Unveiling the Potentials of Circular Economy Values in Logistics and Supply Chain Management

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UNVEILING THE POTENTIALS OF CIRCULAR ECONOMY VALUES IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Abstract

Purpose – The paper aims to unveil the Circular Economy (CE) values with an ultimate goal to provide tenets in a format or structure that can potentially be used for designing a circular, closed-loop supply chain and reverse logistics.

Design/methodology/approach – This is desk-based research whose data were collected from relevant publication databases and other scientific resources, using a wide range of keywords and phrases associated with CE, reverse logistics, product recovery, and other relevant terms. There are five main steps in the reformulation of CE principles: literature filtering, literature analysis, thematic analysis, value definition, and value mapping.

Findings – Fifteen CE values have been identified according to their fundamental concepts, behaviours, characteristics, and theories. The values are grouped into *principles*, *intrinsic attributes* and *enablers*. These values can be embedded into the design process of product recovery management, reverse logistics, and closed-loop supply chain.

Research implications – The paper contributes to the redefinition, identification, and implementation of the CE values, as a basis for the transformation from a traditional to a more circular supply chain. The reformulation of the CE values will potentially affect the way supply chain and logistics systems considering the imperatives of circularity may be designed in the future.

Originality/value – The reformulation principles, intrinsic attributes, and enablers of CE in this paper is considered innovative in terms of improving a better understanding of the notion of CE and how CE can be applied in the context of modern logistics and supply chain management.

Keywords: Circular economy, principles, reverse logistics, supply chain management, closed loop supply chain

Paper type: Literature review

1. Introduction

The Circular Economy (CE) is defined as a global economic model to minimise the consumption of finite resources, which focuses on the intelligent design of materials, product, and systems (EMF, 2013a). It also supports separating treatment between technical and biological materials to maximise the design for reuse, to return to the biosphere and retain value through innovations across fields (Webster, 2015; Lacy and Rutqvist, 2015). Transitioning from the linear to a circular economy not only requires a fine-tuning that reduces the negative impacts of the linear economy, but also a whole system approach that builds upon a number of guiding principles. These principles allow resilience to be built into the CE system, ensuring the long-term generation of economic opportunities and at the same time offering societal and environmental benefits.

CE principles have been elaborated by several researchers in various manners and from various viewpoints: Feng (2004) in Yuan et al. (2006), Pintér (2006), Yuan et al. (2006), Yong (2007), Geng et al. (2012), EMF (2013a, 2015), Stahel (2013), and Pan et al. (2015). Principles, in theory, can support the understanding of a concept; however, principles alone are often insufficient to support the practicality of that concept. This paper therefore aims to reformulate the existing CE principles into CE values (or tenets) in a format or structure that supports the design of a circular, closed-loop supply chain and reverse logistics. In this paper, CE principles were reformulated through five steps: data filtering, literature analysis, thematic analysis, CE values definition, and CE values mapping.

The paper begins with a brief introduction to some key concepts in CE which also cover the fundamentals of CE principles. This is followed by a description of the research approach adopted to collect the data and review existing contributions before presenting the analysis and synthesis. Finally, the implications for research and practice are discussed along the direction for future research.

2. Related research

2.1. Circular Economy (CE)

The idea of CE was coined by Boulding (1966) who expressed it as a "cyclical ecological system which is capable of continuous reproduction of material form even though it cannot escape having inputs of energy". Kneese et al. (1970) in Andersen (2007) mentioned CE from an environmental economic perspective based on a mass balance principle that all material flows can be accounted for; however, it will be the economic values, not the physical flows that guide their management.

Pearce and Turner (1990) divided CE into four functions: amenity values, a resource base for the economy, a sink for residual flows, and a life support system. Hu et al. (2011) expressed the basic philosophy in the CE approach as being to enhance the emergence of an industrial and economic system that relies on cooperation among actors and matter and energy flow management, in which they can use each other's waste material and energy as resources and in this way minimise the system's virgin material and energy input. EMF (2013a) defined CE as an industrial system that supports a restorative concept through the intelligent design of materials, products and systems, and the business model. Preston (2012) interpreted it as redesigning global production and consumption systems, which are a combination of environmental, resources, technology, and consumer demand. The concept encourages business activities to optimise products, components, and materials at the highest utility and value at all times, distinguishing between technical and biological cycles.

