (1990). RSA REPORT. *RSA Journal*, *138*(5411), 726–733. <https://www.jstor.org/stable/41375321>
- Barles, S. (2014). History of waste management and the social and cultural representations of waste. In *The basic environmental history* (pp. 199–226). Springer.
- Bauwens, T., Hekkert, M., & Kirchherr, J. (2020). Circular futures: What Will They Look Like? *Ecological Economics*, *175*, 106703. <https://doi.org/10.1016/j.ecolecon.2020.106703>
- Bell, K. (2015). Can the capitalist economic system deliver environmental justice? *Environmental Research Letters*, *10*(12), 125017. <https://doi.org/10.1088/1748-9326/10/12/125017>
- Beltagy, I., Lo, K., & Cohan, A. (2019). SciBERT: A Pretrained Language Model for Scientific Text. *ArXiv:1903.10676 [Cs]*. <http://arxiv.org/abs/1903.10676>
- Ben-David, J., & Sullivan, T. A. (1975). Sociology of science. *Annual Review of Sociology*, *1*(1), 203–222.
- Benders, J., & Van Veen, K. (2001). What's in a fashion? Interpretative viability and management fashions. *Organization*, *8*(1), 33–53.
- Benders, J., & Verlaar, S. (2003). Lifting parts: Putting conceptual insights into practice. *International Journal of Operations & Production Management*, *23*(7), 757–774. <https://doi.org/10.1108/01443570310481540>
- Bengtsson, F., & Ågerfalk, P. J. (2011). Information technology as a change actant in sustainability innovation: Insights from Uppsala. *The Journal of Strategic Information Systems*, *20*(1), 96–112. <https://doi.org/10.1016/j.jsis.2010.09.007>

- Benyus, J. M. (1997). Biomimicry: Innovation Inspired by Nature. *Governance International Journal Of Policy And Administration*.
- Betancourt Morales, C. M., & Zartha Sossa, J. W. (2020). Circular economy in Latin America: A systematic literature review. *Business Strategy and the Environment*.  
<https://doi.org/10.1002/bse.2515>
- Bhattacharya, J., & Packalen, M. (2020). *Stagnation and scientific incentives*. National Bureau of Economic Research.
- Bickel, M. W. (2019). Reflecting trends in the academic landscape of sustainable energy using probabilistic topic modeling. *Energy, Sustainability and Society*.  
<https://doi.org/10.1186/s13705-019-0226-z>
- Bilotta, G. S., Milner, A. M., & Boyd, I. (2014). On the use of systematic reviews to inform environmental policies. *Environmental Science & Policy*, 42, 67–77.
- Bird, A. (2018). Thomas Kuhn. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy* (Winter 2018). Metaphysics Research Lab, Stanford University.  
<https://plato.stanford.edu/archives/win2018/entries/thomas-kuhn/>
- Bishop, F. L. (2015). Using mixed methods research designs in health psychology: An illustrated discussion from a pragmatist perspective. *British Journal of Health Psychology*, 20(1), 5–20.  
<https://doi.org/10.1111/bjhp.12122>
- Biswas, M. R., & Biswas, A. K. (1982). Major Requirements for Environmental Education. *Environmental Conservation*, 9(2), 125–130. <https://doi.org/10.1017/S0376892900020038>
- Bleakley, A. (2012). The proof is in the pudding: Putting Actor-Network-Theory to work in medical education. *Medical Teacher*, 34(6), 462–467. <https://doi.org/10.3109/0142159X.2012.671977>
- Blei, D. M., & Lafferty, J. D. (2006). Dynamic topic models. *Proceedings of the 23rd International Conference on Machine Learning*, 113–120.

- Blei, D. M., Ng, A. Y., & Jordan, M. I. (2003a). Blei et al., 2003—Latent Dirichlet Allocation. In *Journal of Machine Learning Research*.
- Blei, D. M., Ng, A. Y., & Jordan, M. I. (2003b). Latent dirichlet allocation. *The Journal of Machine Learning Research*, 3, 993–1022.
- Blomsma, F., & Brennan, G. (2017). The emergence of circular economy: A new framing around prolonging resource productivity. *Journal of Industrial Ecology*, 21(3), 603–614.
- Bloomfield, L. (1933). Language.. New York: Henry Holt and Company. *Bolinger, L. Dwight*.(1957). *Locus versus Class*, 31–37.
- Bloor, D. (1991). *Knowledge and social imagery*. University of Chicago Press.
- Boardman, C., & Gray, D. (2010). The new science and engineering management: Cooperative research centers as government policies, industry strategies, and organizations. *The Journal of Technology Transfer*, 35(5), 445–459.
- Bocken, N. M. P., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, 33(5), 308–320. <https://doi.org/10.1080/21681015.2016.1172124>
- Boehm, C. (2001). *Between Technology and Creativity, Challenges and Opportunities for Music Technology in Higher Education*.
- Boell, S., & Cezec-Kecmanovic, D. (2011). *Are systematic reviews better, less biased and of higher quality?*
- Bolelli, L., Ertekin, Ş., & Giles, C. L. (2009). Topic and trend detection in text collections using latent dirichlet allocation. *European Conference on Information Retrieval*, 776–780.
- Bonaccorsi, A., & Vargas, J. (2010). Proliferation dynamics in new sciences. *Research Policy*, 39(8), 1034–1050. <https://doi.org/10.1016/j.respol.2010.05.002>
- Books, P. (1994). PINKER THE LANGUAGE The New Science of Language and Mind. *Neuroscience*.

- Boons, F., Chertow, M., Park, J., Spekkink, W., & Shi, H. (2017). Industrial Symbiosis Dynamics and the Problem of Equivalence: Proposal for a Comparative Framework. *Journal of Industrial Ecology*. <https://doi.org/10.1111/jiec.12468>
- Boons, F., & Roome, N. (2000). Industrial Ecology as a Cultural Phenomenon: On Objectivity as a Normative Position. *Journal of Industrial Ecology*, 4(2), 49–54. <https://doi.org/10.1162/108819800569799>
- Boons, F., Spekkink, W., & Jiao, W. (2014a). A Process Perspective on Industrial Symbiosis. *Journal of Industrial Ecology*, 18(3), 341–355. <https://doi.org/10.1111/jiec.12116>
- Boons, F., Spekkink, W., & Jiao, W. (2014b). A process perspective on industrial symbiosis: Theory, methodology, and application. *Journal of Industrial Ecology*, 18(3), 341–355.
- Boons, F., Spekkink, W., & Mouzakitis, Y. (2011). The dynamics of industrial symbiosis: A proposal for a conceptual framework based upon a comprehensive literature review. *Journal of Cleaner Production*, 19(9), 905–911. <https://doi.org/10.1016/j.jclepro.2011.01.003>
- Boons, F., van Buuren, A., Gerrits, L., & Teisman, G. R. (2009). Towards an approach of evolutionary public management. In *Managing complex governance systems* (pp. 245–264). Routledge.
- Borrello, M., Pascucci, S., & Cembalo, L. (2020). Three propositions to unify circular economy research: A review. *Sustainability*, 12(10), 4069.
- Boulding, K. E. (1966). *The economics of coming Spaceship Earth*. H. Jarrett (ed.). *Environmental quality in a growing economy* (s. 3-14). Baltimore, MD: John Hopkins University Press.
- Boukdedid, R., Abdoul, H., Loustau, M., Sibony, O., & Alberti, C. (2011). Using and reporting the Delphi method for selecting healthcare quality indicators: A systematic review. *PLoS ONE*. <https://doi.org/10.1371/journal.pone.0020476>
- Bovea, M.D. et al. (2018) ‘Options for labelling circular products: Icon design and consumer preferences’, *Journal of cleaner production*, 202, pp. 1253–1263.

- Bowern, C. (2019). *Semantic Change and Semantic Stability: Variation is Key*.  
<https://doi.org/10.18653/v1/w19-4706>
- Bowker, G. C., & Star, S. L. (1999). *Sorting things out: Classification and its consequences*. MIT Press.
- Boyack, K. W., & Börner, K. (2003). Indicator-assisted evaluation and funding of research: Visualizing the influence of grants on the number and citation counts of research papers. In *Journal of the American Society for Information Science and Technology*.  
<https://doi.org/10.1002/asi.10230>
- Bradie, M. (1986). Assessing evolutionary epistemology. *Biology and Philosophy*, 1(4), 401–459.
- Braungart, M., McDonough, W., & Bollinger, A. (2007). Cradle-to-cradle design: Creating healthy emissions—A strategy for eco-effective product and system design. *Journal of Cleaner Production*. <https://doi.org/10.1016/j.jclepro.2006.08.003>
- Brossard, D., Belluck, P., Gould, F., & Wirz, C. D. (2019). Promises and perils of gene drives: Navigating the communication of complex, post-normal science. *Proceedings of the National Academy of Sciences*, 116(16), 7692–7697.
- Bruel, A., Kronenberg, J., Troussier, N., & Guillaume, B. (2019). Linking Industrial Ecology and Ecological Economics: A Theoretical and Empirical Foundation for the Circular Economy. *Journal of Industrial Ecology*. <https://doi.org/10.1111/jiec.12745>
- Brüggemann, M., Lörcher, I., & Walter, S. (2020). Post-normal science communication: Exploring the blurring boundaries of science and journalism. *Journal of Science Communication*, 19(3), A02.
- Buchmann-Duck, J., & Beazley, K. F. (2020). An urgent call for circular economy advocates to acknowledge its limitations in conserving biodiversity. *Science of the Total Environment*, 727, 138602.



- Burnes, B. (1996). No such thing as... a “one best way” to manage organizational change. *Management Decision*.
- Busch, L., Lacy, W. B., & Sachs, C. (1983). Perceived Criteria for Research Problem Choice in the Agricultural Sciences-A Research Note. *Social Forces*, 62(1), 190–200.  
<https://doi.org/10.2307/2578355>
- Busu, M. (2019). Adopting circular economy at the European Union level and its impact on economic growth. *Social Sciences*, 8(5), 159.
- Butin, D. W. (2011). Service learning as an intellectual movement. *Problematizing Service Learning: Critical Reflections for Development and Action*. Charlotte, NC: Information Age Publishing.
- Cabral, L. M. B., & Riordan, M. H. (1994). The Learning Curve, Market Dominance, and Predatory Pricing. *Econometrica*. <https://doi.org/10.2307/2951509>
- Cairney, P. (2018). Three habits of successful policy entrepreneurs. *Policy & Politics*, 46(2), 199–215.
- Calisto Friant, M., Vermeulen, W. J. V., & Salomone, R. (2020a). A typology of circular economy discourses: Navigating the diverse visions of a contested paradigm. *Resources, Conservation and Recycling*, 161, 104917. <https://doi.org/10.1016/j.resconrec.2020.104917>
- Calisto Friant, M., Vermeulen, W. J. V., & Salomone, R. (2020b). A typology of circular economy discourses: Navigating the diverse visions of a contested paradigm. *Resources, Conservation and Recycling*, 161, 104917. <https://doi.org/10.1016/j.resconrec.2020.104917>
- Calisto Friant, M., Vermeulen, W. J. V., & Salomone, R. (2021). Analysing European Union circular economy policies: Words versus actions. *Sustainable Production and Consumption*, 27, 337–353. <https://doi.org/10.1016/j.spc.2020.11.001>

- Callon, M. (1980). Struggles and Negotiations to Define What is Problematic and What is Not. In K. D. Knorr, R. Krohn, & R. Whitley (Eds.), *The Social Process of Scientific Investigation* (Vol. 4, pp. 197–219). Springer Netherlands. [https://doi.org/10.1007/978-94-009-9109-5\\_8](https://doi.org/10.1007/978-94-009-9109-5_8)
- Callon, M. (1984). Some elements of a sociology of translation: Domestication of the scallops and the fishermen of St Brieuc Bay. *The Sociological Review*, 32(1\_suppl), 196–233.
- Campanario, J. M. (1996). The Competition for Journal Space among Referees, Editors, and Other Authors and Its Influence on Journals' Impact Factors. *Journal of the American Society for Information Science (1986-1998)*, 47(3), 184–192.  
<https://www.proquest.com/docview/216901506/abstract/A481F62FF6124CC1PQ/1>
- Campbell, D. T. (1974). *Evolutionary epistemology* (Vol. 1). na.
- Campbell-Johnston, K., Vermeulen, W. J. V., Reike, D., & Brulot, S. (2020). The Circular Economy and Cascading: Towards a Framework. *Resources, Conservation & Recycling: X*, 7, 100038.  
<https://doi.org/10.1016/j.rcrx.2020.100038>
- Carter, S., & Henderson, L. (2005). Approaches to Qualitative data collection in social science. *Handbook of Health Research Methods*.
- Centobelli, P., Cerchione, R., Chiaroni, D., Del Vecchio, P., & Urbinati, A. (2020). Designing business models in circular economy: A systematic literature review and research agenda. *Business Strategy and the Environment*, 29(4), 1734–1749.
- Cetina, K. K., Schatzki, T. R., & Savigny, E. von. (2005). *The Practice Turn in Contemporary Theory*. Routledge.
- Chang, J. (2015). Package 'lda'. Collapsed Gibbs Sampling Methods for Topic Models. In *R package version 1.4.2*. <https://doi.org/10.1109/TCOM.1984.1096090>
- Chang, J. (2017). *lda: Collapsed Gibbs Sampling Methods for Topic Models. R package version 1.4.2*. 2015.

