Journal of Systems Thinking in Practice
JSTINP, *QUARTERLY*
Homepage: jstinp.um.ac.ir
Online ISSN: 2821-1669, Print ISSN: 2980-9460
Review Article
DOI: 10.22067/JSTINP.2024.86123.1086
JSTINP 2024; Vol. 3, No. 3

Systems Thinking in the Circular Economy: An Integrative Literature Review

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How to cite this article

Mehraeen, M., entezarian, N. 2024. Systems Thinking in the Circular Economy: An Integrative Literature Review, *Journal of Systems Thinking in Practice*, *3*(3), pp.68 -90. doi: 10.22067/jstinp.2024.86123.1086.
URL: https://jstinp.um.ac.ir/article_45425.html.

ABSTRACT

In this integrative review, the concept of the Circular Economy (CE) is extensively analyzed from the perspective of Systems Thinking (ST) to gain insights into the circular economy. Seventy-two articles from Scopus and Web of Science databases were reviewed to gain a better understanding of the ambivalent nature of circular economy and systems thinking. The main objective of this study is to provide a clear understanding of the circular economy concept through the lens of systems thinking. Therefore, a thematic framework is presented that synthesizes the literature in a tangible form for researchers, practitioners, and policymakers. This review contributes to a better understanding of the circular economy as a complex and dynamic system. It highlights the interdependencies that can arise in the circular economy and emphasizes the need for holistic and systemic approaches to address these challenges. Through this integrative review, six systems thinking applications in the CE are identified, including Stakeholder engagement in decision-making, innovation, and deep transformational change, implementation of circular business models, life cycle management optimization through better resource management, supply chain optimization and reduced unintended consequences and designing sustainable products. This paper contributes to the existing body of knowledge by identifying future research gaps and opportunities to advance in this field of study consistently. It provides a valuable resource for researchers, practitioners, and policymakers seeking to advance the circular economy agenda.

Keywords

Circular economy (CE), Systems thinking (ST), Integrative review, Sustainability.

Article history

Received: 2024-01-27
Revised: 2024-06-21
Accepted: 2024-07-01
Published (Online): 2024-09-12

Number of Figures: 5 **Number of Tables: 2** **Number of Pages: 23** **Number of References: 100**

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1. Introduction

The concept of the Circular Economy (CE) is an innovative approach to economic systems that aims to replace the current linear system of production by focusing on redesigning systems and creating closed-loop cycles (Murray et al., 2017). This concept has the potential to develop more sustainable business practices that reduce the negative environmental and social impacts of the current business-as-usual scenario (Ghisellini et al., 2016). By implementing CE, significant changes can be made to the way products are designed, produced, used, and brought back into circulation.

The CE is the most recent effort in academic, governmental, and industrial sectors to tackle the environmental strain resulting from human-made mass surpassing all living biomass (Elhacham et al., 2020). However, the CE is distinctive in that it promotes regenerative thinking and design (Burke et al., 2023). It is described as a system that focuses on minimizing resource input and waste, emissions, and energy leakage by slowing, closing, and narrowing material and energy loops (Geissdoerfer et al., 2017).

At the core of the CE are various circularity strategies, also known as value retention strategies or principles, typically categorized within different frameworks denoted by the letter "R". These frameworks range from the basic 3Rs of "reduce, reuse, and recycle" to the more extensive 10Rs of "refuse, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, recover, and remine" (Reike et al., 2018). These strategies for retaining value are not mutually exclusive and can be combined to reduce, delay, or eliminate resource loops (Bocken et al., 2016).

CE involves two main cycles: the technical cycle and the biological cycle of products and materials (Jabbour et al., 2019). The technical cycle is enhanced by extending the lifespan of products, promoting ownership sharing, minimizing value loss, and utilizing advanced technologies (Huynh and Rasmussen, 2021). In the biological cycle, CE aims to preserve biomass value through recycling, shifting to renewable resources, and prolonging the lifespan of bioproducts to reduce waste (Montag, 2023). This approach aims to optimize resource efficiency, increase material utility, and reduce greenhouse gas emissions.

As a result, the implementation of a CE necessitates a holistic approach that spans different levels and incorporates diverse practices across the entire product life cycle (Iacovidou et al., 2021). Consequently, technical solutions need to be improved. They must be supplemented with new business models, essential supply chains, and conducive systemic conditions in order to facilitate the transition to a CE (Ellen MacArthur Foundation, 2022). While terms like stocks,

flows, feedback loops, and leverage points are commonly used in CE literature, there have been few studies that have attempted to clarify the meaning of systems thinking in this context.

