Circular Economy Implementation

Subjects: Economics | Engineering, Industrial | Environmental Sciences
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The circular economy, as a promising response to sustainability issues, is a crucible for carefully designed ecofriendly actions and integrative mechanisms in enterprises, households, and societies for the attainment of the desired outcomes. It is in this context that CE strategies are examined, with the use of metrics, indicators, and standards. The desired outcomes of the CE are well embedded and articulated in the sustainable development goals that the UN and its member countries have vowed to achieve along a designated timeline.

Keywords: reductionist approach ; systems thinking ; circular economy ; systems models ; sustainability ; holons ; unintended outcomes ; sustainable development goals ; nature-based solutions

1. Introduction

As a concept, the circular economy proposes nature-based solutions and mimics Earth's system in its ability to regenerate and restore itself with the use of renewable energy resources and a wide-range of closed-loop strategies (far more than recycling) in order to contain the footprints of the various activities carried out by industries and people, as well as to reduce the pressure on natural resource stocks, despite the constancy of fluxes within the system [1][2][3][4]. This is an exciting concept to explore [5], when countries globally have systematically tried to get by, rather than to do nothing at all, in the hope of achieving sustainability through metabolizing the footprints and externalities from anthropogenic and/or industrial activities and processes, designing out waste, or closing loops. With closing the loops, adherents to the concept have not yet stopped increasing as more promotional efforts are put in place to be extensive in actions and hopefully in results, which indicates the desperation to quickly restore the past environment where people and industries were much safer ecologically. Skene [2] nonetheless argued otherwise, citing closed loops as inconsistent with the laws of nature and Earth as a system where CE is happening. However, for this part of the review, 32 research works published since 2017 were downloaded from Google Scholar with the use of keywords—*circular economy issues, limits, limitations, barriers, and challenges*—in the search to sort out the CE issues that need to be the subject of discussion for the succeeding parts. Out of that number, 21 works were finally selected based on relevance, particularly to the critical aspects of CE implementation to tackle CE issues in both research and practice.

The CE is yet a porous concept and a work in progress, in which the bottlenecks to make CE a reality as researched are mounting at various scales, levels, and perspectives. Divergent views and perspectives are noted, particularly as to which aspects should be essentially clarified in terms of foundations, scope, sectors, categories, indicators, and metrics, among others. These have been strongly manifested in the works of Korhonen et al. [1] and Kirchherr et al. [6], although convergence of the said works is pointed out with the observations made by Kirchherr and van Santen [5] regarding the current state of CE implementation. Particularly, Kirchherr and van Santen [5] observed that the empirical works of CE implementation were yet inadequate, few, biased towards the manufacturing sector and the developed economies, and lacking expert advice. Nonetheless, adherents (adopters and practitioners) have to be continually warned of numerous tradeoffs and deficiencies in many aspects of the implementation of CE strategies, which largely need expert analysis and guidance in the hope of closing the loop successfully [2][7][8]. The works reviewed herein exhibit that while CE is an exciting concept [5], stakeholders across the world have a lot yet to do to prosper significantly on this ambitious endeavor. With the extremely challenging situation in CE implementation, Kirchherr and van Santen [5] warn about the business sector—a main actor of CE—starting to lose grip.

Global circularity is around 9% so far [5], causing positivists to assert that there is a need to do a lot to keep the CE endeavor going with sustained passion and determination. To this end, Korhonen et al. [1] emphasized the importance of understanding the underpinnings of the CE concept, which also extends to the need for further investigation of the six limits of CE they had put together for intelligent/systematic action/response: "thermodynamic limits, system boundary limits, limits posed by the physical scale of the economy, limits posed by path dependency and lock-in, limits of governance and management, and limits of social and cultural definitions." The said limits may not have captured the strong interests of CE researchers at this point, but as seen in Table 1, the willingness to embark upon serious studies on the limiting outcomes of CE implementation initiatives is undeniably increasing. Research on the barriers and issues of CE implementation is rationalized with the interest of finding the ways of overcoming the overlooked and unexplored potential impediments to implementation. The limits are the credible explanations of the current observation about CE implementation in which progress is slowed down by the presence of those impediments, which make the CE only move forward in circles. Table 1 contains these impediments that slow down the efforts to fulfill circularity and put the current CE passion and initiatives onto a dilemmatic course. These impediments have created a tremendous challenge for all CE advocates, stakeholders, and practitioners to review their CE research and practice paradigms and frameworks for the necessary changes to get close to the highly ambitious goal of debunking the impossibility of full circularity for sustainability.

Table 1. The major issues of circular economy implementation.

Scope and Particulars	Sources
Lack of essential information and knowledge (e.g., environmental impacts, CE concept, critical players, efficient strategies, mechanisms, and implementation methods)	[9][6][10][11][12][13][14][15][16][17][18]
Lack of technology, infrastructural, and logistic support	[9][6][11][12][13][14][15][16][17][19][20][21]
Lack of collaborative innovation	[11][13][14][15][19][22]
Uncertain profitability, costliness of the accompanying endeavors, limited funding support, financial risk, and time mismatch in cost and benefit generation	[6][10][11][12][13][14][15][16][19][21][22]
Lack of incentives and enabling sustainability legislation/policy/guidelines	[6][11][12][14][15][16][17][19][20][21][23]
Lack of appropriate standards, metrics, and indicators	[9][11][12][13][14][15][21]
Lack of coherence in directions, contexts, and strategies	[13][23]
Operational risks and lack of expertise	[10][11][14][16]
Lack of consumer interest	[6][11][12][14][15][16][21][22]
Unwanted ecological, economic, and social changes and effects (e.g., emissions, cannibalization, product complexity, externalities preventing companies from exploiting refurbished products, price effects, brand image, and fashion change)	[1][8][11][12][17][24]
Lack of understanding, interest, and enthusiasm among key stakeholders	[9][6][12][14][16][21]
Failure to align with market particularities	[23]
Limited economic feasibility of scaled-up infrastructure and technologies	[15]