- Chang, J., Boyd-Graber, J., Gerrish, S., Wang, C., & Blei, D. M. (2009). Reading tea leaves: How humans interpret topic models. *Advances in Neural Information Processing Systems 22 - Proceedings of the 2009 Conference*.
- Chang, J., Boyd-Graber, J., Wang, C., Gerrish, S., & Blei, D. M. (2009). Reading tea leaves: How humans interpret topic models. *Neural Information Processing Systems*, 22, 288–296.
- Chang, M.-Y., & Huang, W.-J. (2020). A Practical Case Report on the Node Point of a Butterfly Model Circular Economy: Synthesis of a New Hybrid Mineral–Hydrothermal Fertilizer for Rice Cropping. *Sustainability*, 12(3), 1245.
- Charonis, G.-K. (2012). Degrowth, steady state economics and the circular economy: Three distinct yet increasingly converging alternative discourses to economic growth for achieving environmental sustainability and social equity. *World Economic Association Sustainability Conference*, 24.
- Chateau, J., & Mavroeidi, E. (2020). The jobs potential of a transition towards a resource efficient and circular economy. *OECD Environment Working Papers, No. 167, OECD Publishing, Paris*. <https://doi.org/10.1787/28e768df-en>
- Chen, B., Ding, Y., & Ma, F. (2018). Semantic word shifts in a scientific domain. *Scientometrics*, 117(1), 211–226.
- Chen, T.-H., Thomas, S. W., & Hassan, A. E. (2016). A survey on the use of topic models when mining software repositories. *Empirical Software Engineering*, 21(5), 1843–1919.
- Chertow, M. R. (2007). “Uncovering” industrial symbiosis. In *Journal of Industrial Ecology*. <https://doi.org/10.1162/jiec.2007.1110>
- Chiclana, F. et al. (2013) ‘A statistical comparative study of different similarity measures of consensus in group decision making’, *Information Sciences*, 221, pp. 110–123. doi:10.1016/j.ins.2012.09.014.

China's agenda 21: White Paper on China's Population, Environment and Development in the 21st Century. (1994). *China Population Today*, 11(4), 5–8.

*Circular vision in the East*. (n.d.). Retrieved July 21, 2021, from

<https://www.basf.com/global/en/media/magazine/archive/issue-6/circular-vision-in-the-east.html>

Cohen, N. (2016). Policy entrepreneurs and agenda setting. In *Handbook of public policy agenda setting*. Edward Elgar Publishing.

Collins, H. M. (1983). The sociology of scientific knowledge: Studies of contemporary science. *Annual Review of Sociology*, 9(1), 265–285.

Collins-Kreiner, N. (2016). The lifecycle of concepts: The case of 'Pilgrimage Tourism.' *Tourism Geographies*, 18(3), 322–334.

Cooper, T. (1994). *Beyond recycling: The longer life option*.

Cooper, T. (1999). Creating an economic infrastructure for sustainable product design. *Journal of Sustainable Product Design*, 7–17.

Cordella, A., & Shaikh, M. (2006). *From epistemology to ontology: Challenging the constructed 'truth' of ANT*.

Corvellec, H., Böhm, S., Stowell, A., & Valenzuela, F. (2020). Introduction to the special issue on the contested realities of the circular economy. *Culture and Organization*, 26(2), 97–102.

<https://doi.org/10.1080/14759551.2020.1717733>

COSTANZA, R., & DALY, H. E. (1992). Natural Capital and Sustainable Development. *Conservation Biology*. <https://doi.org/10.1046/j.1523-1739.1992.610037.x>

Cowan, D., Morgan, K., & McDermont, M. (2009). Nominations: An actor-network approach. *Housing Studies*, 24(3), 281–300.

Cressman, D. (2009). *A brief overview of actor-network theory: Punctualization, heterogeneous engineering & translation*.

- Cresswell, K. M., Worth, A., & Sheikh, A. (2010). Actor-Network Theory and its role in understanding the implementation of information technology developments in healthcare. *BMC Medical Informatics and Decision Making*, 10(1), 67. <https://doi.org/10.1186/1472-6947-10-67>
- Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.
- Creswell, J. W., & Creswell, J. W. (2007). *Qualitative inquiry & research design: Choosing among five approaches* (2nd ed). Sage Publications.
- Creswell, J. W., & Tashakkori, A. (2007). *Differing perspectives on mixed methods research*. Sage Publications Sage CA: Los Angeles, CA.
- Crompton, H. (2007). Mode 2 knowledge production: Evidence from orphan drug networks. *Science and Public Policy*, 34(3), 199–211. <https://doi.org/10.3152/030234207X197066>
- Czarniawska, B. (2008). How to misuse institutions and get away with it: Some reflections on institutional theory(ies). In *The Sage Handbook of Organizational Institutionalism* (pp. 769–782).
- Czarniawska, B. (2009). Emerging Institutions: Pyramids or Anthills? *Organization Studies*, 30(4), 423–441. <https://doi.org/10.1177/0170840609102282>
- Czarniawska, B., & Joerges, B. (2011). Travels of Ideas. In *Translating Organizational Change* (pp. 13–48). De Gruyter. <https://www.degruyter.com/document/doi/10.1515/9783110879735.13/html>
- Czarniawska, B., & Panozzo, F. (2008). Preface: Trends and fashions in management studies. *International Studies of Management & Organization*, 38(1), 3–12.
- Dahdul, W., Manda, P., Cui, H., Balhoff, J. P., Dececchi, T. A., Ibrahim, N., Lapp, H., Vision, T., & Mabee, P. M. (2018). Annotation of phenotypes using ontologies: A gold standard for the

training and evaluation of natural language processing systems. *Database : The Journal of Biological Databases and Curation*. <https://doi.org/10.1093/database/bay110>

D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lähinen, K., Korhonen, J., Leskinen, P.,

Matthies, B. D., & Toppinen, A. (2017a). Green, circular, bio economy: A comparative analysis of sustainability avenues. *Journal of Cleaner Production*, 168, 716–734.

D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lähinen, K., Korhonen, J., Leskinen, P.,

Matthies, B. D., & Toppinen, A. (2017b). Green, circular, bio economy: A comparative analysis of sustainability avenues. *Journal of Cleaner Production*.

<https://doi.org/10.1016/j.jclepro.2017.09.053>

D'amato, D., Droste, N., Winkler, K. J., & Toppinen, A. (2019). Thinking green, circular or bio:

Eliciting researchers' perspectives on a sustainable economy with Q method. *Journal of Cleaner Production*, 230, 460–476.

Davis, L., Taylor, H., & Reyes, H. (2014). Lifelong learning in nursing: A Delphi study. *Nurse Education Today*. <https://doi.org/10.1016/j.nedt.2013.04.014>

Dayeen, F. R., Sharma, A. S., & Derrible, S. (2020). A text mining analysis of the climate change literature in industrial ecology. *Journal of Industrial Ecology*.

<https://doi.org/10.1111/jiec.12998>

de Jesus, A., Antunes, P., Santos, R., & Mendonça, S. (2019). Eco-innovation pathways to a circular economy: Envisioning priorities through a Delphi approach. *Journal of Cleaner Production*.

<https://doi.org/10.1016/j.jclepro.2019.04.049>

de Jesus, A., & Mendonça, S. (2018). Lost in Transition? Drivers and Barriers in the Eco-innovation Road to the Circular Economy. *Ecological Economics*, 145, 75–89.

<https://doi.org/10.1016/j.ecolecon.2017.08.001>

- Deephouse, D. L., & Suchman, M. (2008). Legitimacy in Organizational Institutionalism. In *The SAGE Handbook of Organizational Institutionalism* (pp. 49–77). SAGE Publications Ltd. <https://doi.org/10.4135/9781849200387.n2>
- Delen, D., & Crossland, M. D. (2008a). Seeding the survey and analysis of research literature with text mining. *Expert Systems with Applications*, 34(3), 1707–1720.
- Delen, D., & Crossland, M. D. (2008b). Seeding the survey and analysis of research literature with text mining. *Expert Systems with Applications*. <https://doi.org/10.1016/j.eswa.2007.01.035>
- Deloitte. (2016). *Deloitte Sustainability. Circular economy potential for climate change mitigation. November*, 0–43.
- Den Hollander, M. C., Bakker, C. A., & Hultink, E. J. (2017). Product design in a circular economy: Development of a typology of key concepts and terms. *Journal of Industrial Ecology*, 21(3), 517–525.
- Denzin, N. K., & Lincoln, Y. S. (2011). *The Sage handbook of qualitative research*. sage.
- Desing, H., Brunner, D., Takacs, F., Nahrath, S., Frankenberger, K., & Hischier, R. (2020). A circular economy within the planetary boundaries: Towards a resource-based, systemic approach. *Resources, Conservation and Recycling*, 155, 104673.
- DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, 147–160.
- Drews, C. (1993). The concept and definition of dominance in animal behaviour. *Behaviour*. <https://doi.org/10.1163/156853993X00290>
- Dridi, A., Gaber, M. M., Azad, R. M. A., & Bhogal, J. (2019). Leap2trend: A temporal word embedding approach for instant detection of emerging scientific trends. *IEEE Access*, 7, 176414–176428.
- Dryzek, J. S. (2013). *The Politics of the Earth: Environmental Discourses*. OUP Oxford.



- Du, M., Wang, B., & Zhang, N. (2018). National research funding and energy efficiency: Evidence from the National Science Foundation of China. *Energy Policy*, 120, 335–346.  
<https://doi.org/10.1016/j.enpol.2018.05.058>
- Dubossarsky, H., Weinshall, D., & Grossman, E. (2016). Verbs change more than nouns: A bottom-up computational approach to semantic change. *Lingue e Linguaggio*, 15(1), 7–28.
- Dubossarsky, H., Weinshall, D., & Grossman, E. (2017). Outta control: Laws of semantic change and inherent biases in word representation models. *Proceedings of the 2017 Conference on Empirical Methods in Natural Language Processing*, 1136–1145.
- Duit, A., Feindt, P. H., & Meadowcroft, J. (2016). Greening Leviathan: The rise of the environmental state? *Environmental Politics*, 25(1), 1–23.
- Ebadi, A., & Schiffauerova, A. (2015). How to Receive More Funding for Your Research? Get Connected to the Right People! *PLOS ONE*, 10(7), e0133061.  
<https://doi.org/10.1371/journal.pone.0133061>
- Eckersley, R. (2004). *The green state: Rethinking democracy and sovereignty*. MIT Press.
- Edelenbos, J., Gerrits, L., & Van Gils, M. (2008). The coevolutionary relation between Dutch mainport policies and the development of the seaport Rotterdam. *Emergence: Complexity and Organization*, 10(2), 49.
- Edelheim, J. R., Thomas, K., Åberg, K. G., & Phi, G. (2018). What do conferences do? What is academics' intangible return on investment (ROI) from attending an academic tourism conference? *Journal of Teaching in Travel & Tourism*, 18(1), 94–107.
- EEA. (2014). *Resource-efficient green economy and EU policies*.  
<https://www.eea.europa.eu/publications/resourceefficient-green-economy-and-eu>
- Ehrenfeld, J. (2004). Industrial ecology: A new field or only a metaphor? *Journal of Cleaner Production*, 12(8–10), 825–831.

- Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review*, 14(4), 532–550. <https://doi.org/10.2307/258557>
- Ellen MacArthur, E. (2013). Towards the circular economy. *Journal of Industrial Ecology*, 2, 23–44.
- Erkman, S. (1997). Industrial ecology: An historical view. In *Journal of Cleaner Production*. [https://doi.org/10.1016/s0959-6526\(97\)00003-6](https://doi.org/10.1016/s0959-6526(97)00003-6)
- Ernst & Young Accountants LLP. (2015). *Are you ready for the circular economy?*
- Etzkowitz, H. (1993). Enterprises from science: The origins of science-based regional economic development. *Minerva*, 326–360.
- Etzkowitz, H., & Kemelgor, C. (1998). The role of research centres in the collectivisation of academic science. *Minerva*, 271–288.
- Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From National Systems and “Mode 2” to a Triple Helix of university–industry–government relations. *Research Policy*, 29(2), 109–123.
- Faruqui, M. *et al.* (2016) ‘Problems With Evaluation of Word Embeddings Using Word Similarity Tasks’, in *Proceedings of the 1st Workshop on Evaluating Vector-Space Representations for NLP. Proceedings of the 1st Workshop on Evaluating Vector-Space Representations for NLP*, Berlin, Germany: Association for Computational Linguistics, pp. 30–35. doi:10.18653/v1/W16-2506.
- Feinerer, I. (2013). Introduction to the tm Package Text Mining in R. *Accessible En Ligne: Http://Cran.r-Project.Org/Web/Packages/Tm/Vignettes/Tm.Pdf.*
- Fernandez-Cano, A., Torralbo, M., & Vallejo, M. (2004). Reconsidering Price’s model of scientific growth: An overview. *Scientometrics*, 61(3), 301–321.
- Fetscherin, M., & Usunier, J. (2012). Corporate branding: An interdisciplinary literature review. *European Journal of Marketing*, 46(5), 733–753. <https://doi.org/10.1108/03090561211212494>