The EMF (2013a) divided CE into two types of circle: technical materials and biological materials circles, both of which have similar reverse processes. The circle of technical materials consists of maintaining, reusing/distributing, refurbishing/remanufacturing and recycling. In the circle of biological materials, specific treatments, such as extraction of biochemical feedstock and anaerobic digestion/composting, are required before the biological materials can be safely released to the biosphere. In both circles, leakage must be minimised so as to maximise the amount of materials to be reprocessed hence re-circulated back to the point of use.

2.2. Circular Economy Principles

A 'principle' is generally intended as a fundamental truth that serves as the foundation of a system. The CE principles can therefore be seen as the fundamental truth about the circular economy, representing the whole concept of CE, and by understanding the principles, it should provide a better understanding of the CE itself. CE principles have been identified by numerous researchers in different contexts. Huamao and Fengqi (2007) and Yuan et al. (2006) summarised the CE principles in "3R", which stands for *reduction*, *reuse* and *recycling* of materials/energy. Hu et al. (2011) expressed the basic philosophy of CE as enhancing the emergence of an industrial and economic system, relying on cooperation among actors and matter, and using waste material and energy as resources to minimise the system's virgin material and energy input. Stahel (2013) in EMF (2013b) emphasised the importance of CE principles in the implementation of the CE concept. He mentioned CE principles as including economics and profit maximisation; material and resource sufficiency and efficiency; an intelligent use of human labour; and caring. Additionally, he expressed the rules of CE principles as: profitable and resource efficient; value maintained; circular flow; cost efficient: reuse, repair and remanufacture; and needs functioning markets.

EMF (2013a) conveyed several guiding principles in their report which include: *1) design out waste*, meaning that when a product is designed, the designer needs to consider the biological or technical material cycle that can be reprocessed; *2) build resilience through diversity*, meaning that there is a need to build a system resilience covering several aspects within the CE; *3) work towards using energy from renewable sources*, meaning that energy usage per unit of output needs to be reduced and the shift to renewable energy needs to be accelerated by design, i.e. treating the economy as a valuable resource; *4) think in system*, meaning a set of components or objects that interact with each other to achieve the goals in real-world, non-linear, feedback-rich systems, particularly living systems; and *5) think in cascades*, meaning maximising the retaining value of a product that can contribute optimally before going back to the biosphere or continuing loops. In 2015 EMF described CE principles through other views, which are preserving enhanced natural capital, optimising resource yields, and fostering system effectiveness.

3. Research programme

3.1. Aim, objectives and approach

The aim of this paper is to unveil the Circular Economy (CE) values with an ultimate goal to provide tenets in a format or structure that can potentially be used for designing a circular, closed-loop supply chain and reverse logistics. To achieve the aim, the following objectives have been set to identify the existing principles of CE and then redefine and reformulate these into the CE values.

3.2 Search Strategy

The approach adopted was mainly through a systematic literature review whose data were collected from relevant publication databases and other scientific resources, using a wide range of keywords and phrases associated with CE, and other related keywords, for instance principle, reverse logistics, product recovery, repair, refurbishment, remanufacturing, and cannibalisation. These were then combined with the publicly available materials and various media (case studies, videos, seminars, presentations). All phrases were determined to have a strong association with the core of this research.

The process began by identifying the papers from the relevant databases including Google Scholar, Scopus, IEEE, and EBSCO using a combination of keywords, as shown in Table 1, resulting in 941 journal and 509 conference papers being extracted. During the searching process, some books such as “A New Dynamic Effective Business in a Circular Economy” by Webster et al. (2013), technical reports, such as “Towards the circular economy” by EMF (2013a), and briefing papers such as “A Global Redesign? Shaping the Circular Economy” by Preston (2012) were also identified as useful resources, and hence are included in the analysis.