Systems thinking is a methodology suggested for organizing and conceptualizing the various components of the CE (Aggesund, 2018). The concept of CE is fragmented, lacking a coherent framework, requiring exploration from a systems perspective for integrating ideas and bridging gaps in theory and practice. System thinking, as a participatory approach, can blend diverse perspectives and address social aspects in CE literature. Systems thinking is the scientific approach to making dependable predictions about behavior by developing an understanding of the underlying structure of a system. It enables us to gain a better understanding and predict the consequences of our decisions across different sectors, economic actors, time, and space (Probst and Bassi, 2017). Systems thinking is well-suited for conceptualizing the CE because it deals with complicated and complex systems.

Various perspectives exist on how the CE is conceptualized and illustrated in academic literature (Kirchherr et al., 2023). In order to develop a cohesive framework and bring clarity to the subject, this article utilizes an integrative research approach to knowledge construction. This integrative literature review critically evaluates and combines key literature on the subject cohesively, resulting in the creation of fresh frameworks and viewpoints (Dwertmann and van Knippenberg, 2021; Torraco, 2016). It is especially suitable when research pertaining to a specific topic is scattered across various fields and has not been comprehensively examined and merged (Elsbach and Van Knippenberg, 2020). The primary objective of the integrative review is to bridge different communities of practice studying the same topic (Cronin and George, 2023). Integrative reviews can be applied to both emerging and more established research fields and although they are a pertinent approach in business research, their utilization is still limited (Snyder, 2019). Furthermore, "the integrative review is most useful when different communities of practice appear to be working independently, and their research could be enhanced by synthesizing their findings" (Cronin and George, 2023). The present condition of literature concerning the CE is highly conducive to this approach. Despite a growing number of publications on the subject, research on the CE remains a relatively nascent field (Alcalde-Calonge, 2022). As a fragmented concept lacking coherence, the CE concept requires further exploration to facilitate the integration of varied ideas and perspectives (Hassan and Faggian, 2023). This intricacy emphasizes the necessity for a cohesive comprehension of current and evolving subjects (De Angelis, 2022). This article depends on the utilization of key academic

sources to consolidate the current state of knowledge. In order to improve conceptual clarity, this article examines the framework and applications of systemic thinking in the CE.

The paper is organized as follows: Section 2 describes the theoretical background within CE systems and the foundations for applying systems thinking modeling to investigate CE research in the field. Section 3 outlines the research methodology employed. Section 4 contains results, relevant discussions, and contributions. Finally, section 5 delineates the conclusion and emerging research avenues.

2. Theoretical background

2.1. Circular economy (CE)

The idea of CE has gained importance among policymakers as a vital approach to dealing with sustainability issues (Korhonen et al., 2018; Yu et al., 2022). The CE is defined by the United Nations Environment Program (UNEP) as an economy that aims to reduce resource consumption and waste generation by reusing and recycling wastes throughout the production, distribution, and consumption processes (UNEP, 2011). Developed and industrialized countries, like Japan, were among the first to adopt the CE as an economic development strategy, particularly within the industrial sector, with the goal of minimizing waste generation in the production process and reducing imports (UNEP, 2011).

The CE aims to shift economic systems away from the traditional take-make-waste approach towards more efficient and regenerative processes. It includes measures such as improving product durability, implementing green public procurement, extending producer responsibility, and enhancing materials recovery (Isenhour et al., 2023). It is seen as a promising solution to urgent environmental challenges such as climate change, biodiversity loss, and resource depletion. The CE seeks to reduce production and consumption costs while providing significant environmental benefits. Furthermore, it has the potential to improve social and economic advantages, which in turn can help alleviate various pressures on the Earth's resources (Khajuria et al., 2022).

The CE is seen as a new approach to development that analyses consumption, production, and materials management systemically. Consequently, the environmental impacts of waste, social repercussions, and economic outcomes become the pillars of the analysis driving potential investments in the CE (Lehmann et al., 2022).

Given the broad definition of the CE, a wide range of indicators is needed to assess the performance of any CE investment or policy. These indicators include (Bassi et al., 2021;

Topliceanu et al., 2022): (1) Consumption: This indicator focuses on human behavior, such as affluence, culture, and personal preferences for purchasing different products and services. Together with population and economic growth, it determines the total volume of products and materials used in the economy. (2) Production: This indicator considers various production processes across different industries, from early-stage product design to operational efficiency. It assesses how efficiently resources are used and waste is minimized throughout the production chain. (3) Materials Management: This indicator examines how resources and waste are managed throughout their lifecycle, including extraction, manufacturing, use, and disposal. It looks at the efficiency of resource use, recycling rates, and the reduction of waste generation. (4) Social and Environmental Outcomes: These indicators assess the impacts of CE practices on social well-being and environmental quality. They consider the reduction of pollution and resource depletion, as well as the improvement of human health and well-being. (5) Trade: This indicator examines the impact of CE practices on international trade patterns. It considers the potential for new markets and job creation, as well as the implications for global resource flows and supply chains (Bassi et al., 2021; Topliceanu et al., 2022). By considering these indicators, policymakers and investors can evaluate the effectiveness and sustainability of CE initiatives. This comprehensive assessment allows for a holistic understanding of the potential benefits and challenges associated with transitioning to a CE.