- Fitch-Roy, O., Benson, D., & Monciardini, D. (2020). Going around in circles? Conceptual recycling, patching and policy layering in the EU circular economy package. *Environmental Politics*, 29(6), 983–1003. <https://doi.org/10.1080/09644016.2019.1673996>
- Fligstein, N. (1991). The structural transformation of American industry: An institutional account of the causes of diversification in the largest firms, 1919-1979. *The New Institutionalism in Organizational Analysis*, 311, 336.
- Fligstein, N., & McAdam, D. (2011). Toward a General Theory of Strategic Action Fields. *Sociological Theory*, 29(1), 1–26. <https://doi.org/10.1111/j.1467-9558.2010.01385.x>
- Fodor, J. A. (1975a). *The language of thought* (Vol. 5). Harvard university press.
- Fodor, J. A. (1975b). The Language of Thought: First Approximations. In *The Language of Thought*.
- Fogelberg, H., & Thorpenberg, S. (2012). Regional innovation policy and public–private partnership: The case of Triple Helix Arenas in Western Sweden. *Science and Public Policy*, 39(3), 347–356.
- Fokkens, A., Ter Braake, S., Maks, I., & Ceolin, D. (2016). On the semantics of concept drift: Towards formal definitions of semantic change. *Proceedings of Drift-a-LOD*, 247–265.
- Foster, J. G., Rzhetsky, A., & Evans, J. A. (2015). Tradition and Innovation in Scientists' Research Strategies. *American Sociological Review*, 80(5), 875–908. <https://doi.org/10.1177/0003122415601618>
- Foulonneau, M. (2014). Open data in service design. *Electronic Journal of E-Government*, 12(2), pp97-105.
- Foulonneau, M., Turki, S., Vidou, G., & Martin, S. (2014). From Open data to data-driven services. *Proceedings of the 14th European Conference on EGovernment*, 101–108.
- Foy, S. L., Schleifer, C., & Tiryakian, E. A. (2018). The Rise of Rational Choice Theory as a Scientific/Intellectual Movement in Sociology. *The American Sociologist*, 49(1), 16–36. <http://dx.doi.org/10.1007/s12108-017-9335-3>

- Frenken, K., & Schor, J. (2017). Putting the sharing economy into perspective. *Environmental Innovation and Societal Transitions*. <https://doi.org/10.1016/j.eist.2017.01.003>
- Frermann, L., & Lapata, M. (2016). A bayesian model of diachronic meaning change. *Transactions of the Association for Computational Linguistics*, 4, 31–45.
- Frickel, S., & Gross, N. (2005). A General Theory of Scientific/Intellectual Movements. *American Sociological Review*, 70(2), 204–232. <https://doi.org/10.1177/000312240507000202>
- Frosch, R. A., & Gallopoulos, N. E. (1989). Strategies for Manufacturing. *Scientific American*, 261(3), 144–153. <https://www.jstor.org/stable/24987406>
- Funtowicz, S. O., & Ravetz, J. R. (1993). Science for the post-normal age. *Futures*, 25(7), 739–755. [https://doi.org/10.1016/0016-3287\(93\)90022-L](https://doi.org/10.1016/0016-3287(93)90022-L)
- Gad, C., & Bruun Jensen, C. (2010). On the Consequences of Post-ANT. *Science, Technology, & Human Values*, 35(1), 55–80. <https://doi.org/10.1177/0162243908329567>
- Gagné, M., & Deci, E. L. (2005). Self-determination theory and work motivation. *Journal of Organizational Behavior*, 26(4), 331–362. <https://doi.org/10.1002/job.322>
- Gaikwad, S. V., Chaugule, A., & Patil, P. (2014). Text mining methods and techniques. *International Journal of Computer Applications*, 85(17).
- Garcia-Bernabeu, A., Hilario-Caballero, A., Pla-Santamaria, D., & Salas-Molina, F. (2020). A process oriented MCDM approach to construct a circular economy composite index. *Sustainability*, 12(2), 618.
- Gärdenfors, P. (2004). *Conceptual spaces: The geometry of thought*. MIT press.
- Garrod, B., & Fyall, A. (2000). Managing heritage tourism. *Annals of Tourism Research*. [https://doi.org/10.1016/S0160-7383\(99\)00094-8](https://doi.org/10.1016/S0160-7383(99)00094-8)
- Garza-Reyes, J. A., Salomé Valls, A., Peter Nadeem, S., Anosike, A., & Kumar, V. (2019). A circularity measurement toolkit for manufacturing SMEs. *International Journal of Production Research*. <https://doi.org/10.1080/00207543.2018.1559961>

- Geisendorf, S., & Pietrulla, F. (2018). The circular economy and circular economic concepts—A literature analysis and redefinition. *Thunderbird International Business Review*.  
<https://doi.org/10.1002/tie.21924>
- Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017a). The Circular Economy – A new sustainability paradigm? In *Journal of Cleaner Production*.  
<https://doi.org/10.1016/j.jclepro.2016.12.048>
- Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017b). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, 143, 757–768.  
<https://doi.org/10.1016/j.jclepro.2016.12.048>
- Geng, Y., & Doberstein, B. (2008). Developing the circular economy in China: Challenges and opportunities for achieving “leapfrog development.” In *International Journal of Sustainable Development and World Ecology*. <https://doi.org/10.3843/SusDev.15.3:6>
- Geng, Y., Fu, J., Sarkis, J., & Xue, B. (2012a). Towards a national circular economy indicator system in China: An evaluation and critical analysis. *Journal of Cleaner Production*.  
<https://doi.org/10.1016/j.jclepro.2011.07.005>
- Geng, Y., Fu, J., Sarkis, J., & Xue, B. (2012b). Towards a national circular economy indicator system in China: An evaluation and critical analysis. *Journal of Cleaner Production*, 23(1), 216–224. <https://doi.org/10.1016/j.jclepro.2011.07.005>
- Geng, Y., Sarkis, J., & Ulgiati, S. (2016). Sustainability, well-being, and the circular economy in China and worldwide. *Science*, 6278, 73–76.
- Geng, Y., Zhu, Q., Doberstein, B., & Fujita, T. (2009). Implementing China’s circular economy concept at the regional level: A review of progress in Dalian, China. *Waste Management*, 29(2), 996–1002. <https://doi.org/10.1016/j.wasman.2008.06.036>

- Genovese, A., & Pansera, M. (2020). The Circular Economy at a Crossroads: Technocratic Eco-Modernism or Convivial Technology for Social Revolution? *Capitalism Nature Socialism*, 0(0), 1–19. <https://doi.org/10.1080/10455752.2020.1763414>
- George, D. A. R., Lin, B. C. ang, & Chen, Y. (2015). A circular economy model of economic growth. *Environmental Modelling and Software*. <https://doi.org/10.1016/j.envsoft.2015.06.014>
- Ghiasi, S. and Grunwald, D. (2000) ‘A comparison of two architectural power models’, in International Workshop on Power-Aware Computer Systems. Springer, pp. 137–151.
- Ghisellini, P., Cialani, C., & Ulgiati, S. (2016a). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, 114, 11–32. <https://doi.org/10.1016/j.jclepro.2015.09.007>
- Ghisellini, P., Cialani, C., & Ulgiati, S. (2016b). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, 114, 11–32. <https://doi.org/10.1016/j.jclepro.2015.09.007>
- Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. SAGE Publications. <http://ebookcentral.proquest.com/lib/manchester/detail.action?docID=1024114>
- Gill, P., Stewart, K., Treasure, E., & Chadwick, B. (2008). Methods of data collection in qualitative research: Interviews and focus groups. *British Dental Journal*. <https://doi.org/10.1038/bdj.2008.192>
- Ginga, C. P., Ongpeng, J. M. C., Daly, M., & Klarissa, M. (2020). Circular economy on construction and demolition waste: A literature review on material recovery and production. *Materials*, 13(13), 2970.

- Glavič, P. (2015). Chemical and Process Industries Beyond Gross Domestic Product. *Chemical Engineering Transactions*, 45, 1801–1806.
- Goertz, G. (2006). *Social science concepts: A user's guide* Princeton University Press.
- Gontier, N. (2006). *Evolutionary Epistemology, Language, and Culture: A Non-Adaptationist Systems Theoretical Approach*. Springer.
- Gough, I. (2016). Welfare states and environmental states: A comparative analysis. *Environmental Politics*, 25(1), 24–47.
- Graetz, F., & Smith, A. C. T. (2010). Managing Organizational Change: A Philosophies of Change Approach. *Journal of Change Management*, 10(2), 135–154.  
<https://doi.org/10.1080/14697011003795602>
- Grant, K. (2015). Knowledge management: An enduring but confusing fashion. *Leading Issues in Knowledge Management*, 2, 1–26.
- Gray, D. E., Iles, P., & Watson, S. (2011). Spanning the HRD academic-practitioner divide: Bridging the gap through mode 2 research. *Journal of European Industrial Training*.
- Greenhill, S. J., Wu, C.-H., Hua, X., Dunn, M., Levinson, S. C., & Gray, R. D. (2017). Evolutionary dynamics of language systems. *Proceedings of the National Academy of Sciences*, 114(42), E8822–E8829.
- Greenwood, R., Oliver, C., Lawrence, T. B., & Meyer, R. E. (2017). *The SAGE Handbook of Organizational Institutionalism*. SAGE.
- Gregson, N., Crang, M., Fuller, S., & Holmes, H. (2015). Interrogating the circular economy: The moral economy of resource recovery in the EU. *Economy and Society*, 44(2), 218–243.  
<https://doi.org/10.1080/03085147.2015.1013353>
- Greyson, J. (2007). An economic instrument for zero waste, economic growth and sustainability. *Journal of Cleaner Production*. <https://doi.org/10.1016/j.jclepro.2006.07.019>



- Griffiths, T. L., & Steyvers, M. (2004). Finding scientific topics. *Proceedings of the National Academy of Sciences of the United States of America*.  
<https://doi.org/10.1073/pnas.0307752101>
- Groskovs, S., & Ulhøi, J. P. (2018). The middle manager in search of business model innovation. *Journal of Business Strategy*, 40(4), 3–10. <https://doi.org/10.1108/JBS-04-2018-0061>
- Grun, B., & Hornik, K. (2011). *topicmodels: An R package for fitting topic models*.
- Grün, B., & Hornik, K. (2011). Topicmodels: An r package for fitting topic models. *Journal of Statistical Software*. <https://doi.org/10.18637/jss.v040.i13>
- Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of Qualitative Research*, 2(163–194), 105.
- Guerci, M., Radaelli, G., & Shani, A. B. (2019). Conducting Mode 2 research in HRM: A phase-based framework. *Human Resource Management*, 58(1), 5–20.
- Guerreiro, J., Rita, P., & Trigueiros, D. (2016). A Text Mining-Based Review of Cause-Related Marketing Literature. *Journal of Business Ethics*. <https://doi.org/10.1007/s10551-015-2622-4>
- Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods*, 18(1), 59–82.
- Gulordava, K., & Baroni, M. (2011). A distributional similarity approach to the detection of semantic change in the Google Books Ngram corpus. *Proceedings of the GEMS 2011 Workshop on Geometrical Models of Natural Language Semantics*, 67–71.
- Gustin, B. H. (1973). Charisma, Recognition, and the Motivation of Scientists. *American Journal of Sociology*, 78(5), 1119–1134. <https://www.jstor.org/stable/2776628>
- Hall, D., Jurafsky, D., & Manning, C. D. (2008a). Studying the history of ideas using topic models. *EMNLP 2008 - 2008 Conference on Empirical Methods in Natural Language Processing, Proceedings of the Conference: A Meeting of SIGDAT, a Special Interest Group of the ACL*.  
<https://doi.org/10.3115/1613715.1613763>

- Hall, D., Jurafsky, D., & Manning, C. D. (2008b). Studying the History of Ideas Using Topic Models. *Proceedings of the 2008 Conference on Empirical Methods in Natural Language Processing*, 363–371. <https://www.aclweb.org/anthology/D08-1038>
- Hallegatte, S., Heal, G., Fay, M., & Treguer, D. (2012). From Growth to Green Growth—A Framework. *National Bureau of Economic Research*. <https://doi.org/10.3386/w17841>
- Halvorsen, T., & Nyhagen, A. (2011). *Academic Identities—Academic Challenges? American and European Experience of the Transformation of Higher Education and Research*. Cambridge Scholars Publishing.
- Hambrick, D. C., & Chen, M.-J. (2008). New Academic Fields as Admittance-Seeking Social Movements: The Case of Strategic Management. *The Academy of Management Review*, 33(1), 32–54. <https://doi.org/10.2307/20159375>
- Hamilton, W. L., Leskovec, J., & Jurafsky, D. (2016). Diachronic word embeddings reveal statistical laws of semantic change. *ArXiv Preprint ArXiv:1605.09096*.
- Hannigan, J. (2014). *Environmental sociology*. Routledge.
- Hardy, C., Phillips, N., & Clegg, S. (2001). Reflexivity in Organization and Management Theory: A Study of the Production of the Research ‘Subject’. *Human Relations*, 54(5), 531–560. <https://doi.org/10.1177/0018726701545001>
- Hardy, M.A. (2004) ‘Handbook of data analysis’.
- Hartley, K., van Santen, R., & Kirchherr, J. (2020). Policies for transitioning towards a circular economy: Expectations from the European Union (EU). *Resources, Conservation and Recycling*, 155, 104634.
- Hashimi, H., Hafez, A. and Mathkour, H. (2015) ‘Selection criteria for text mining approaches’, *Computers in Human Behavior*, 51, pp. 729–733. doi:10.1016/j.chb.2014.10.062.