Table 1 Summary of literature search strategy for CE principles

Search string	Database							
	Google Scholar		Scopus		IEEE Xplore		EBSCO	
	Journal	Conference Paper	Journal	Conference Paper	Journal	Conference Paper	Journal	Conference Paper
Circular economy	574	131	139	250	0	101	213	-
Circular economy AND Principle	4	9	2	3	0	0	5	0
Circular economy AND Reverse logistics	0	1	0	8	0	5	1	-
Circular economy AND Product Recovery	2	0	0	0	0	0	0	-
Circular economy AND Repair	0	0	0	0	0	0	0	-
Circular economy AND Refurbishment	0	0	0	0	0	0	0	-
Circular economy AND Remanufacturing	0	1	0	0	0	0	1	-
Circular economy AND Cannibalisation	0	0	0	0	0	0	0	-
Total	580	142	141	261	0	106	220	0

The literature in Table 1 was identified by reading the title. If the titles met this research purpose, they were collected and stored. The next process was to read the abstract and keywords. In this process the literature was classified based on its similar purpose and keywords. Reading the full paper was necessary in order to analyse CE characteristics, principles, values, concepts, case studies, and other relevant research results more deeply. Within the selection process of the literature, some filtering criteria, such as types of document (journal and conference papers) and language (English), were applied.

The *principle* string is important as it is the main purpose of this reformulation. The search string also combines the *Circular Economy* keyword with other keywords such as *Reverse Logistics*, *Product Recovery*, *Repair*, *Refurbishment*, *Remanufacturing*, and *Cannibalisation*. Furthermore, in Table 1, the results columns show the number of journals and conference papers found. The results have indicated that the "circular economy" string provided the dominant result, whereas the others are relatively small, even zero; for instance, "circular economy AND repair" in all of the databases.

There are six steps that were adopted: data collection, data filtering, literature analysis, thematic analysis, CE values definition and mapping of CE value (see Figure 1).

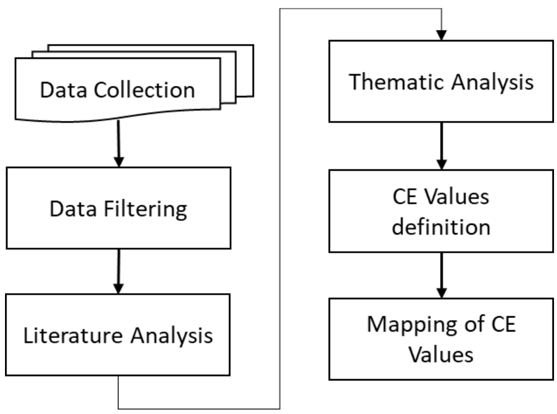

Figure 1 Research approach

4. Results

4.1 Reformulation of CE Principles

4.1.1 Data Filtering

All potential sources of papers were filtered by various processes: reading the title, abstract, keywords and full paper filtering; those filtering processes resulted in 51 papers (Table 2).

Filtering criteria, for instance language (English), type of document (journal and conference paper), and article title, were rigorously applied. The 51 papers that were identified at the end of the filtering process include journal papers, conference papers, text books, white papers, technical reports, and online articles.

Table 2 Selected literature results for CE principles

No	Author	Reference
Journal		
J01	Ekins (1989)	Environmental Conservation
J02	Feng (2004) in Yuan et al. (2006)	Journal of Material Cycles and Waste Management
J03	Yuan et al. (2006)	Journal of Industrial Ecology
J04	Hongchun (2006)	Journal of Ecological Economy
J05	Huamao and Fengqi (2007)	Chinese Journal of Population Resources and Environment
J06	Yong (2007)	Journal of Material Cycles and Waste Management
J07	Geng and Doberstein (2008)	International Journal of Sustainable Development & World Ecology
J08	Dajian (2008)	Chinese Journal of Population Resources and Environment
J09	Chen (2009)	System Research and Behavioral Science
J10	Park et al. (2010)	Journal of Cleaner Production
J11	Mathews and Tan (2011)	Journal of Industrial Ecology
J12	Hu at al. (2011)	Journal of Cleaner Production
J13	Zhu et al. (2010)	Journal of Environmental Management
J14	Geng et al. (2012)	Journal of Cleaner Production
J15	Su et al. (2013)	Journal of Cleaner Production
J16	Ma et al. (2014)	Journal of Cleaner Production
J17	Ma et al. (2015)	Journal of Cleaner Production
J18	Li and Ma (2015)	Journal of Cleaner Production
J19	Pan et al. (2015)	Journal of Cleaner Production
J20	Blomsma and Brennan (2017)	Journal of Industrial Ecology
J21	Hollander et al. (2017)	Journal of Industrial Ecology
J22	Kalmykova et al. (2018)	Journal of Resources, Conservation & Recycling
J23	Vouvoulis (2018)	Journal of Environmental Science & Health
Conference proceedings		
C01	Li et al. (2009)	Second Asia-Pacific Conference on Computational Intelligence and Industrial Applications
C02	Yang (2011)	BMEI
C03	Xuan et al. (2011)	ICEED
C04	Ying and Li-jun (2012)	International Conference on Solid State Devices and Materials Science
C05	Zheng and Zheng (2013)	International Asia Conference on Industrial Engineering and Management Innovation