2. Reductionist versus Systems Perspectives towards 'Doing the Right Strategies Right' for Circular Economy Implementation

The circular economy has been a promising concept towards sustainable development, which is extensively advocated by policymakers, business individuals, government units, and other practitioners across the world. With the increasing number of subscribing countries and institutions worldwide, it has gained much better traction over time with the demonstration of the concept's diversity of so-called implementable strategies and options to design waste out and to reduce pressure on natural resource stocks through a wide range of closed-loop strategies. Even on a conceptual level, the CE has been argued to be farfetched to impossible, as implementing circular strategies in the hope of designing waste out means undertaking similar processes of input and energy consumption and generating another kind of footprint to carry out the circular processes on a macro level (see Korhonen et al. [1][25] and Skene [2] for further explanation). Given natural laws, implementing the CE would mean attaining the sustainability targets at different kinds of costs. Anastas [7] mentioned some of these costs as a result of the discovery and implementation of beneficial interventions and knowledge products. In an attempt to circularize economies, several issues are noted to have caused impediments to CE implementation. This work has noted numerous inadequacies from the review of published CE initiatives since 2017, wherein addressing information, technology, and infrastructure needs is vital alongside with providing an enabling environment for the CE to take root through incentives, collaborative relationships, interest, and demand for new products and services, coherent directions, and meaningful standards, among others. These issues of CE implementation suggest the requisites that current societies and stakeholders have to work out to properly set up the enabling environment for the CE. With this, it has been shown that the CE will hardly be an implementable concept if those requisites are not responded to in time.

The persistent use of the reductionist approach perpetuates silo/compartmentalized thinking, which Anastas [7] demonstrated was a particular cause for shortfalls in the anticipation of unintended outcomes that again induce costs to the environment and society. This kind of approach is ruled out here as lacking relevance in the context of the CE where *at the outset CE is already pronounced as systemic in nature*. The use of the reductionist approach should have been expanded to be inclusive of relevant parameters to properly evaluate the overall results of a circular intervention. The system approach was already around by the time the CE was introduced since it was developed in the 1950s to address the inadequacies of the reductionist approach. The recent European Green Deal is interesting to be followed up on/followed through with based on the systems perspective. Such an ambitious sustainable development agenda across Europe is a bold move to reckon with for posterity where massive structural changes and tradeoffs are anticipated with its implementation. These changes and tradeoffs are the challenges of the European scientific community to prepare for consequences against its present industries running its macroeconomy. Having the CE as an important part of the Deal makes it highly ambitious, inasmuch as a macrolevel CE poses important unanswered questions, especially whether it is going to work and what transitional challenges will have to overcome. The world will absolutely be watching for the unfolding of the CE under this Deal as an example for other countries to think about.

However, the application of the system approach to the CE is quite slow. Seven decades later, only a few studies have tried it in CE evaluation. Across the world, the CE still has very little empirical research with respect to conceptual research. The adoption of system analysis for the CE's implementation as demonstrated by Muth et al. [26] shows the rigors in undertaking it, which apparently requires transdisciplinarity, diversity of expertise, and team effort. System approaches are complex, which underlie interlinked relationships that reductionist models can help to form. However, these approaches are inclusive/comprehensive, which inform stakeholders through the preview of unintended outcomes beneficial in the evaluation of options (e.g., prevention vs. recycling in the study of Muth et al. [26] on food loss and waste via a supply chain framework). In addition, exciting frameworks for developing innovations at present are compatible with the CE as a system and timely integration of these may make CE more effective as a self-regenerating system. In view of the need to have holistic computable models via systems thinking, system analytical procedures (e.g., system dynamics, etc.) must further develop to advise the formulation of systems models relevant to the evaluation of CE initiatives.

We mention numerous challenges (see Box 1) on which the academic/scientific community can focus its attention. Inasmuch as those challenges comprise the void that needs to be explored at this point, these constitute the academic opportunities for the necessary attempts on the further development of the systems approaches for CE analysis and on making these approaches manageable for use among the stakeholders (particularly the researchers and the practitioners). Systems approaches have been unattractive for use because of the inherent complexities in using them. Further research on this aspect is suggested to define the complexity that addresses the major tradeoffs in the environment, the society, and the economy. Since the circular economy contributes towards sustainable development, the three pillars of SD must be represented in the systems model accordingly. Priority indicators of these pillars need to be considered. It is also interesting to look into the possibility of integrating the life-cycle based models in view of their various useful thresholds, critical impact indicators and temporal windows. In this situation, convergence of experts is necessary to deal with the challenges on the manageability of these complex systems models, with which the digital science experts can greatly help. Finally, based on relevance and generation of meaningful findings, this work emphasizes the importance of increasing the application of system models in the evaluation of CE issues and implementation to expedite the learning process about systems analytical tools among the various stakeholders for insightful basis in decision making regarding sustainability actions/programs.

Box 1. The challenges of systems thinking and approaches [27].

- The continuing proliferation of frameworks, approaches, and methodologies with each having its own spe-cialized lexicon, so that complexity of the field (beyond any single methodology) is hard for anyone to fully understand.
- The concomitant partial fragmentation of the systems thinking research community, with divisions that reflect preferences of both methodologies (system dynamics, viable system modelling, soft systems method-ology, critical systems thinking, etc.) and application domains (engineering, operations research, public policy, environmental management, etc.).
- The near impossibility of offering a two-minute introductory narrative to a newcomer to the systems thinking field that respects the variety of systems approaches.
- The need for clarity and common purpose around unresolved questions and prospective research.

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