- Hauge, K. H., & Barwell, R. (2017). Post-normal science and mathematics education in uncertain times: Educating future citizens for extended peer communities. *Futures*, 91, 25–34.
- Hauser, J., & Katz, G. (1998). Metrics: You are what you measure! *European Management Journal*, 16(5), 517–528. [https://doi.org/10.1016/S0263-2373\(98\)00029-2](https://doi.org/10.1016/S0263-2373(98)00029-2)
- Hawley, P. H. (1999). The Ontogenesis of Social Dominance: A Strategy-Based Evolutionary Perspective. *Developmental Review*. <https://doi.org/10.1006/drev.1998.0470>
- Hazra, A. (2017) ‘Using the confidence interval confidently’, *Journal of Thoracic Disease*, 9(10), pp. 4125–4130. doi:10.21037/jtd.2017.09.14.
- Henry, M., Schraven, D., Bocken, N., Frenken, K., Hekkert, M., & Kirchherr, J. (2021). The battle of the buzzwords: A comparative review of the circular economy and the sharing economy concepts. *Environmental Innovation and Societal Transitions*, 38, 1–21. <https://doi.org/10.1016/j.eist.2020.10.008>
- Hess, D. J., & Frickel, S. (2014). Introduction: Fields of knowledge and theory traditions in the sociology of science. In *Fields of Knowledge: Science, Politics and Publics in the Neoliberal Age*. Emerald Group Publishing Limited.
- Hessels, L. K., & van Lente, H. (2008). Re-thinking new knowledge production: A literature review and a research agenda. *Research Policy*, 37(4), 740–760. <https://doi.org/10.1016/j.respol.2008.01.008>
- Heurkens, E., & Dąbrowski, M. (2020). Circling the square: Governance of the circular economy transition in the Amsterdam Metropolitan Area. *European Spatial Research and Policy*, 27(2), 11–31.
- Hindle, A., Godfrey, M. W., & Holt, R. C. (2009). What’s hot and what’s not: Windowed developer topic analysis. *2009 IEEE International Conference on Software Maintenance*, 339–348. <https://doi.org/10.1109/ICSM.2009.5306310>

- Hinton, G. and Roweis, S.T., 2002, December. Stochastic neighbor embedding. In NIPS (Vol. 15, pp. 833-840).
- Hitchings, R. (2003). People, plants and performance: On actor network theory and the material pleasures of the private garden. *Social & Cultural Geography*, 4(1), 99–114.  
<https://doi.org/10.1080/1464936032000049333>
- Hobson, K., & Lynch, N. (2016). Diversifying and de-growing the circular economy: Radical social transformation in a resource-scarce world. *Futures*, 82, 15–25.  
<https://doi.org/10.1016/j.futures.2016.05.012>
- Hoffman, A. J. (1999). Institutional Evolution and Change: Environmentalism and the U.S. Chemical Industry. *The Academy of Management Journal*, 42(4), 351–371.  
<https://doi.org/10.2307/257008>
- Homrich, A. S., Galvao, G., Abadia, L. G., & Carvalho, M. M. (2018). The circular economy umbrella: Trends and gaps on integrating pathways. *Journal of Cleaner Production*, 175, 525–543.
- Homrich, A. S., Galvão, G., Abadia, L. G., & Carvalho, M. M. (2018). The circular economy umbrella: Trends and gaps on integrating pathways. In *Journal of Cleaner Production*.  
<https://doi.org/10.1016/j.jclepro.2017.11.064>
- Horta, H., & Veloso, F. M. (2007). Opening the box: Comparing EU and US scientific output by scientific field. *Technological Forecasting and Social Change*, 74(8), 1334–1356.  
<https://doi.org/10.1016/j.techfore.2007.02.013>
- Howard, M., Hopkinson, P., & Miemczyk, J. (2019). The regenerative supply chain: A framework for developing circular economy indicators. *International Journal of Production Research*, 57(23), 7300–7318.
- Hull, D. L. (1975). Central Subjects and Historical Narratives. *History and Theory*, 14(3), 253–274.  
<https://doi.org/10.2307/2504863>

- Hull, D. L. (2010). *Science as a Process: An Evolutionary Account of the Social and Conceptual Development of Science*. University of Chicago Press.
- Hyland, K. (2009). *Academic Discourse: English In A Global Context*. A&C Black.
- Li, X. *et al.* (2016) ‘Integrating Topic Modeling with Word Embeddings by Mixtures of vMFs’, in *Proceedings of COLING 2016, the 26th International Conference on Computational Linguistics: Technical Papers*. COLING 2016, Osaka, Japan: The COLING 2016 Organizing Committee, pp. 151–160. Available at: <https://aclanthology.org/C16-1015> (Accessed: 22 December 2021).
- Inigo, E. A., & Blok, V. (2019). Strengthening the socio-ethical foundations of the circular economy: Lessons from responsible research and innovation. *Journal of Cleaner Production*, 233, 280–291. <https://doi.org/10.1016/j.jclepro.2019.06.053>
- Inzalkar, S. and Sharma, J. (2015) ‘A survey on text mining-techniques and application’, *International Journal of Research In Science & Engineering*, 24, pp. 1–14.
- Islam, A. K. M. N., Mäntymäki, M., & Turunen, M. (2019). Why do blockchains split? An actor-network perspective on Bitcoin splits. *Technological Forecasting and Social Change*, 148, 119743. <https://doi.org/10.1016/j.techfore.2019.119743>
- Ivanova, I. (2014). Quadruple Helix Systems and Symmetry: A Step Towards Helix Innovation System Classification. *Journal of the Knowledge Economy*, 5(2), 357–369. <https://doi.org/10.1007/s13132-014-0201-z>
- Jabareen, Y. (2008). A New Conceptual Framework for Sustainable Development. *Environment, Development and Sustainability*, 10(2), 179–192. <https://doi.org/10.1007/s10668-006-9058-z>
- Jablonowski, M. (2011). In Defense of Planning in the Eco-State. *Synthesis/Regeneration: A Magazine of Green Social Thought*, 56, 36.

- Jackson, T. (1993). *Clean Production Strategies Developing Preventive Environmental Management in the Industrial Economy*. CRC Press.
- Jacobs, M. (1993). *The green economy: Environment, sustainable development and the politics of the future*. UBC press.
- Jaeger-Erben, M., Jensen, C., Hofmann, F., & Zwiers, J. (2021). There is no sustainable circular economy without a circular society. *Resources, Conservation and Recycling*, 168, 105476. <https://doi.org/10.1016/j.resconrec.2021.105476>
- Jatowt, A., & Duh, K. (2014). A framework for analyzing semantic change of words across time. *IEEE/ACM Joint Conference on Digital Libraries*, 229–238.
- Jessop, B. (2017). Varieties of academic capitalism and entrepreneurial universities. *Higher Education*, 73(6), 853–870.
- Jiang, H., Qiang, M., & Lin, P. (2016). A topic modeling based bibliometric exploration of hydropower research. In *Renewable and Sustainable Energy Reviews*. <https://doi.org/10.1016/j.rser.2015.12.194>
- Jiao, W., & Boons, F. (2014). Toward a research agenda for policy intervention and facilitation to enhance industrial symbiosis based on a comprehensive literature review. *Journal of Cleaner Production*, 67, 14–25. <https://doi.org/10.1016/j.jclepro.2013.12.050>
- Jiao, W., & Boons, F. (2017). Policy durability of Circular Economy in China: A process analysis of policy translation. *Resources, Conservation and Recycling*, 117, 12–24. <https://doi.org/10.1016/j.resconrec.2015.10.010>
- Jiao, W., Boons, F., Teisman, G., & Li, C. (2018). Durable policy facilitation of Sustainable Industrial Parks in China: A perspective of co-evolution of policy processes. *Journal of Cleaner Production*, 192, 179–190. <https://doi.org/10.1016/j.jclepro.2018.04.226>

- Jie, T., & Nianfeng, L. (1995). Some problems of ecological environmental geology in arid and semiarid areas of China. *Environmental Geology*, 26(1), 64–67.  
<https://doi.org/10.1007/BF00776034>
- Jurafsky, D., & Martin, J. H. (n.d.). *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition*.
- Kao, A., & Poteet, S. R. (2007). *Natural Language Processing and Text Mining*. Springer Science & Business Media.
- Kauppinen, I. (2015). Towards a theory of transnational academic capitalism. *British Journal of Sociology of Education*, 36(2), 336–353.
- Kaushik, V., & Walsh, C. A. (2019). Pragmatism as a research paradigm and its implications for social work research. *Social Sciences*, 8(9), 255.
- Keeney, S., Hasson, F., & McKenna, H. P. (2001). A critical review of the Delphi technique as a research methodology for nursing. *International Journal of Nursing Studies*.  
[https://doi.org/10.1016/S0020-7489\(00\)00044-4](https://doi.org/10.1016/S0020-7489(00)00044-4)
- Kenter, T., Wevers, M., Huijnen, P., & de Rijke, M. (2015). Ad Hoc Monitoring of Vocabulary Shifts over Time. *Proceedings of the 24th ACM International on Conference on Information and Knowledge Management*, 1191–1200. <https://doi.org/10.1145/2806416.2806474>
- Kezar, A. (2011). *Understanding and Facilitating Organizational Change in the 21st Century: Recent Research and Conceptualizations: ASHE-ERIC Higher Education Report, Volume 28, Number 4*.
- Kirchherr, J., & Piscicelli, L. (2019). Towards an Education for the Circular Economy (ECE): Five Teaching Principles and a Case Study. *Resources, Conservation and Recycling*, 150, 104406.  
<https://doi.org/10.1016/j.resconrec.2019.104406>



- Kirchherr, J., Reike, D., & Hekkert, M. (2017a). Conceptualizing the circular economy: An analysis of 114 definitions. In *Resources, Conservation and Recycling*.  
<https://doi.org/10.1016/j.resconrec.2017.09.005>
- Kirchherr, J., Reike, D., & Hekkert, M. (2017b). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, 127, 221–232.
- Kitcher, P. (1998). A Plea For Science Studies. In Noretta Koertge (ed.), *A House Built on Sand: Exposing Postmodernist Myths About Science*. (pp. 32–56). Oxford: Oxford University Press.
- Kivunja, C. (2018). Distinguishing between Theory, Theoretical Framework, and Conceptual Framework: A Systematic Review of Lessons from the Field. *International Journal of Higher Education*, 7(6), 44. <https://doi.org/10.5430/ijhe.v7n6p44>
- Kliniewicz, K. (2016). The emergent dynamics of a technological research topic: The case of graphene. *Scientometrics*, 106(1), 319–345. <https://doi.org/10.1007/s11192-015-1780-6>
- Knorr-Cetina, K. D. (1981). The Scientist as a Practical Reasoner: Introduction to a Constructivist and Contextual Theory of Knowledge. In *The Manufacture of Knowledge* (pp. 1–32). Elsevier. <https://doi.org/10.1016/B978-0-08-025777-8.50009-8>
- Korhonen, J., Nuur, C., Feldmann, A., & Birkie, S. E. (2018). Circular economy as an essentially contested concept. *Journal of Cleaner Production*.  
<https://doi.org/10.1016/j.jclepro.2017.12.111>
- KPMG. (2019). *Accelerating towards a circular economy*. February.
- Kuhn, T. (2021). *The structure of scientific revolutions*. Princeton University Press.
- Kuhn, T. S. (1990). The Road since Structure. *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association*, 1990(2), 3–13.  
<https://doi.org/10.1086/psaprobienmeetp.1990.2.193054>
- Kühne, M., Blinn, N., Rosenkranz, C., & Nüttgens, M. (2011). *Diffusion of Web 2.0 in healthcare: A complete inventory count in the German health insurance landscape*.

- Kulkarni, V., Al-Rfou, R., Perozzi, B., & Skiena, S. (2015). Statistically significant detection of linguistic change. *Proceedings of the 24th International Conference on World Wide Web*, 625–635.
- Kunc, M., Mortenson, M. J., & Vidgen, R. (2018). A computational literature review of the field of System Dynamics from 1974 to 2017. *Journal of Simulation*.  
<https://doi.org/10.1080/17477778.2018.1468950>
- Kutuzov, A., Øvrelid, L., Szymanski, T., & Velldal, E. (2018). Diachronic word embeddings and semantic shifts: A survey. *ArXiv Preprint ArXiv:1806.03537*.
- Kvale, S. (2008). *Doing interviews*. Sage.
- Lakatos, E. S., Vlad, M. F., Pacurariu, R. L., Szilagyi, A., & Cadar, D. (2021). A New, Consonant Approach of Circular Economy Based on the Conservation of the Fundamental Scalars of Physics. *Circular Economy and Sustainability*, 1–15.
- Lam, A. (2011). What motivates academic scientists to engage in research commercialization: ‘Gold’, ‘ribbon’ or ‘puzzle’? *Research Policy*, 40(10), 1354–1368.  
<https://doi.org/10.1016/j.respol.2011.09.002>
- Lampel, J., & Meyer, A. D. (2008). Field-configuring events as structuring mechanisms: How conferences, ceremonies, and trade shows constitute new technologies, industries, and markets. *Journal of Management Studies*, 45(6), 1025–1035.
- Langley, A. (1999). Strategies for Theorizing from Process Data. *The Academy of Management Review*, 24(4), 691–710. <https://doi.org/10.2307/259349>
- Latour, B. (1979). Steve Woolgar. *Laboratory Life: The Construction of Scientific Facts*.
- Latour, B. (1984). The powers of association. *The Sociological Review*, 32(1\_suppl), 264–280.
- Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Harvard university press.
- Latour, B. (1996). *Aramis, or the Love of Technology*. Harvard University Press.

- Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory*. Oxford university press.
- Law, J. (2009). Actor network theory and material semiotics. *The New Blackwell Companion to Social Theory*, 3, 141–158.
- Lazarevic, D., & Valve, H. (2017a). Narrating expectations for the circular economy: Towards a common and contested European transition. *Energy Research and Social Science*.  
<https://doi.org/10.1016/j.erss.2017.05.006>
- Lazarevic, D., & Valve, H. (2017b). Narrating expectations for the circular economy: Towards a common and contested European transition. *Energy Research & Social Science*, 31, 60–69.  
<https://doi.org/10.1016/j.erss.2017.05.006>
- Lecocq, X., Demil, B., & Ventura, J. (2010). Business Models as a Research Program in Strategic Management: An Appraisal based on Lakatos. *M@n@gement*, Vol. 13(4), 214–225.  
<https://www.cairn.info/revue-management-2010-4-page-214.htm>
- Leech, N. L., & Onwuegbuzie, A. J. (2009). A typology of mixed methods research designs. *Quality & Quantity*, 43(2), 265–275.
- Leipold, S., & Petit-Boix, A. (2018). The circular economy and the bio-based sector—Perspectives of European and German stakeholders. *Journal of Cleaner Production*, 201, 1125–1137.  
<https://doi.org/10.1016/j.jclepro.2018.08.019>
- LeMoyne, R. et al. (2008) ‘Virtual proprioception with real-time step detection and processing’, in 2008 30th Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE, pp. 4238–4241.
- Levoso, A. S., Gasol, C. M., Martínez-Blanco, J., Durany, X. G., Lehmann, M., & Gaya, R. F. (2020). Methodological framework for the implementation of circular economy in urban systems. *Journal of Cleaner Production*, 248, 119227.

- Lewandowski, M. (2016). Designing the business models for circular economy-towards the conceptual framework. In *Sustainability (Switzerland)*. <https://doi.org/10.3390/su8010043>
- Leydesdorff, L. (2012). The Triple Helix, Quadruple Helix, ..., and an N-Tuple of Helices: Explanatory Models for Analyzing the Knowledge-Based Economy? *Journal of the Knowledge Economy*, 3(1), 25–35. <https://doi.org/10.1007/s13132-011-0049-4>
- Leydesdorff, L., & Deakin, M. (2011). The triple-helix model of smart cities: A neo-evolutionary perspective. *Journal of Urban Technology*, 18(2), 53–63.
- Leydesdorff, L., & Zawdie, G. (2010). The triple helix perspective of innovation systems. *Technology Analysis & Strategic Management*, 22(7), 789–804. <https://doi.org/10.1080/09537325.2010.511142>
- Li, X., Yang, K., & Xiao, X. (2016). Scientific advice in China: The changing role of the Chinese Academy of Sciences. *Palgrave Communications*, 2(1), 1–8. <https://doi.org/10.1057/palcomms.2016.45>
- Lieder, M., & Rashid, A. (2016). Towards circular economy implementation: A comprehensive review in context of manufacturing industry. *Journal of Cleaner Production*, 115, 36–51.
- Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry*. SAGE.
- Lind, F., Styhre, A., & Aaboen, L. (2013). Exploring university-industry collaboration in research centres. *European Journal of Innovation Management*, 16(1), 70–91. <https://doi.org/10.1108/14601061311292869>
- Loiseau, E., Saikku, L., Antikainen, R., Droste, N., Hansjürgens, B., Pitkänen, K., Leskinen, P., Kuikman, P., & Thomsen, M. (2016). Green economy and related concepts: An overview. *Journal of Cleaner Production*. <https://doi.org/10.1016/j.jclepro.2016.08.024>
- Lorange, P., Scott Morton, M. F., & Ghoshal, S. (1986). *Strategic control systems*, St. Paul, MN: West Publishing.

- Loroño-Leturiondo, M., & Davies, S. R. (2018). Responsibility and science communication: Scientists' experiences of and perspectives on public communication activities. *Journal of Responsible Innovation*, 5(2), 170–185.
- Loughlin, K. G., & Moore, L. F. (1979). Using delphi to achieve congruent objectives and activities in a pediatrics department. *Academic Medicine*. <https://doi.org/10.1097/00001888-197902000-00006>
- Lüdeke-Freund, F., & Dembek, K. (2017). Sustainable business model research and practice: Emerging field or passing fancy? *Journal of Cleaner Production*, 168, 1668–1678.
- Lynch, M., & Bogen, D. (1997). Sociology's Asociological "Core": An Examination of Textbook Sociology in Light of the Sociology of Scientific Knowledge. *American Sociological Review*, 62(3), 481–493. <https://doi.org/10.2307/2657317>
- Maddox, P. (2020, January 20). Comment: A circular economy is the only way forward for fashion. *Drapers*. <http://www.drapersonline.com/insight/comment/comment-a-circular-economy-is-the-only-way-forward-for-fashion>
- Mah, A. (2021). Future-proofing capitalism: The paradox of the circular economy for plastics. *Global Environmental Politics*, 21(2), 121–142.
- Mahanty, S., Boons, F., Handl, J., & Batista-Navarro, R. (2019). Studying the Evolution of the 'Circular Economy' Concept Using Topic Modelling. *International Conference on Intelligent Data Engineering and Automated Learning*, 259–270.
- Mahpour, A. (2018). Prioritizing barriers to adopt circular economy in construction and demolition waste management. *Resources, Conservation and Recycling*. <https://doi.org/10.1016/j.resconrec.2018.01.026>
- Mähring, M., Holmström, J., Keil, M., & Montealegre, R. (2004). Trojan actor-networks and swift translation: Bringing actor-network theory to IT project escalation studies. *Information Technology & People*.

- Manning, S., Boons, F., von Hagen, O., & Reinecke, J. (2012). National contexts matter: The co-evolution of sustainability standards in global value chains. *Ecological Economics*, 83, 197–209. <https://doi.org/10.1016/j.ecolecon.2011.08.029>
- Margaret C. Harrell; Melissa A. Bradley. (2009). Data Collection Methods Semi-Structured Interviews and Focus Groups. In *Distribution*. <https://doi.org/978-0-8330-4889-9>
- Margolis, E., & Laurence, S. (2005). *Concepts*.  
<https://plato.stanford.edu/archives/sum2019/entries/concepts/>
- Masi, D., Day, S., & Godsell, J. (2017a). Supply chain configurations in the circular economy: A systematic literature review. *Sustainability*, 9(9), 1602.
- Masi, D., Day, S., & Godsell, J. (2017b). Supply chain configurations in the circular economy: A systematic literature review. In *Sustainability (Switzerland)*.  
<https://doi.org/10.3390/su9091602>
- Masi, D., Kumar, V., Garza-Reyes, J. A., & Godsell, J. (2018). Towards a more circular economy: Exploring the awareness, practices, and barriers from a focal firm perspective. *Production Planning & Control*, 29(6), 539–550. <https://doi.org/10.1080/09537287.2018.1449246>
- Mathews, J. A., & Tan, H. (2016). Circular economy: Lessons from China. In *Nature*.  
<https://doi.org/10.1038/531440a>
- Mativenga, P. T., Sultan, A. A. M., Agwa-Ejon, J., & Mbohwa, C. (2017). Composites in a Circular Economy: A Study of United Kingdom and South Africa. *Procedia CIRP*.  
<https://doi.org/10.1016/j.procir.2016.11.270>
- Mayes, R., Hurst, B., & Hine, A. (2021). *ANT Stakeholder Action Mapping Tool and User Guide*.
- McCarthy, J., Meredith, D., & Bonnin, C. (2021). Actor motivations to engage with collaborative agri-environmental policy: An assemblage based exploration. *Journal of Rural Studies*, 87, 88–98. <https://doi.org/10.1016/j.jrurstud.2021.08.025>

- McCormick, K., & Kautto, N. (2013). The Bioeconomy in Europe: An Overview. *Sustainability (Switzerland)*. <https://doi.org/10.3390/su5062589>
- McDowall, W., Geng, Y., Huang, B., Barteková, E., Bleischwitz, R., Türkeli, S., Kemp, R., & Doménech, T. (2017a). Circular economy policies in China and Europe. *Journal of Industrial Ecology*, 21(3), 651–661.
- McDowall, W., Geng, Y., Huang, B., Barteková, E., Bleischwitz, R., Türkeli, S., Kemp, R., & Doménech, T. (2017b). Circular Economy Policies in China and Europe. *Journal of Industrial Ecology*. <https://doi.org/10.1111/jiec.12597>
- McInerney, P.-B. (2008). Showdown at Kykuit: Field-configuring events as loci for conventionalizing accounts. *Journal of Management Studies*, 45(6), 1089–1116.
- McKenna, H. P. (1994). The Delphi technique: A worthwhile research approach for nursing? *Journal of Advanced Nursing*. <https://doi.org/10.1111/j.1365-2648.1994.tb01207.x>
- McKinsey. (2016). The Circular Economy: Moving from Theory to Practice. In *McKinsey Center for Business and Environment*. <https://doi.org/10.1108/CMS-10-2013-0192>
- Meadowcroft, J. (2005). From welfare state to ecostate. *The State and the Global Ecological Crisis*, 3–23.
- Meadowcroft, J. (2012). Greening the state. *Comparative Environmental Politics: Theory, Practice, and Prospects*, 63–87.
- Merli, R., Preziosi, M., & Acampora, A. (2018a). How do scholars approach the circular economy? A systematic literature review. *Journal of Cleaner Production*, 178, 703–722.
- Merli, R., Preziosi, M., & Acampora, A. (2018b). How do scholars approach the circular economy? A systematic literature review. In *Journal of Cleaner Production*. <https://doi.org/10.1016/j.jclepro.2017.12.112>
- Merton, R. K. (1973). *The sociology of science: Theoretical and empirical investigations*. University of Chicago press.



- Meyer, A. D. (1982). Adapting to environmental jolts. *Administrative Science Quarterly*, 515–537.
- Meyer, A. D., Gaba, V., & Colwell, K. A. (2005). Organizing far from equilibrium: Nonlinear change in organizational fields. *Organization Science*, 16(5), 456–473.
- Michel, J.-B., Shen, Y. K., Aiden, A. P., Veres, A., Gray, M. K., Team, G. B., Pickett, J. P., Hoiberg, D., Clancy, D., & Norvig, P. (2011). Quantitative analysis of culture using millions of digitized books. *Science*, 331(6014), 176–182.
- Mikolov, T., Sutskever, I., Chen, K., Corrado, G. S., & Dean, J. (2013). Distributed representations of words and phrases and their compositionality. *Advances in Neural Information Processing Systems*, 3111–3119.
- Mimno, D., Wallach, H., Talley, E., Leenders, M., & McCallum, A. (2011). Optimizing Semantic Coherence in Topic Models. *Proceedings of the 2011 Conference on Empirical Methods in Natural Language Processing*, 262–272. <https://www.aclweb.org/anthology/D11-1024>
- Mintrom, M., & Luetjens, J. (2017). Policy entrepreneurs and problem framing: The case of climate change. *Environment and Planning C: Politics and Space*, 35(8), 1362–1377.
- Mintrom, M., & Norman, P. (2009). Policy Entrepreneurship and Policy Change. *Policy Studies Journal*, 37(4), 649–667. <https://doi.org/10.1111/j.1541-0072.2009.00329.x>
- Mitnick, B. M. (2019). The distinction of fields. *Business & Society*, 58(7), 1309–1333.
- Mitra, S., Mitra, R., Maity, S. K., Riedl, M., Biemann, C., Goyal, P., & Mukherjee, A. (2015). An automatic approach to identify word sense changes in text media across timescales. *Natural Language Engineering*, 21(5), 773–798.
- Mohrman, S. A., & Lawler, E. E. (2011). Research for theory and practice. *Useful Research: Advancing Theory and Practice*, 9–33.
- Moraga, G., Huysveld, S., Mathieux, F., Blengini, G. A., Alaerts, L., Van Acker, K., De Meester, S., & Dewulf, J. (2019). Circular economy indicators: What do they measure? *Resources, Conservation and Recycling*, 146, 452–461.

- Morales, C. M. B., & Sossa, J. W. Z. (2020). Circular economy in Latin America: A systematic literature review. *Business Strategy and the Environment*, 29(6), 2479–2497.  
<https://doi.org/10.1002/bse.2515>
- Moran, S. *et al.* (2016) ‘Enhancing First Story Detection using Word Embeddings’, in *Proceedings of the 39th International ACM SIGIR conference on Research and Development in Information Retrieval. SIGIR '16: The 39th International ACM SIGIR conference on research and development in Information Retrieval*, Pisa Italy: ACM, pp. 821–824.  
[doi:10.1145/2911451.2914719](https://doi.org/10.1145/2911451.2914719).
- Moreau, V., Sahakian, M., Griethuysen, P. van, & Vuille, F. (2017). Coming Full Circle: Why Social and Institutional Dimensions Matter for the Circular Economy. *Journal of Industrial Ecology*, 21(3), 497–506. <https://doi.org/10.1111/jiec.12598>
- Morgan, D. L. (2007). Paradigms Lost and Pragmatism Regained: Methodological Implications of Combining Qualitative and Quantitative Methods. *Journal of Mixed Methods Research*, 1(1), 48–76. <https://doi.org/10.1177/2345678906292462>
- Morgan, D. L. (2014). Pragmatism as a Paradigm for Social Research. *Qualitative Inquiry*, 20(8), 1045–1053. <https://doi.org/10.1177/1077800413513733>
- Moro, S., Cortez, P., & Rita, P. (2015). Business intelligence in banking: A literature analysis from 2002 to 2013 using text mining and latent Dirichlet allocation. *Expert Systems with Applications*. <https://doi.org/10.1016/j.eswa.2014.09.024>
- Morseletto, P. (2020). Restorative and regenerative: Exploring the concepts in the circular economy. *Journal of Industrial Ecology*, 24(4), 763–773. <https://doi.org/10.1111/jiec.12987>
- Müller, M. (2015). Assemblages and Actor-networks: Rethinking Socio-material Power, Politics and Space. *Geography Compass*, 9(1), 27–41. <https://doi.org/10.1111/gec3.12192>
- Mullins, N. C. (1973). *Theories and theory groups in contemporary American sociology*. New York: Harper & Row.