A systemic approach is frequently employed to gain a deeper understanding of the intricate causal relationships that exist between these domains. The CE employs systems thinking to design products that are intended to be recycled or reused (Bassi et al., 2021). The difference between a traditional linear economy and a CE is shown in engineering in the image below (Figure 1). Engineering the Circular Life Cycle is a concept in sustainable engineering and design that aims to reduce waste and promote the reuse and recycling of materials throughout the product life cycle. This approach focuses on creating products and systems that minimize environmental impact and contribute to a CE.

Implementing a CE requires knowledge integration and systems thinking across different sectors, such as agriculture, industrial production, and materials management, as well as involving societal and economic stakeholders like firms, consumers, and institutions. In order to assess the effectiveness of CE interventions, all three dimensions of development (society, economy, and environment) must be considered, as well as the assessment of results over time, encompassing short-, medium-, and long-term effects (Bassi et al., 2021).

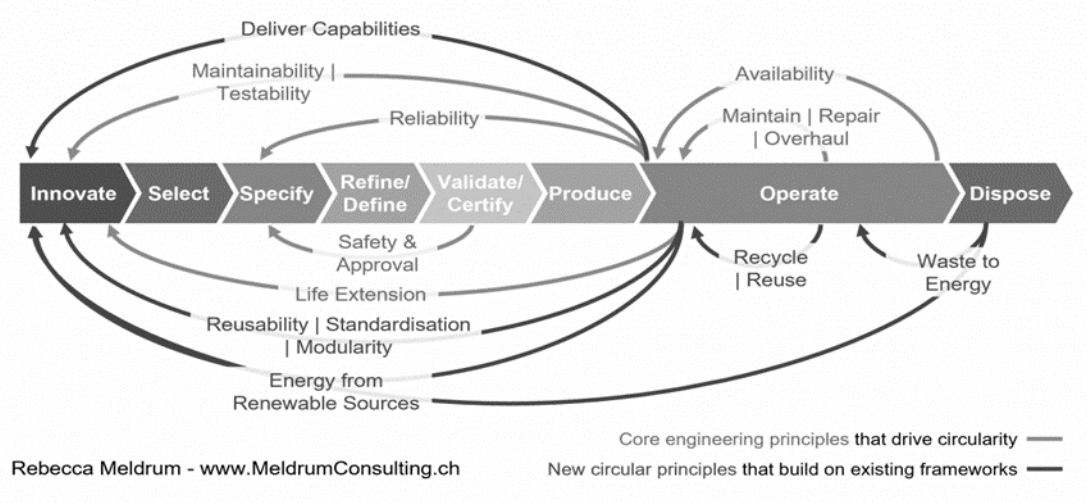

Figure 1. Engineering the circular life cycle. source: Meldrum (2023)

2.2. Systems thinking (ST) in CE

Systems thinking is integrated into various theories, ontologies, concepts, and tools used across disciplines to tackle the challenges of achieving changes and transitioning towards a circular and sustainable future. Systems, which are often described as more than the mere sum of their parts consist of elements, relationships, structure, and purpose. Systems thinking involves comprehensively approaching and analyzing the components of a system, understanding their interconnections and structure, and studying how systems operate over time, all within the broader context of larger systems (Ratinen and Linnanen, 2022).

The economy is a system in which individuals utilize resources to engage in activities that create value. Individuals exchange goods and services in markets with the goal of maximizing overall utility for society. However, based on its behavior, a crucial function of the economy is to expand and grow. This growth is often desired to occur at a consistent or even accelerating rate, typically following an exponential pattern. Economic growth is assessed through the measurement of the gross domestic product (GDP), serving as the principal metric for evaluating the economy (Robinson, 2022).

Systems thinking is considered important for fully understanding the causes of problems and potential solutions (Whalen et al., 2018). It allows for the analysis of a system and the identification of ways to change it to meet the needs of a specific group. While the literature recognizes the need for systems thinking in designing for a CE, it often only calls for holistic thinking without providing specific methods. The varied origins of the CE concept, its present role in comprehensive economic discussions, its sustainability context, and the challenges in implementing it due to its current narrow approaches highlight the necessity for a

comprehensive examination of the CE concept within systems. The relevance of Systems Thinking approaches to CE lies in the fact that CE is based on systems ecology. These approaches enable a more thorough examination of the intricate and dynamic aspects of contemporary production, distribution, and consumption processes. It facilitates the redirection of CE objectives towards integrated socio-ecological goals for sustainable development (Hassan and Faggian, 2023). However, there are several systems thinking methods that can be useful in the context of designing for a CE. These include the Circularity Thinking method, which helps explore current and future circular systems; the Circularity Compass, which identifies wastes in the system (Blomsma and Brennan, 2018); and the Circularity Grid, which generates an understanding of the relationships among different parts of the system.