C06	Jawahir and Bradley (2016)	The Global Conference on Sustainable Manufacturing
Textbooks		
B01	Boulding (1966)	The Economics of the Coming Spaceship Earth
B02	Kneese et al. (1970)	Economics and the Environment: A materials balance approach
B03	Pearce and Turner (1990)	Economics of Natural Resources and the Environment
B04	Lovins (2013)	A New Dynamic Effective Business in a Circular Economy
B05	Stahel (2013)	A New Dynamic Effective Business in a Circular Economy
B06	Tuppen (2013)	A New Dynamic Effective Business in a Circular Economy
B07	Sempels (2013)	A New Dynamic Effective Business in a Circular Economy
B08	Mulhall and Braungart (2013)	A New Dynamic Effective Business in a Circular Economy
B09	Pinjing et al. (2013)	Waste as a resource
B10	Webster (2015)	The circular economy: a wealth of flows
B11	Lacy and Rutqvist (2015)	Waste to Wealth: The Circular Economy Advantage
White papers, technical reports, online articles		
O01	Pintér (2006)	http://siteresources.worldbank.org
O02	Clift and Allwood (2011)	http://www.ellenmacarthurfoundation.org
O03	Preston (2012)	Chathamhouse.org
O04	EMF (2012)	Ellen MacArthur Foundation
O05	Marion (2012)	Ecocitynotes.com
O06	EMF (2013a)	Ellen MacArthur Foundation
O07	IMSA (2013)	Amsterdam: IMSA
O08	EMF (2014)	Ellen MacArthur Foundation
O09	EMF (2015)	Ellen MacArthur Foundation
O10	UNEP (2015)	United Nations Environment Programme
O11	ERN (2016)	European Remanufacturing Network

4.1.2 Literature Analysis

The 51 papers were then analysed to obtain various essential themes (such as from the intersection of definitions, characteristics, principles, or other information across the authors). For example, Pearce and Turner (1990), EMF (2013a), and Lacy and Rutqvist (2015) conveyed CE definitions; they explained the similar terms (such as those about the economy, environment, circularity, etc.). The analysis continued by mapping the relevant information provided by each author (See Figure 2 which illustrates the 51 authors). After the analysis process and regrouping, those keys with a similar meaning will be grouped within one representative key. The results of regrouping are shown in Table 3. In this process, 12 themes were found: economy, environment, circularity, system thinking, cascades, reverse cycle, collaboration, recovery, market, technology, innovation, and waste.