- Münch, R. (2014). *Academic capitalism: Universities in the global struggle for excellence*. Routledge.
- Murdoch, J. (1998). The spaces of actor-network theory. *Geoforum*, 29(4), 357–374.
- Murray, A., Skene, K., & Haynes, K. (2017a). The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context. *Journal of Business Ethics*. <https://doi.org/10.1007/s10551-015-2693-2>
- Murray, A., Skene, K., & Haynes, K. (2017b). The circular economy: An interdisciplinary exploration of the concept and application in a global context. *Journal of Business Ethics*, 140(3), 369–380.
- Naustdalslid, J. (2014). Circular economy in China – the environmental dimension of the harmonious society. *International Journal of Sustainable Development & World Ecology*, 21(4), 303–313. <https://doi.org/10.1080/13504509.2014.914599>
- Navis, C., & Glynn, M. A. (2010). How New Market Categories Emerge: Temporal Dynamics of Legitimacy, Identity, and Entrepreneurship in Satellite Radio, 1990–2005. *Administrative Science Quarterly*, 55(3), 439–471. <https://doi.org/10.2189/asqu.2010.55.3.439>
- Neale, J., Allen, D., & Coombes, L. (2005). Qualitative research methods within the addictions. *Addiction*.
- Neuman, Y., Hames, H., & Cohen, Y. (2017). An information-based procedure for measuring semantic change in historical data. *Measurement*, 105, 130–135.
- New Circular Economy Action Plan*. (n.d.). [Text]. European Commission - European Commission. Retrieved September 21, 2021, from [https://ec.europa.eu/commission/presscorner/detail/en/ip\\_20\\_420](https://ec.europa.eu/commission/presscorner/detail/en/ip_20_420)
- Newman, D., Noh, Y., Talley, E., Karimi, S., & Baldwin, T. (2010). Evaluating topic models for digital libraries. *Proceedings of the 10th Annual Joint Conference on Digital Libraries - JCDL '10*, 215. <https://doi.org/10.1145/1816123.1816156>

- Nijholt, J. J., & Benders, J. (2007). Coevolution in Management Fashions: The Case of Self-Managing Teams in The Netherlands. *Group & Organization Management*, 32(6), 628–652.  
<https://doi.org/10.1177/1059601106293781>
- Nikolenko, S. I., Koltcov, S., & Koltsova, O. (2017a). Topic modelling for qualitative studies. *Journal of Information Science*, 43(1), 88–102.
- Nikolenko, S. I., Koltcov, S., & Koltsova, O. (2017b). Topic modelling for qualitative studies. *Journal of Information Science*. <https://doi.org/10.1177/0165551515617393>
- Niskanen, J., Anshelm, J., & McLaren, D. (2020). Local conflicts and national consensus: The strange case of circular economy in Sweden. *Journal of Cleaner Production*, 261, 121117.
- Nobre, G. C., & Tavares, E. (2017). Scientific literature analysis on big data and internet of things applications on circular economy: A bibliometric study. *Scientometrics*.  
<https://doi.org/10.1007/s11192-017-2281-6>
- Nogueira, A., Ashton, W. S., & Teixeira, C. (2019). Expanding perceptions of the circular economy through design: Eight capitals as innovation lenses. *Resources, Conservation and Recycling*, 149, 566–576.
- Nowotny, H., Scott, P. B., & Gibbons, M. T. (2013). *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty*. John Wiley & Sons.
- NOWOTNY, H., SCOTT, P., & GIBBONS, M. (2003). INTRODUCTION: “Mode 2” Revisited: The New Production of Knowledge. *Minerva*, 41(3), 179–194.  
<https://www.jstor.org/stable/41821245>
- Nowotny, H., Scott, P., & Gibbons, M. (2003). Introduction: ‘Mode 2’ revisited: The new production of knowledge. *Minerva*, 41(3), 179–194.
- Nowotny, H., Scott, P., & Gibbons, M. (2006). Re-thinking science: Mode 2 in societal context. *Knowledge Creation, Diffusion, and Use in Innovation Networks and Knowledge Clusters. A Comparative Systems Approach across the United States, Europe and Asia*, 39–51.

- Nunez-Mir, G. C., Iannone, B. V., Pijanowski, B. C., Kong, N., & Fei, S. (2016). Automated content analysis: Addressing the big literature challenge in ecology and evolution. In *Methods in Ecology and Evolution*. <https://doi.org/10.1111/2041-210X.12602>
- OECD. (2020). *Improving resource efficiency and the circularity of economies for a greener world*. <https://doi.org/10.1787/1b38a38f-en>
- Oesterreich, T. D., Schuir, J., & Teuteberg, F. (2020). The emperor's new clothes or an enduring IT fashion? Analyzing the lifecycle of industry 4.0 through the lens of management fashion theory. *Sustainability*, 12(21), 8828.
- Ogunmakinde, O. E. (2019). A review of circular economy development models in China, Germany and Japan. *Recycling*, 4(3), 27.
- Okoli, C., & Pawlowski, S. D. (2004). The Delphi method as a research tool: An example, design considerations and applications. *Information and Management*. <https://doi.org/10.1016/j.im.2003.11.002>
- Onwuegbuzie, A. J., & Leech, N. L. (2005). On becoming a pragmatic researcher: The importance of combining quantitative and qualitative research methodologies. *International Journal of Social Research Methodology*, 8(5), 375–387.
- Orlikowski, M., Hartung, M., & Cimiano, P. (2018). Learning Diachronic Analogies to Analyze Concept Change. *Proceedings of the Second Joint SIGHUM Workshop on Computational Linguistics for Cultural Heritage, Social Sciences, Humanities and Literature*, 1–11. <https://www.aclweb.org/anthology/W18-4501>
- Osborne, J., Collins, S., Ratcliffe, M., Millar, R., & Duschl, R. (2003). What “ideas-about-science” should be taught in school science? A delphi study of the expert community. *Journal of Research in Science Teaching*. <https://doi.org/10.1002/tea.10105>

- Owen, R., Pansera, M., Macnaghten, P., & Randles, S. (2021). Organisational institutionalisation of responsible innovation. *Research Policy*, 50(1), 104132.  
<https://doi.org/10.1016/j.respol.2020.104132>
- Özdemir, V., Fisher, E., Dove, E. S., Burton, H., Wright, G. E., Masellis, M., & Warnich, L. (2012). End of the beginning and public health pharmacogenomics: Knowledge in ‘Mode 2’ and P5 medicine. *Current Pharmacogenomics and Personalized Medicine*, 10(1), 1.
- Pajunen, K. (2008). The Nature of Organizational Mechanisms. *Organization Studies*, 29(11), 1449–1468. <https://doi.org/10.1177/0170840607096384>
- Park, T. (2011). Academic capitalism and its impact on the American professoriate. *Journal of the Professoriate*, 6(1), 84–96.
- Passoth, J.-H., & Rowland, N. J. (2010). Actor-network state: Integrating actor-network theory and state theory. *International Sociology*, 25(6), 818–841.
- Paul-Hus, A., Desrochers, N., de Rijcke, S., & Rushforth, A. D. (2017). The reward system of science. *Aslib Journal of Information Management*, 69(5).  
<https://ora.ox.ac.uk/objects/uuid:4a72193d-bccd-4e2b-a674-ce038579706e>
- Pauli, G., & Corbis, G. S. (2010). The Blue economy: Growth, opportunity and a sustainable ocean economy. *UNEP Our Planet Making in Work*.
- Pearce, D. W., & Turner, R. K. (1990). *Economics of natural resources and the environment*. JHU press.
- Pennington, J., Socher, R., & Manning, C. D. (2014). Glove: Global vectors for word representation. *Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing (EMNLP)*, 1532–1543.
- Perry, D. K. (2001). *American pragmatism and communication research*. Routledge.

- Pesce, M., Tamai, I., Guo, D., Critto, A., Brombal, D., Wang, X., Cheng, H., & Marcomini, A. (2020). Circular economy in China: Translating principles into practice. *Sustainability*, 12(3), 832.
- Piazza, A., & Abrahamson, E. (2020). Fads and Fashions in Management Practices: Taking Stock and Looking Forward. *International Journal of Management Reviews*, 22(3), 264–286. <https://doi.org/10.1111/ijmr.12225>
- Pinch, T. J., & Bijker, W. E. (1984). The Social Construction of Facts and Artefacts: Or How the Sociology of Science and the Sociology of Technology might Benefit Each Other. *Social Studies of Science*, 14(3), 399–441. <https://doi.org/10.1177/030631284014003004>
- Pinker, S. (1995). *The language instinct: The new science of language and mind* (Vol. 7529). Penguin UK.
- Pipan, T., & Czarniawska, B. (2010). How to construct an actor-network: Management accounting from idea to practice. *Critical Perspectives on Accounting*, 21(3), 243–251. <https://doi.org/10.1016/j.cpa.2008.04.001>
- Popper, K. R. (1972). *Objective knowledge* (Vol. 360). Oxford University Press Oxford.
- Prendeville, S., Cherim, E., & Bocken, N. (2018). Circular Cities: Mapping Six Cities in Transition. *Environmental Innovation and Societal Transitions*. <https://doi.org/10.1016/j.eist.2017.03.002>
- Priem, R. L. (2006). What happens when special issues just aren't "special" anymore? *Journal of Management Inquiry*, 15(4), 383–388.
- Priem, R. L. (2007). Let's make special issues "special" once again. *Journal of Management Inquiry*, 16(3), 246–249.
- Primc, K., Kalar, B., Slabe-Erker, R., Dominko, M., & Ogorevc, M. (2020). Circular economy configuration indicators in organizational life cycle theory. *Ecological Indicators*, 116, 106532.



- Ralph, N. (2021). A conceptual merging of circular economy, degrowth and conviviality design approaches applied to renewable energy technology. *Journal of Cleaner Production*, 319, 128549.
- Ranga, M., & Etzkowitz, H. (2013). Triple Helix systems: An analytical framework for innovation policy and practice in the Knowledge Society. *Industry and Higher Education*, 27(4), 237–262.
- Ranta, V., Aarikka-Stenroos, L., & Mäkinen, S. J. (2018). Creating value in the circular economy: A structured multiple-case analysis of business models. *Journal of Cleaner Production*. <https://doi.org/10.1016/j.jclepro.2018.08.072>
- Ranta, V., Aarikka-Stenroos, L., Ritala, P., & Mäkinen, S. J. (2018). Exploring institutional drivers and barriers of the circular economy: A cross-regional comparison of China, the US, and Europe. *Resources, Conservation and Recycling*, 135, 70–82.
- Ravetz, I. R. (1999). What is post-normal science. *Futures-the Journal of Forecasting Planning and Policy*, 31(7), 647–654.
- Recchia, G., Jones, E., Nulty, P., Regan, J., & de Bolla, P. (2016). Tracing shifting conceptual vocabularies through time. *European Knowledge Acquisition Workshop*, 19–28.
- Reike, D., Vermeulen, W. J. V., & Witjes, S. (2018a). The circular economy: New or Refurbished as CE 3.0? —Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. *Resources, Conservation and Recycling*. <https://doi.org/10.1016/j.resconrec.2017.08.027>
- Reike, D., Vermeulen, W. J. V., & Witjes, S. (2018b). The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. *Resources, Conservation and Recycling*, 135, 246–264. <https://doi.org/10.1016/j.resconrec.2017.08.027>

- Reinecke, J., Manning, S., & von Hagen, O. (2012). The Emergence of a Standards Market: Multiplicity of Sustainability Standards in the Global Coffee Industry. *Organization Studies*, 33(5–6), 791–814. <https://doi.org/10.1177/0170840612443629>
- Reiss, S. (2012). Intrinsic and Extrinsic Motivation. *Teaching of Psychology*, 39(2), 152–156. <https://doi.org/10.1177/0098628312437704>
- Repo, P., Anttonen, M., Mykkänen, J., & Lammi, M. (2018). Lack of congruence between European citizen perspectives and policies on circular economy. *European Journal of Sustainable Development*, 7(1), 249–249.
- Repp, L., Hekkert, M., & Kirchherr, J. (2021). Circular economy-induced global employment shifts in apparel value chains: Job reduction in apparel production activities, job growth in reuse and recycling activities. *Resources, Conservation and Recycling*, 171, 105621.
- Richards, G. (2015). Events in the Network Society: The Role of Pulsar and Iterative Events. *Event Management*, 19(4), 553–566. <https://doi.org/10.3727/152599515X14465748512849>
- Rincón-Moreno, J., Ormazábal, M., Álvarez, M. J., & Jaca, C. (2020). Advancing Circular Economy performance indicators and their application in Spanish companies. *Journal of Cleaner Production*, 279, 123605. <https://doi.org/10.1016/j.jclepro.2020.123605>
- Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., de Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., ... Foley, J. (2009). Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society*. <https://doi.org/10.5751/ES-03180-140232>
- Röder, M., Both, A., & Hinneburg, A. (2015). Exploring the space of topic coherence measures. *Proceedings of the Eighth ACM International Conference on Web Search and Data Mining*, 399–408.