3. Methodology

This article utilizes an integrative review method, which is frequently employed to address new and emerging subjects that necessitate a thorough grasp of current empirical and theoretical literature (Torraco, 2016). The integrative literature review method analyses and synthesizes the key concepts and arguments that are put forward in academic or scholarly writings to generate new insights and identify future research directions (Cronin and George, 2023). In this study, the integrative literature review approach is used to critique and synthesize insights from the fields of CE and systems thinking. This approach to CE allows for the development of new perspectives, theories, and research directions. The review was conducted following a systematic process of planning, execution, and analysis.

3.1. Planning

The first step of the review involved creating a map of the literature to clarify the main concepts of CE and systems thinking and how they are related. A primary literature search was done to identify keywords and confirm the gap in the literature. During the initial planning stage, specific keywords were carefully established in alignment with the objectives of the research, which aimed to assess the extent of understanding and implementation of CE practices and strategies using a systems thinking approach. Two distinct sets of terms were identified to guarantee the utmost relevance: "CE" and phrases associated with "systems thinking". This meticulous process facilitated the selection of pertinent literature for the comprehensive review. The inquiry was designed to systematically search for specific terms within the titles, abstracts, and keywords of scholarly publications. These terms were meticulously selected to encompass

a broad spectrum of the most pertinent literature pertaining to the application of systems thinking within the realm of CE. It is essential to acknowledge that certain materials may have been inadvertently omitted from this review. The titles, abstracts, and, in some cases, the entire text of the resulting sample were assessed to determine their relevance according to the criteria outlined in Table 1.

Table 1. The criteria utilized for the screening process of the articles

Database	Scopus, Web of Science, Google Scholar
Field	Title, keywords, abstracts
Search string	("circular economy" OR " CE") AND ("systems thinking" OR "ST")
Type of publication	Journal articles, book chapters, conference proceedings
Language	English
Period	between 2013 to 2024

Thus, this integrative review does not purport to offer a comprehensive analysis but instead aims to present a representative sample of the existing knowledge concerning the implementation of CE with a systems thinking approach at a specific juncture in time. The chosen terms were employed in a supplement fashion, ensuring that each contributed to the overall pool of publications retrieved in the search results.

3.2. Execution

In the execution stage, multiple criteria were established to select the most suitable papers for the study. The study utilized two databases, Scopus and Web of Science, as well as the Google Scholar search engine, to ensure thorough and high-quality coverage. The search criteria were designed to encompass journal articles and conference proceedings in English. During the selection process, duplicate entries were removed. The titles, abstracts, and, if necessary, the full texts of articles were assessed to identify those that could best contribute to the study and offer insights into the connections between CE and systems thinking based on the outlined criteria. After conducting a comprehensive search and screening process,72 scientific papers between 2013 and 2024 were selected for this research. These papers provide insights into CE and systems thinking practices and their interrelationships. They include Qualitative and quantitative studies on CE functions and strategies examined with a systems thinking approach, as well as studies that mention CE practices and strategies for systems thinking, even if systems thinking is not the main focus of the studies (Figure 2).

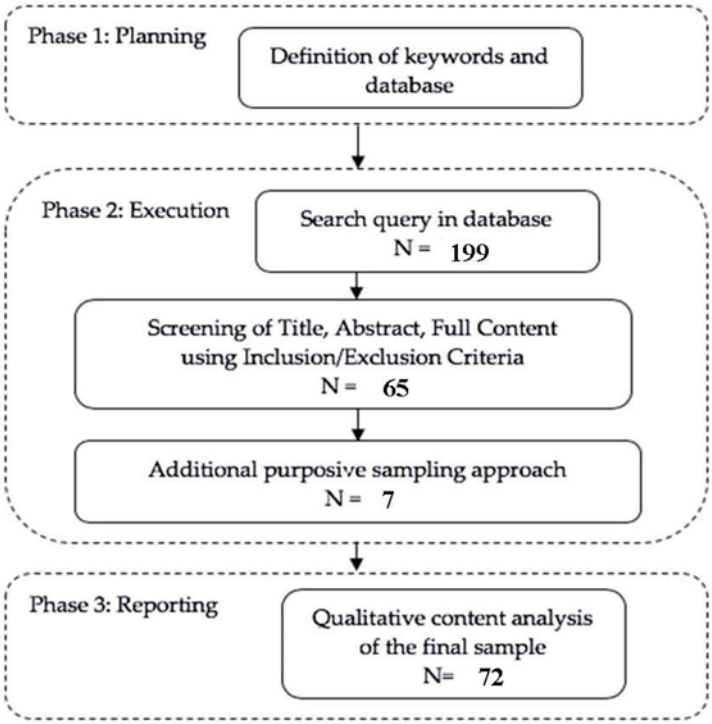

Figure 2. Summary of the methodological approach based on Tranfield et al. (2003)

3.3. Analysis

This research employed a qualitative content analysis method (Becker et al., 2012) to analyze selected documents. This approach aimed to identify key themes present in the literature. The analysis process involved reading and rewording the articles, as well as inductively coding their contents. The codes derived from the analysis were then reviewed for similarities and grouped into categories. This iterative process allowed the researchers to identify larger patterns by continuously moving between the data and emerging ideas. Afterward, the different categories were combined into general themes (Table 2), which were used to analyze and, in detail, understand how systems thinking is connected to a CE.