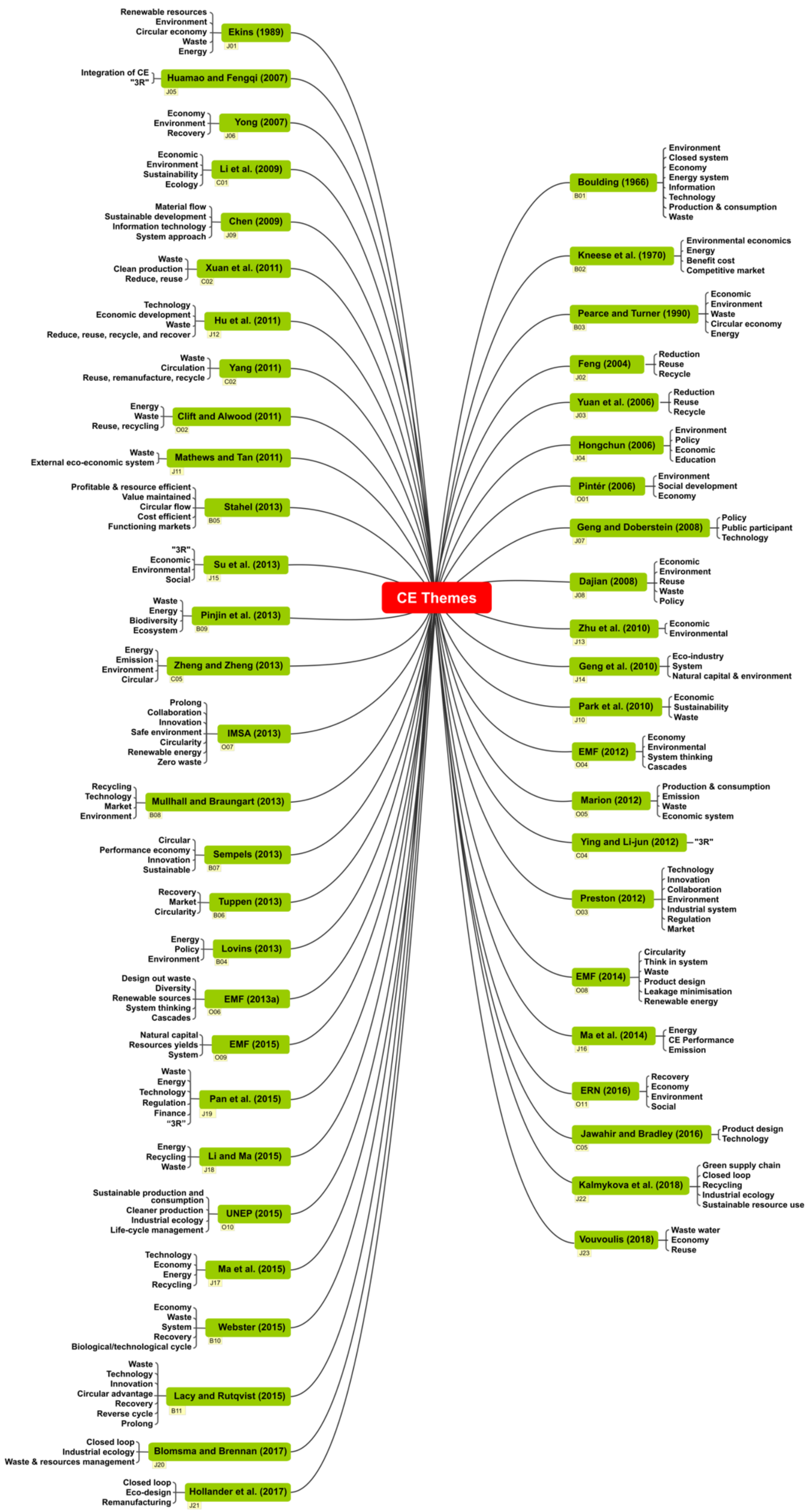

Figure 2 Identification of the CE themes

Table 3 Thematic classification of CE principles

No	Reference	Theme												Total
		Economy	Environment	Circularity	System thinking	Cascades	Reverse cycle	Collaboration	Recovery	Market	Technology	Innovation	Waste	
1	Boulding (1966)	x	x	x										3
2	Pearce and Turner (1990)	x	x		x		x		x				x	6
3	Huang (2004)								x					1
4	Yuan et al. (2006)		x						x					2
5	Huamao and Fengqi (2007)				x				x					2
6	Parker (2007)								x			x		2
7	Mathews and Tan (2011)	x	x	x	x				x					5
8	Park et al. (2010)	x	x								x			3
9	Hu et al. (2011)	x	x				x				x		x	5
10	Yang (2011)	x	x	x	x				x					5
11	Zheng and Zheng (2013)						x						x	2
12	Yong (2007)	x	x	x					x					4
13	Kneese et al. (1970) in Andersen (2007)	x	x	x										3
14	Dajian (2008)	x	x						x					3
15	Clift and Allwood (2011)	x								x				2
16	Preston (2012)		x		x					x				3
17	EMF (2012)	x	x	x	x	x	x		x	x	x		x	10
18	EMF (2013a)	x	x	x	x	x	x	x	x	x	x		x	11
19	Hopkinson and Spicer (2013) in EMF (2013b)			x		x	x		x					4
20	Tuppen (2013) in EMF (2013b)			x		x	x		x					4
21	Sempels (2013) in EMF (2013b)	x		x								x		3
22	Mulhall and Braungart (2013) in Ellen MacArthur Foundation (2013)		x	x					x			x		4
23	Stahel (2013) in EMF (2013b)	x		x	x				x	x				5
24	IMSA (2013)			x	x	x	x	x	x		x		x	8
25	Ellen MacArthur Foundation and	x	x								x	x		4