- Rodrigues, C., & Melo, A. I. (2013). The triple helix model as inspiration for local development policies: An experience-based perspective. *International Journal of Urban and Regional Research*, 37(5), 1675–1687.
- Rohrdantz, C., Hautli, A., Mayer, T., Butt, M., Keim, D., & Plank, F. (2011). Towards tracking semantic change by visual analytics. *Association for Computational Linguistics*, 305–310.
- Rosner, F., Hinneburg, A., Röder, M., Nettling, M., & Both, A. (2014). Evaluating topic coherence measures. *ArXiv:1403.6397 [Cs]*. <http://arxiv.org/abs/1403.6397>
- Rudolph, M., & Blei, D. (2018). Dynamic Embeddings for Language Evolution. *Proceedings of the 2018 World Wide Web Conference on World Wide Web - WWW '18*, 1003–1011.  
<https://doi.org/10.1145/3178876.3185999>
- Ruse, M. (2021). *Philosophy after Darwin: Classic and Contemporary Readings*. Princeton University Press.
- Ryan, R. M., & Deci, E. L. (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology*, 25(1), 54–67.  
<https://doi.org/10.1006/ceps.1999.1020>
- Saavedra, Y. M. B., Iritani, D. R., Pavan, A. L. R., & Ometto, A. R. (2018). Theoretical contribution of industrial ecology to circular economy. In *Journal of Cleaner Production*.  
<https://doi.org/10.1016/j.jclepro.2017.09.260>
- Sagi, E., Kaufmann, S., & Clark, B. (2009). Semantic density analysis: Comparing word meaning across time and phonetic space. *Proceedings of the Workshop on Geometrical Models of Natural Language Semantics*, 104–111.
- Saidani, M., Yannou, B., Leroy, Y., Cluzel, F., & Kendall, A. (2019). A taxonomy of circular economy indicators. In *Journal of Cleaner Production*.  
<https://doi.org/10.1016/j.jclepro.2018.10.014>

- Sarker, S., Sarker, S., & Sidorova, A. (2006). Understanding business process change failure: An actor-network perspective. *Journal of Management Information Systems*, 23(1), 51–86.
- Sauvé, S., Bernard, S., & Sloan, P. (2016). Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research. *Environmental Development*, 17, 48–56.
- Schäfer, W. (2012). *Finalization in Science: The Social Orientation of Scientific Progress*. Springer Science & Business Media.
- Schmidt, R., Lyytinen, K., Keil, M., & Cule, P. (2001). Identifying software project risks: An international Delphi study. *Journal of Management Information Systems*.  
<https://doi.org/10.1080/07421222.2001.11045662>
- Schneiberg, M., & Lounsbury, M. (2008). Social Movements and Institutional Analysis. In *The SAGE Handbook of Organizational Institutionalism* (pp. 650–672). SAGE Publications Ltd.  
<https://doi.org/10.4135/9781849200387.n28>
- Schöggel, J.-P., Stumpf, L., & Baumgartner, R. J. (2020). The narrative of sustainability and circular economy-A longitudinal review of two decades of research. *Resources, Conservation and Recycling*, 163, 105073.
- Schönemann, P. H. (1966). A generalized solution of the orthogonal procrustes problem. *Psychometrika*, 31(1), 1–10.
- Schröder, P., Albaladejo, M., Ribas, P. A., MacEwen, M., & Tilkanen, J. (2020). The circular economy in Latin America and the Caribbean. *Chatam House*.
- Schröder, P., Bengtsson, M., Cohen, M., Dewick, P., Hofstetter, J., & Sarkis, J. (2019). Degrowth within—Aligning circular economy and strong sustainability narratives. *Resources, Conservation and Recycling*, 146, 190–191.
- Schröder, P., Lemille, A., & Desmond, P. (2020). Making the circular economy work for human development. *Resources, Conservation and Recycling*, 156, 104686.

- Scott, D., & Usher, R. (2010). *Researching education: Data, methods and theory in educational enquiry*. Bloomsbury Publishing.
- Scott, P. (2003). The ethical implications of the new research paradigm. *Science and Engineering Ethics*, 9(1), 73–84. <https://doi.org/10.1007/s11948-003-0021-1>
- Scott, S. M. (1995). *Institutions and organizations*.
- Scott, W. R. (1987). The Adolescence of Institutional Theory. *Administrative Science Quarterly*, 32(4), 493–511. <https://doi.org/10.2307/2392880>
- Scott, W. R. (1994). Conceptualizing organizational fields: Linking organizations and societal systems. *Systemrationalitat Und Partialinteresse*, 203–221.
- Selznick, P. (1996). Institutionalism “Old” and “New.” *Administrative Science Quarterly*, 41(2), 270–277. <https://doi.org/10.2307/2393719>
- Seuring, S., & Müller, M. (2008). Core issues in sustainable supply chain management—A Delphi study. *Business Strategy and the Environment*. <https://doi.org/10.1002/bse.607>
- Shapin, S. (1982). History of science and its sociological reconstructions. *History of Science*, 20(3), 157–211.
- Shapin, S. (2018). *The scientific revolution*. University of Chicago Press.
- Shelley, K. D., Kamya, C., Mpanya, G., Mulongo, S., Nagasha, S. N., Beylerian, E., Duber, H. C., Hernandez, B., Osterman, A., Phillips, D. E., Shearer, J. C., & Collaborators, on behalf of the G. F. P. C. E. I. consortium. (2020). Partnership and Participation—A Social Network Analysis of the 2017 Global Fund Application Process in the Democratic Republic of the Congo and Uganda. *Annals of Global Health*, 86(1). <https://doi.org/10.5334/aogh.2961>
- Shim, Y., & Shin, D.-H. (2016). Analyzing China’s Fintech Industry from the Perspective of Actor–Network Theory. *Telecommunications Policy*, 40(2), 168–181. <https://doi.org/10.1016/j.telpol.2015.11.005>

- Shin, S. H., Kwon, O. K., Ruan, X., Chhetri, P., Lee, P. T. W., & Shahparvari, S. (2018). Analyzing sustainability literature in maritime studies with text mining. *Sustainability (Switzerland)*.  
<https://doi.org/10.3390/su10103522>
- Shin, S.-H., Kwon, O. K., Ruan, X., Chhetri, P., Lee, P. T.-W., & Shahparvari, S. (2018). Analyzing Sustainability Literature in Maritime Studies with Text Mining. *Sustainability*, 10(10), 3522.  
<https://doi.org/10.3390/su10103522>
- Shinn, T. (2002). The Triple Helix and New Production of Knowledge: Prepackaged Thinking on Science and Technology. *Social Studies of Science*, 32(4), 599–614.  
<https://doi.org/10.1177/0306312702032004004>
- Shunta, Y. (2021). International trade and circular economy—Policy alignment. *OECD Trade and Environment Working Papers, No. 2021/02, OECD Publishing, Paris*,.  
<https://doi.org/10.1787/ae4a2176-en>.
- Signoretta, P. E., Buffel, V., & Bracke, P. (2019). Mental wellbeing, air pollution and the ecological state. *Health & Place*, 57, 82–91. <https://doi.org/10.1016/j.healthplace.2019.03.003>
- Silvis, E., & M. Alexander, P. (2014). A study using a graphical syntax for actor-network theory. *Information Technology & People*, 27(2), 110–128. <https://doi.org/10.1108/ITP-06-2013-0101>
- Singh, R. K., Kumar, A., Garza-Reyes, J. A., & de Sá, M. M. (2020). Managing operations for circular economy in the mining sector: An analysis of barriers intensity. *Resources Policy*.  
<https://doi.org/10.1016/j.resourpol.2020.101752>
- Slaughter, S., & Leslie, L. L. (1997). *Academic capitalism: Politics, policies, and the entrepreneurial university*.
- Slaughter, S., & Leslie, L. L. (2001). Expanding and Elaborating the Concept of Academic Capitalism. *Organization*, 8(2), 154–161. <https://doi.org/10.1177/1350508401082003>

- Smith, K. (2010). Research, policy and funding—academic treadmills and the squeeze on intellectual spaces 1. *The British Journal of Sociology*, 61(1), 176–195.
- Sommerauer, P., & Fokkens, A. (2019). Conceptual change and distributional semantic models: An exploratory study on pitfalls and possibilities. *Proceedings of the 1st International Workshop on Computational Approaches to Historical Language Change*, 223–233.
- Sørensen, F., Bærenholdt, J. O., & Greve, K. A. G. M. (2019). Circular economy tourist practices. In *Current Issues in Tourism*. <https://doi.org/10.1080/13683500.2019.1706456>
- Spekkink, W. (2013). Institutional capacity building for industrial symbiosis in the Canal Zone of Zeeland in the Netherlands: A process analysis. *Journal of Cleaner Production*, 52, 342–355. <https://doi.org/10.1016/j.jclepro.2013.02.025>
- Stahel, W. R. (2016). The circular economy. In *Nature*. <https://doi.org/10.1038/531435a>
- Starbuck, W. H. (2009). The constant causes of never-ending faddishness in the behavioral and social sciences. *Scandinavian Journal of Management*, 25(1), 108–116. <https://doi.org/10.1016/j.scaman.2008.11.005>
- Stevens, K., Kegelmeyer, P., Andrzejewski, D., & Buttler, D. (2012). Exploring Topic Coherence over Many Models and Many Topics. *Proceedings of the 2012 Joint Conference on Empirical Methods in Natural Language Processing and Computational Natural Language Learning*, 952–961. <https://www.aclweb.org/anthology/D12-1087>
- Stinchcombe, A. L. (1968). *Constructing Social Theories*. University of Chicago Press. <https://press.uchicago.edu/ucp/books/book/chicago/C/bo3618306.html>
- Strothman, P., & Sonnemann, G. (2017). Circular economy, resource efficiency, life cycle innovation: Same objectives, same impacts? *The International Journal of Life Cycle Assessment*, 22(8), 1327–1328.
- Su, B., Heshmati, A., Geng, Y., & Yu, X. (2013). A review of the circular economy in China: Moving from rhetoric to implementation. *Journal of Cleaner Production*, 42, 215–227.



- Sun, L., & Yin, Y. (2017a). Discovering themes and trends in transportation research using topic modeling. *Transportation Research Part C: Emerging Technologies*.  
<https://doi.org/10.1016/j.trc.2017.01.013>
- Sun, L., & Yin, Y. (2017b). Discovering themes and trends in transportation research using topic modeling. *Transportation Research Part C: Emerging Technologies*, 77, 49–66.  
<https://doi.org/10.1016/j.trc.2017.01.013>
- Swain, R. B., & Sweet, S. (2021). Sustainable Consumption and Production: Introduction to Circular Economy and Beyond. In *Sustainable Consumption and Production, Volume II* (pp. 1–16). Springer.
- Swanson, R. A., & Chermack, T. J. (2013). *Theory building in applied disciplines*. Berrett-Koehler Publishers.
- Tahmasebi, N., Borin, L., & Jatowt, A. (2018). Survey of computational approaches to lexical semantic change. *ArXiv Preprint ArXiv:1811.06278*.
- Tang, X. (2018). A state-of-the-art of semantic change computation. *Natural Language Engineering*, 24(5), 649–676.
- Tatnall, A. (2005). Actor-network theory in information systems research. In *Encyclopedia of Information Science and Technology, First Edition* (pp. 42–46). IGI Global.
- ten Wolde, A. (2016). Briefing: Governments as drivers for a circular economy. *Proceedings of the Institution of Civil Engineers - Waste and Resource Management*, 169(4), 149–150.  
<https://doi.org/10.1680/jwarm.16.00017>
- Thakur, N. *et al.* (2019) ‘COMPARATIVE ANALYSIS OF RANKING FUNCTIONS FOR RETRIEVING INFORMATION FROM MEDICAL REPOSITORY’, *Malaysian Journal of Computer Science*, 32(1), pp. 18–30. doi:10.22452/mjcs.vol32no1.2.

- Thomas, S. W., Adams, B., Hassan, A. E., & Blostein, D. (2014). Studying software evolution using topic models. *Science of Computer Programming*, 80, 457–479.  
<https://doi.org/10.1016/j.scico.2012.08.003>
- Thorngate, W., & Chowdhury, W. (2014). By the Numbers: Track Record, Flawed Reviews, Journal Space, and the Fate of Talented Authors. In B. Kamiński & G. Koloch (Eds.), *Advances in Social Simulation* (Vol. 229, pp. 177–188). Springer Berlin Heidelberg.  
[https://doi.org/10.1007/978-3-642-39829-2\\_16](https://doi.org/10.1007/978-3-642-39829-2_16)
- Tóth, G. (2019). Circular Economy and its Comparison with 14 Other Business Sustainability Movements. *Resources*, 8(4), 159.
- Toulmin, S. (1972). Rationality and scientific discovery. *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association*, 1972, 387–406.
- Toulmin, S. E. (1967). The evolutionary development of natural science. *American Scientist*, 55(4), 456–471.
- Türkeli, S., Kemp, R., Huang, B., Bleischwitz, R., & McDowall, W. (2018). Circular economy scientific knowledge in the European Union and China: A bibliometric, network and survey analysis (2006–2016). *Journal of Cleaner Production*, 197, 1244–1261.  
<https://doi.org/10.1016/j.jclepro.2018.06.118>
- Turnpenny, J., Jones, M., & Lorenzoni, I. (2011). Where Now for Post-Normal Science?: A Critical Review of its Development, Definitions, and Uses. *Science, Technology, & Human Values*, 36(3), 287–306. <https://doi.org/10.1177/0162243910385789>
- Urbinati, A., Chiaroni, D., & Chiesa, V. (2017). Towards a new taxonomy of circular economy business models. *Journal of Cleaner Production*.  
<https://doi.org/10.1016/j.jclepro.2017.09.047>
- Vakkuri, J. (2004). Institutional change of universities as a problem of evolving boundaries. *Higher Education Policy*, 17(3), 287–309.