4. Result and discussion

The trend of article publication shows that the number of articles published in this field has been on an upward trend from 2013 to 2023 year. This evolution, mainly in recent years, shows the importance of this topic in the literature and has become an emerging trend (Figure 3).

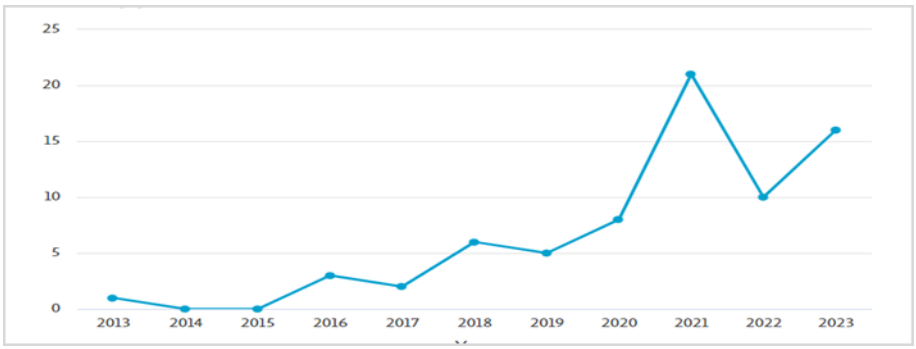

Figure 3. Distribution of articles from 2013 to 2023 year

A first look at the dispersion of the papers among many different subjects shows that although the query is focused on the terms "systems thinking" and "circular economy", papers appeared in a very wide range of subjects. The papers mainly examine CE in the domains of Environmental Science, Engineering, Social Sciences, and Energy. Figure 4 shows the distribution of articles by subject area in the 72 papers collected.

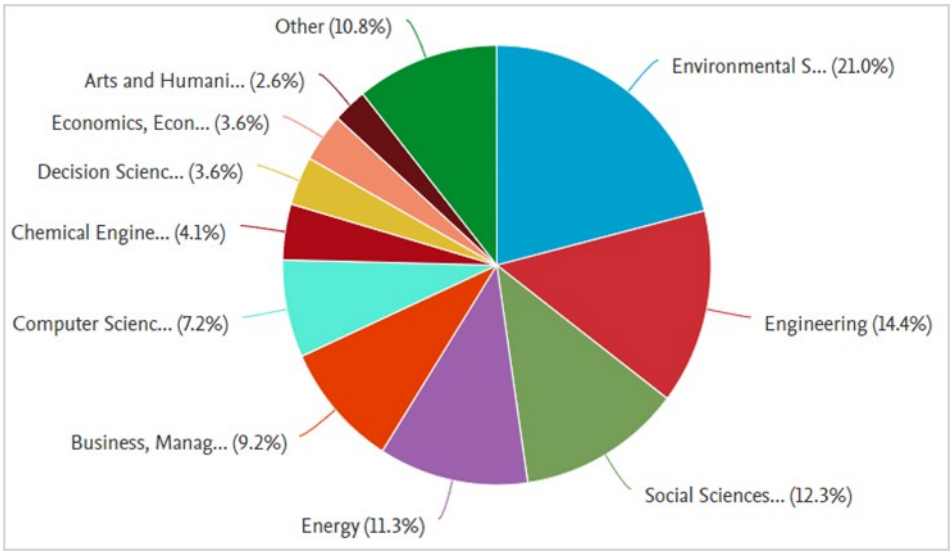

Figure 4. Distribution of articles from document by subject area

This paper introduces a new method by combining the concepts of CE and systems thinking to examine their connections. Systems thinking is an important approach for implementing CE practices. The paper reviews existing research and identifies six applications for using systems thinking in a CE. These applications are designed to identify underlying causes, understand the dynamics of the system, create product-service systems, manage the life cycle of products optimally through systems, enhance risk management, and promote sustainability (Table 2 and Figure 5).