	McKinsey & Co (2013) in Ellen MacArthur Foundation (2013)													
26	EMF (2014)	x	x	x	x	x	x		x	x	x	x	x	11
27	Ma et al. (2014)		x						x				x	3
28	EMF (2015)	x	x	x	x	x	x		x	x			x	9
29	Webster (2015)	x	x	x	x	x	x		x			x	x	9
30	Lacy and Rutqvist (2015)	x	x	x		x	x		x			x	x	8
31	Blomsma and Brennan (2017)			x									x	2
32	Hollander et al. (2017)		x	x					x					3
33	Kalmykova et al. (2018)	x	x	x			x		x					5
34	Vouvoulis (2018)						x						x	2
Total		20	22	20	12	9	14	2	23	7	7	7	13	

4.1.3 Thematic Analysis

The information in Table 3 was analysed to produce the CE principles, while the values describe the specific usefulness of the concept. In this stage, a deeper analysis was required, in which each theme above will be defined in order to find the consistency of the theme. Through this stage, the CE values will be reformulated. In fact, one theme can produce one or more values and one theme possibly can overlap others as well. Basically, those themes shown above were reformulated to find the suitable CE values. For example, the "economy" theme will be analysed based on all information surrounding the theme, such as the position of the economy in this concept, in what way the economic extension will influence the implementing process, and how to implement this aspect, etc. The information discovered was elaborated to represent the CE value from the "economy" aspect.

Through the analysis, 15 CE values, i.e. system thinking, circularity, innovation, built-in resilience, cascades orientation, waste elimination, technology-driven, market availability, optimisation of change, economic optimisation, maximisation of retained value, leakage minimisation, collaborated network, shift to the renewable energy, and environmental consciousness, have been reformulated. Some values, e.g. leakage minimisation, maximisation of retained value, shift to renewable energy, built-in resilience and optimisation of change, are not directly related to the themes but do have an indirect link to them. ***Leakage minimisation*** emerges in the reverse cycle theme and can be controlled quantitatively. It can also be implemented differently in other contexts or activities. ***Maximisation of retained value*** is closely related to the economy, cascades, reverse cycle and environment themes. ***Shift to renewable energy*** has a strong link with the environmental aspect in terms of resources. ***Built-in resilience*** and ***optimisation of change*** originated from the ***system thinking*** *theme*. The overall mapping of the CE themes into CE values is illustrated in Figure 3.