- Valenzuela, F., & Böhm, S. (2017). Against wasted politics: A critique of the circular economy. *Ephemera: Theory & Politics in Organization*, 17(1), 23–60.  
<http://www.ephemerajournal.org/contribution/against-wasted-politics-critique-circular-economy>
- van Altena, A. J., Moerland, P. D., Zwinderman, A. H., & Olabarriaga, S. D. (2016). Understanding big data themes from scientific biomedical literature through topic modeling. *Journal of Big Data*. <https://doi.org/10.1186/s40537-016-0057-0>
- Van de Ven, A. H., & Engleman, R. M. (2004). Event- and outcome-driven explanations of entrepreneurship. *Journal of Business Venturing*, 19(3), 343–358.  
[https://doi.org/10.1016/S0883-9026\(03\)00035-1](https://doi.org/10.1016/S0883-9026(03)00035-1)
- van de Ven, A. H., & Poole, M. S. (1995). Explaining Development and Change in Organizations. *The Academy of Management Review*, 20(3), 510–540. <https://doi.org/10.2307/258786>
- Van de Ven, A. H., & Poole, M. S. (2005). Alternative Approaches for Studying Organizational Change. *Organization Studies*, 26(9), 1377–1404.  
<https://doi.org/10.1177/0170840605056907>
- Van de Ven, A. H., & Sun, K. (2011). Breakdowns in Implementing Models of Organization Change. *Academy of Management Perspectives*, 25(3), 58–74.  
<https://www.jstor.org/stable/23045051>
- van der Heijden, J., Kuhlmann, J., Lindquist, E., & Wellstead, A. (2021). Have policy process scholars embraced causal mechanisms? A review of five popular frameworks. *Public Policy and Administration*, 36(2), 163–186. <https://doi.org/10.1177/0952076718814894>
- van Hoof, B., & Duque-Hernández, J. (2020). Supply Chain Management for Circular Economy in Latin America: RedES-CAR in Colombia. In *Industrial Symbiosis for the Circular Economy* (pp. 103–118). Springer.

- Van Zolingen, S. J., & Klaassen, C. A. (2003). Selection processes in a Delphi study about key qualifications in senior secondary vocational education. *Technological Forecasting and Social Change*, 70(4), 317–340.
- Vanhamäki, S., Rinkinen, S., & Manskinen, K. (2021). *Adapting a Circular Economy in Regional Strategies of the European Union. Sustainability 2021*, 13, 1518. s Note: MDPI stays neutral with regard to jurisdictional claims in published ....
- Vayda, A. P. (1983). Progressive contextualization: Methods for research in human ecology. *Human Ecology*, 11(3), 265–281.
- Velenturf, A. P. M., Archer, S. A., Gomes, H. I., Christgen, B., Lag-Brotons, A. J., & Purnell, P. (2019). Circular economy and the matter of integrated resources. *Science of The Total Environment*, 689, 963–969. <https://doi.org/10.1016/j.scitotenv.2019.06.449>
- Velenturf, A. P. M., & Purnell, P. (2017). Resource Recovery from Waste: Restoring the Balance between Resource Scarcity and Waste Overload. *Sustainability*, 9(9), 1603. <https://doi.org/10.3390/su9091603>
- Velis, C. (2018). *No circular economy if current systemic failures are not addressed*. SAGE Publications Sage UK: London, England.
- Venables, M. (2013). Interview [Dame Ellen Macarthur]. *Engineering Technology*, 8(6), 40–43. <https://doi.org/10.1049/et.2013.0603>
- Verrax, F. (2017). Engineering ethics and post-normal science: A French perspective. *Futures*, 91, 76–79.
- Vogt, W. P., Gardner, D. C., & Haeffele, L. M. (2012). *When to use what research design*. Guilford Press.
- Völker, T., Kovacic, Z., & Strand, R. (2020). Indicator development as a site of collective imagination? The case of European Commission policies on the circular economy. *Culture and Organization*, 26(2), 103–120. <https://doi.org/10.1080/14759551.2019.1699092>

- Wagner, C. S. (2009). *The new invisible college: Science for development*. Brookings Institution Press.
- Wang, L. (2020). Analysis of the Characteristics and Translation Skills of American Slang in the Big Bang Theory. *Theory and Practice in Language Studies*, 10(10), 1248–1253.
- Wang, S., Schlobach, S., & Klein, M. (2011). Concept drift and how to identify it. *Journal of Web Semantics*, 9(3), 247–265. <https://doi.org/10.1016/j.websem.2011.05.003>
- Wang, X., & McCallum, A. (2006). Topics over time: A non-markov continuous-time model of topical trends. *Proceedings of the 12th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, 424–433.
- Wang, Y., Bowers, A. J., & Fikis, D. J. (2017). Automated Text Data Mining Analysis of Five Decades of Educational Leadership Research Literature: Probabilistic Topic Modeling of EAQ Articles From 1965 to 2014. *Educational Administration Quarterly*. <https://doi.org/10.1177/0013161X16660585>
- Watson, R. T. (2005). Turning science into policy: Challenges and experiences from the science–policy interface. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 360(1454), 471–477. <https://doi.org/10.1098/rstb.2004.1601>
- WCED. (1987a). Our Common Future (The Brundtland Report). In *Medicine and War*. <https://doi.org/10.1080/07488008808408783>
- WCED. (1987b). *Report of the World Commission on Environment and Development: Our Common Future*. <https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf>
- Weingart, P. (1997). From “Finalization” to “Mode 2”: Old wine in new bottles? *Social Science Information*, 36(4), 591–613.
- Weintraub, E. R. (2002). *How Economics Became a Mathematical Science*. Duke University Press.

- Wevers, M., Kenter, T., & Huijnen, P. (2015). Concepts through time: Tracing concepts in Dutch Newspaper Discourse (1890–1990) using word embeddings. *Digital Humanities*, 2015, 1.
- Wevers, M., & Koolen, M. (2020). Digital begriffsgeschichte: Tracing semantic change using word embeddings. *Historical Methods: A Journal of Quantitative and Interdisciplinary History*, 53(4), 226–243.
- Wieser, H. (2016). Beyond Planned Obsolescence: Product Lifespans and the Challenges to a Circular Economy. *GAIA - Ecological Perspectives for Science and Society*, 25(3), 156–160.  
<https://doi.org/10.14512/gaia.25.3.5>
- Wilkie, A. O. M. (1994). The molecular basis of genetic dominance. In *Journal of Medical Genetics*.  
<https://doi.org/10.1136/jmg.31.2.89>
- Williams, M., & Moser, T. (2019). The art of coding and thematic exploration in qualitative research. *International Management Review*, 15(1), 45–55.
- Wilson, D. C. (2007). Development drivers for waste management. *Waste Management and Research*. <https://doi.org/10.1177/0734242X07079149>
- Winans, K., Kendall, A., & Deng, H. (2017). The history and current applications of the circular economy concept. In *Renewable and Sustainable Energy Reviews*.  
<https://doi.org/10.1016/j.rser.2016.09.123>
- Winzenried, A., Law, D., Hughes, P., Johnson, D., Healey, S., Warner, D., Hannan, K., & Giovenco, G. (2010). Chapter 1—Towards an organisational theory for information professionals. In A. Winzenried, D. Law, P. Hughes, D. Johnson, S. Healey, D. Warner, K. Hannan, & G. Giovenco (Eds.), *Visionary Leaders for Information* (pp. 23–61). Chandos Publishing.  
<https://doi.org/10.1016/B978-1-876938-85-7.50002-6>
- World Economic Forum. (2014). *Towards the circular economy: Accelerating the scale-up across global supply chains*.  
[http://www3.weforum.org/docs/WEF\\_ENV\\_TowardsCircularEconomy\\_Report\\_2014.pdf](http://www3.weforum.org/docs/WEF_ENV_TowardsCircularEconomy_Report_2014.pdf)

- World Economic Forum. (2020). *The Road Ahead: A policy research agenda for automotive circularity CIRCULAR CARS INITIATIVE POLICY WORKSTREAM*.  
[http://www3.weforum.org/docs/WEF\\_A\\_policy\\_research\\_agenda\\_for\\_automotive\\_circularity\\_2020.pdf](http://www3.weforum.org/docs/WEF_A_policy_research_agenda_for_automotive_circularity_2020.pdf)
- World Economic Forum. (2021). *3 reasons why embracing the circular economy can be powerful for middle income countries*. <https://www.weforum.org/agenda/2021/01/why-middle-income-countries-should-embrace-circular-economy/>
- Wray, K. B. (2002). The Epistemic Significance of Collaborative Research. *Philosophy of Science*, 69(1), 150–168. <https://doi.org/10.1086/338946>
- Wu, R., Geng, Y., & Liu, W. (2017). Trends of natural resource footprints in the BRIC (Brazil, Russia, India and China) countries. *Journal of Cleaner Production*, 142, 775–782.
- Wuketits, F. M. (1984). *Concepts and approaches in evolutionary epistemology: Towards an evolutionary theory of knowledge* (Vol. 36). Springer Science & Business Media.
- WWF. (2016). Living Planet Report 2016: Risk and resilience in a new era. In *WWF International*.
- Xu, F. J. (2012). The studies of the concept plan of the fengcheng industrial park towards the circular economy. *Advanced Materials Research*, 598, 220–223.
- Xu, Y., & Kemp, C. (2015). A Computational Evaluation of Two Laws of Semantic Change. *CogSci*.
- Yang, D., Kleissl, J., Gueymard, C. A., Pedro, H. T. C., & Coimbra, C. F. M. (2018). History and trends in solar irradiance and PV power forecasting: A preliminary assessment and review using text mining. *Solar Energy*. <https://doi.org/10.1016/j.solener.2017.11.023>
- Yang, S., Yu, C., Li, X., & Yu, Q. (2011). A Case Study of Industrial Symbiosis: YunFu Boli Co., Ltd. in China. *2011 Asia-Pacific Power and Energy Engineering Conference*, 1–3.  
<https://doi.org/10.1109/APPEEC.2011.5748605>
- Yang, Y. N. (2003). *Testing the Stability of Experts' Opinions between Successive Rounds of Delphi Studies*.



- Yin, R. K. (2009). *Case Study Research: Design and Methods*. SAGE.
- Yong, R. (2007). The circular economy in China. *Journal of Material Cycles and Waste Management*. <https://doi.org/10.1007/s10163-007-0183-z>
- Yousuf, M. I. (2007). Using experts' opinions through Delphi technique. *Practical Assessment, Research and Evaluation*.
- Yuan, Z., Bi, J., & Moriguichi, Y. (2006). The circular economy: A new development strategy in China. *Journal of Industrial Ecology*, 10(1–2), 4–8.
- Yvonne Feilzer, M. (2010). Doing Mixed Methods Research Pragmatically: Implications for the Rediscovery of Pragmatism as a Research Paradigm. *Journal of Mixed Methods Research*, 4(1), 6–16. <https://doi.org/10.1177/1558689809349691>
- Zapp, M., & Powell, J. J. W. (2017). Moving towards Mode 2? Evidence-based policy-making and the changing conditions for educational research in Germany. *Science and Public Policy*, 44(5), 645–655. <https://doi.org/10.1093/scipol/scw091>
- Zhang, L., Yuan, Z., Bi, J., Zhang, B., & Liu, B. (2010). Eco-industrial parks: National pilot practices in China. *Journal of Cleaner Production*, 18(5), 504–509.
- Zhao, W., Chen, J. J., Perkins, R., Liu, Z., Ge, W., Ding, Y., & Zou, W. (2015a). A heuristic approach to determine an appropriate number of topics in topic modeling. *BMC Bioinformatics*. <https://doi.org/10.1186/1471-2105-16-S13-S8>
- Zhao, W., Chen, J. J., Perkins, R., Liu, Z., Ge, W., Ding, Y., & Zou, W. (2015b). A heuristic approach to determine an appropriate number of topics in topic modeling. *BMC Bioinformatics*, 16(13), 1–10.
- Zhou, K., Bonet Fernandez, D., Wan, C., Denis, A., & Juillard, G.-M. (2014). A study on circular economy implementation in China. *Working Paper IPAG Business School*, 312, 3.
- Zhu, Y., Yan, E., & Wang, F. (2017). Semantic relatedness and similarity of biomedical terms: Examining the effects of recency, size, and section of biomedical publications on the

performance of word2vec. *BMC Medical Informatics and Decision Making*, 17(1), 95.

<https://doi.org/10.1186/s12911-017-0498-1>

Zink, T., & Geyer, R. (2017). Circular economy rebound. *Journal of Industrial Ecology*, 21(3), 593–602.