Table 2. Applications for systems thinking in a CE. Source: authors

Approach	Attribute	(Expected) Outcome	Reference
Stakeholder engagement in decision	Systems thinking encourages collaboration and cooperation among various stakeholders in the circular economy. By involving stakeholders such as manufacturers, consumers, policymakers, and waste management organizations in the decision-making process, systems thinking can facilitate the adoption of circular practices and the co-creation of sustainable solutions.	Holistic approach and Understanding system dynamics, The use of Multiple stakeholders in decisions, Considering relationships between different factors (processes, values, and stakeholders)	Véliz et al.(2023), Demartini et al.(2023), Brinton et al.(2023), AlMashaqbeh & MuniveHernandez (2023), Ghufran et al.(2022), Esfandabadi et al.(2022), Robinson (2022), Bassi et al.(2021), Balanay & Halog (2021), Fanta et al.(2021),Termeer & Metze(2019), Esfandabadi & Ranjbari(2023)
Innovation and Deep transformational change	Systems thinking encourages a holistic and integrated approach to innovation in the circular economy. By considering the broader system and its dynamics, systems thinking can help identify opportunities for technological advancements, business model innovation, and systemic change toward a more circular economy.	Fundamental changes to production and consumption systems, The use of ICT to enable the transition towards circular economy, Environmental protection	Blomsma and Brennan (2023), Royle & Gibson(2023), Whitehill et al.(2022), Harder et al.(2022), Russo & van Timmeren(2022), Žilinskaitė et al.(2021), Iacovidou et al.(2021), Iida et al.(2021), Freire(2020), Giraldo Nohra et al.(2020), Chen (2020), Termeer & Metze(2019), Nogueira et al.(2019), Hall & Velez-Colby(2018), Gorissen Vrancken & Manshoven (2016)
Implementation of Circular business models	Systems thinking supports the development and implementation of circular business models. By understanding the broader system in which a business operates, including its stakeholders and external environment, systems thinking can help identify innovative ways to design products, offer services, and manage resources circularly.	Business model configuration, Resource decoupling, Creating a market for recyclable products. Collaboration between multiple stakeholders in the design and operation of the reverse logistics system	Ding et al.(2023), Migliaccio et al.(2023), Hidalgo-Carvajal et al.(2023), Yhdego(2021), Lugnet & Larsson (2021), Waring & Liyanage(2021), Dan & Østergaard(2021), Bakırlıoğlu et al.(2021), Mendoza et al.(2017), Lobos(2017), Pollard et al.(2016)
Life cycle management optimization through Better resource	Systems thinking helps in understanding the entire lifecycle of a product or service, from its production to its disposal. By considering the inputs, processes, outputs, and impacts at each stage, businesses and policymakers can identify opportunities for waste reduction, resource efficiency, and circularity.	Reducing natural resource over-exploitation, Preserving and increasing the value of resources used in production and consumption, using renewable resources, recycling materials, and reducing energy consumption	Anastasiades et al. (2023), Demartini et al.(2023), Russell et al. (2023), Fassio & Chirilli (2023), Friedman (2023), Ng & Yang(2023), Keßler et al.(2021), Roy et al.(2021), Tong et al.(2021), Savolainen et al.(2020), Mohan & Katakojwala(2021), Somoza-Tornos et al.(2020), Whalen & Whalen(2018), Balanay & Halog(2016), Webster (2013)
Supply chain optimization and reduced unintended consequences	Systems thinking enables businesses to identify unintended consequences, barriers, and opportunities for collaboration. By considering the interconnections and interdependencies between suppliers, manufacturers, distributors, and consumers, systems thinking can help optimize the supply chain, reduce waste, and improve resource utilization.	Reducing supply chain risks, The use of flexible developing models, Extended decision making and functional failure mode and effects analysis (FMEA) models	AlMashaqbeh & Munive-Hernandez (2023) Shafik & Case(2022) Barnabè & Nazir(2022) Blomsma &Brennan(2018)
Designing sustainable products	Systemic thinking can be used to design durable, repairable, and recyclable products. It can help reduce waste, promote a circular economy, and increase sustainability in product production and consumption.	Sustainable decisions in the circular economy, Sustainable mass production, The incorporation of Sustainable Development Goals (SDGs) into corporate sustainability strategies	Maher et al.(2023), Shams Esfandabadi & Ranjbari(2023), Dokter et al.(2022), Nyakudya & Ayomoh(2022), El-Khawad et al.(2022), Metic & Pigosso(2022), Ghufran et al.,(2022), Allen et al.(2021), Keßler et al.(2021), Stuiver & O'hara(2021), Chen (2021), Sumter et al.(2021), Allen & Tomoaia-Cotisel(2021), Cho (2021), Lu & Halog(2020), Sumter et al.(2020), Fassio & Tecco(2019), Hussain & Jahanzaib(2018), Perey et al.(2018), Poberezhna(2018)

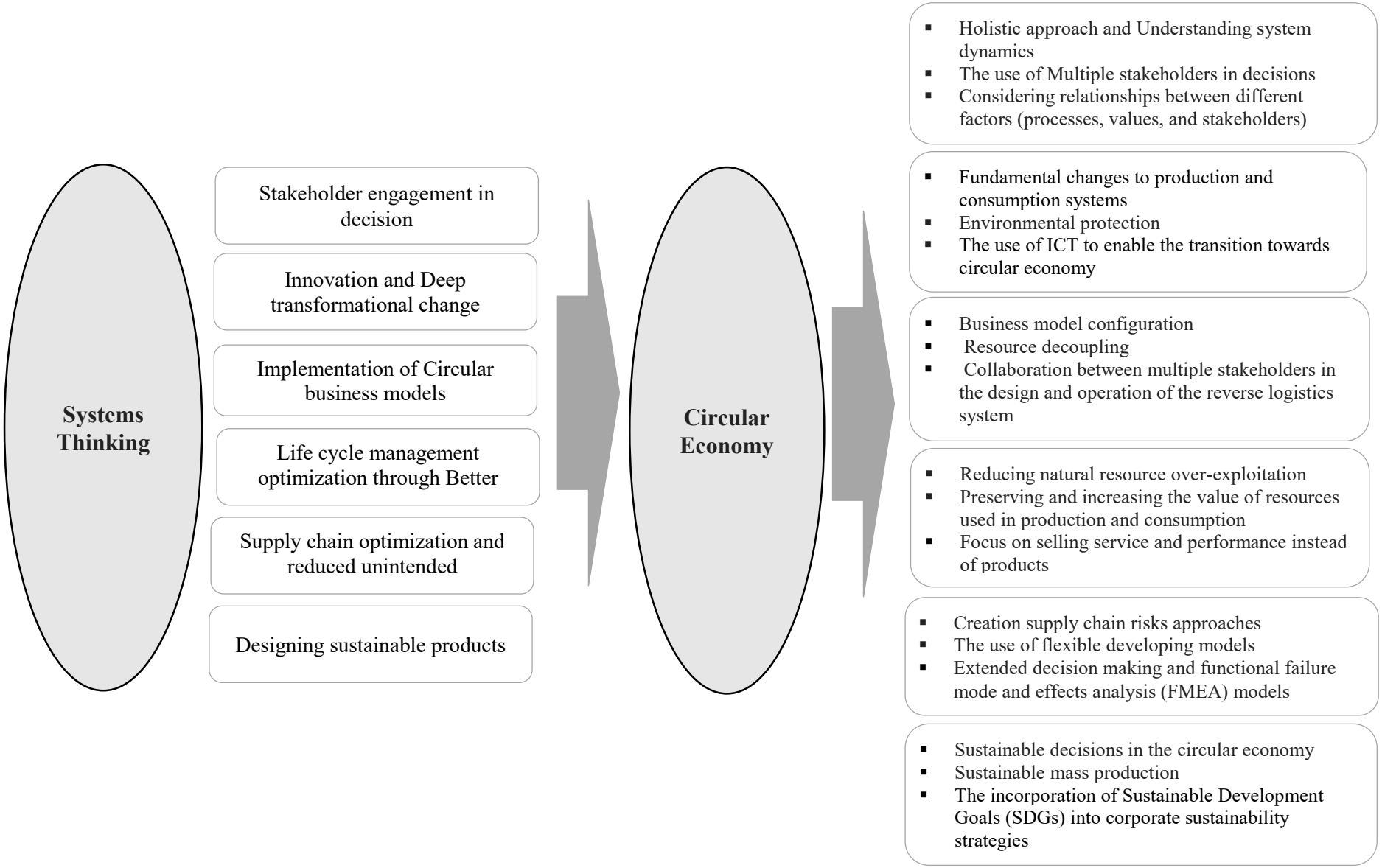

Figure 5. A model for utilizing systems thinking within the context of a CE.

DOI: 10.22067/JSTINP.2024.86123.1086

This combined knowledge improves comprehension of systems thinking within a CE and lays the groundwork for additional research in this field. However, the transition signifies a substantial reorganization of the current CE, emphasizing greater integration and cooperation with systems thinking (Ghafoor et al., 2023).

- Systems thinking is a way of understanding complex systems by considering the relationships between their parts and how they interact with each other. The impact of systems thinking on the CE is significant, as discussed below:

- Systems thinking provides a holistic approach to understanding the dynamics between processes, values, and stakeholders in the CE. It encourages collaboration and stakeholder engagement in the CE transition. By involving diverse stakeholders and considering their perspectives, decision-makers can develop more inclusive and effective CE strategies. It helps to identify potential barriers to implementation and develop strategies to overcome them.

- Systems thinking helps in understanding the interconnections and interdependencies between various components and processes within the CE. This understanding is crucial for designing effective circular systems and identifying potential bottlenecks or areas for improvement.

- Systems thinking helps identify feedback loops within the CE, where the outputs of one process or component can become inputs for another. By understanding these feedback loops, decision-makers can optimize resource flows and minimize waste generation. Systems thinking also helps develop better solutions for the CE. By considering the interactions between different parts of the system, it is possible to design products and processes that are more efficient, sustainable, and resilient.

- The CE is a complex system with many interrelated parts. Systems thinking provides a useful means of cutting through this complexity and focusing on the dynamics between processes, values, and stakeholders. Systems thinking allows for the analysis of system dynamics, including the behavior of stocks and flows, delays, and feedback mechanisms. This analysis helps in predicting the long-term effects of CE interventions and designing strategies for system resilience and adaptability.

- A CE involves complex system operations, such as product-service systems, remanufacturing, and repair. Systems thinking can help design these systems to be more efficient and effective.

- Systems thinking helps define the boundaries of the CE system and understand its interactions with the broader socio-economic and environmental systems. This understanding

enables a holistic approach to CE implementation and prevents unintended consequences or externalities. By considering different perspectives and scenarios, responses can be broadened, and risks can be prevented. Also, it can help businesses better navigate system risks, barriers, and opportunities and can lead to more sustainable and profitable business practices.

- CE practices require deep transformational change in the way we produce, consume, and dispose of goods and services. Systems thinking can help promote this change by identifying the underlying causes of problems and developing solutions that address them. It provides a framework for systemic innovation in the CE. It helps identify leverage points for intervention, explore alternative system configurations, and design novel business models and technologies that support circularity.

- A key objective of a circular economy is to cycle products and materials through systems that are regenerative and restorative. Systems thinking can help identify the most effective ways to achieve this objective. Applying systems thinking to circular economy practices can help unlock the sustainability potential of circular processes. It can help progress the sustainability agenda and lead to a more sustainable future.

5. Conclusions

The CE is a topic that is widely discussed worldwide. Currently, most discussions focus on the importance of achieving a CE and the associated benefits. The CE is a concept that aims to create a sustainable and regenerative economic system by minimizing waste and maximizing resource efficiency. Systems thinking, on the other hand, is an approach that considers the interconnections and interdependencies between various components of a system. This integrated literature review explores the applications of systems thinking in the context of the CE. The review examines various studies and research papers that highlight the benefits of applying systems thinking in the CE.

This study identifies several key applications of systems thinking in the CE that must be taken into account to facilitate the transition towards a CE, namely, Stakeholder engagement in decision-making, innovation and deep transformational change, implementation of circular business models, life cycle management optimization through Better resource management, supply chain optimization and reduced unintended consequences and designing sustainable products. Firstly, this study emphasizes the importance of considering the entire lifecycle of a product or service, from production to disposal. By adopting a systems thinking approach, businesses and policymakers can identify opportunities to reduce waste and improve resource

efficiency at every stage of the product lifecycle. Systems thinking helps in identifying feedback loops within the CE, where the outputs of one process or component can become inputs for another. By understanding these feedback loops, decision-makers can optimize resource flows and minimize waste generation. Secondly, this study highlights the need for collaboration and cooperation between different stakeholders in the CE. Systems thinking encourages a holistic view of the system, which can help identify potential synergies and opportunities for collaboration. By involving various stakeholders, such as manufacturers, consumers, and waste management organizations, in the decision-making process, systems thinking can facilitate the implementation of CE practices. Systems thinking encourages collaboration and stakeholder engagement in the CE transition.

Furthermore, the review emphasizes the role of systems thinking in addressing the complexity and uncertainty associated with the CE. The CE involves multiple interconnected systems, including supply chains, waste management systems, and consumer behavior. Systems thinking provides a framework for understanding and managing these complex systems, enabling businesses and policymakers to make informed decisions and anticipate potential challenges. Systems thinking helps in understanding the interconnections and interdependencies between various components and processes within the CE. This understanding is crucial for designing effective circular systems and identifying potential bottlenecks or areas for improvement.

This comprehensive approach provides a practical method for navigating complex systems. It highlights the connections between processes, values, and individuals within the value chain, as well as their dependence on cultural, spatial, and temporal factors. Adopting a systems thinking-based approach can develop the necessary skills to recognize and comprehend Stable circular trends, thereby facilitating forward-thinking and investment in sustainable transitions. In turn, this approach can assist in prioritizing and transforming our current practices, expediting the transition to a CE in a sustainable way. Systems thinking is a crucial method for comprehending and advancing the CE. There are numerous significant avenues for future research in this developing field that could offer fresh perspectives and increase awareness regarding the demands of this emerging phenomenon. Therefore, it is necessary to conduct research in order to develop more comprehensive frameworks for understanding CE systems, which include examining the interactions between various processes, stakeholders, and values. Future studies should also take into account factors that can be improved through a systems thinking approach, such as resource recovery systems and the promotion of more effective CE

strategies at the local level. Additionally, research should explore the development and adoption of circular business models, the role of systems thinking in identifying the root causes of CE challenges and implementing better solutions, and the potential of systems thinking to encourage the development of more sustainable products and services. In summary, future research on the CE using a systems thinking approach should focus on developing more comprehensive and effective methods for understanding and promoting circularity in various scales and contexts.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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