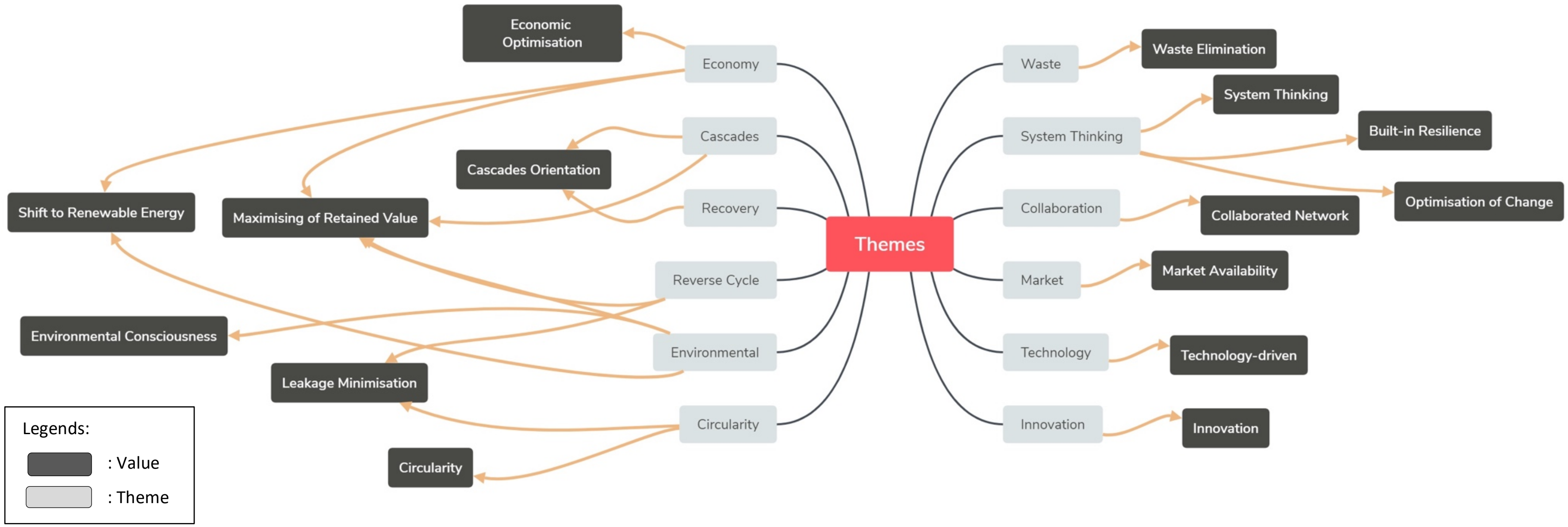

Figure 3 Mapping the CE themes into CE values

4.1.4 Circular Economy Values Definition

The 15 CE values need to be defined; this process has been completed by using all of the information that was collected.

Value #1. *Systems thinking* suggests that CE has to be looked at holistically, and all of the elements/components in the CE have to be considered as a system that integrates and influences one with another. (Chen, 2009; Li et al., 2009; EMF, 2013a).

Value #2. *Circularity* advocates developing a circular process to preserve the value of a product or component or material by keeping it in use longer through, e.g. repair, reuse, remanufacture and recycle (Pintér, 2006; Yong, 2007; Chen, 2009; Mathews and Tan, 2011; Yang, 2011; EMF, 2015; Lacy and Rutqvist, 2015; UNEP, 2015; Webster, 2015; Blomsma and Brennan, 2017; Hollander et al., 2017).

Value #3. *Innovation* enables CE by suggesting the use of new, novel methods and ideas to stimulate redesign and rethink a system in CE to reach the optimum results of its purpose (IMSA, 2013; Sempels, 2013).

Value #4. *Built-in resilience* is related to the internal capacity, robustness and responsiveness of a CE system to recover quickly from various disturbances, e.g. economy, technology, etc. (EMF, 2013a, 2015), hence becoming more resilient.

Value #5. *Cascades orientation* aims to keep the materials, be they products, components or materials or biological nutrients, longer in circulation and for them to be transformed into different types of products or materials (IMSA, 2013; EMF, 2015; Lacy and Rutqvist, 2015; Webster, 2015; Hollander et al., 2017; Kalmykova et al., 2018; Vouvoulis, 2018).

Value #6. *Waste elimination* emphasises that waste must be eliminated from the very beginning of the product design, and systematically considers, at subsequent circulation stages, how waste can be further reduced and eliminated (Geng et al., 2009; Mathews and Tan, 2011; Blomsma and Brennan, 2017; Vouvoulis, 2018).

Value #7. *Technology-driven*, suitable and economically viable technologies may be adopted to enable tracing the materials and products throughout the circulation, particularly in product recovery. The main goal is to achieve efficiency and effectiveness that supports the optimisation of operations (Geng and Doberstein, 2008; Pan et al., 2015).

Value #8. *Market availability*, be it a new or existing one, will enable the CE to create new business opportunities, thus encouraging the reusability of products, components or materials (Geng and Doberstein, 2008; Preston, 2012; Stahel, 2013; Ma et al., 2015).

Value #9. *Optimisation of change* is essential in the implementation of system or business models affected by the dynamics of problems, and takes into account the environmental, resources, technology, and consumer demand (EMF, 2013a, 2015).

Value #10. *Economic optimisation* aims to achieve the production and consumption, service and supply of money, so that a resilient economy can be created, e.g. by improving material productivity, enhancing innovation capabilities, or shifting from mass production to skilled labour (Pintér, 2006; Yong, 2007; Ma et al., 2015; Kalmykova et al., 2018).

Value #11. *Maximisation of retained value* aims to retain products or components that, over time, decline in value, by creating a suitable treatment system so that the value can be prolonged (Yuan et al., 2006; Huamao and Fengqi, 2007; Dajian, 2008; Mathews and Tan, 2011).

Value #12. *Leakage minimisation* upholds the avoidance of loss of opportunities to maximise the cascaded usage period of (a) biological materials and the inability to incorporate the nutrient back into the biosphere due to contamination, and (b) technical materials that are lost due to loss of materials, energy, components and materials are not (or cannot be) recovered. (EMF 2013a, 2015).

Value #13. *Collaborative network* is needed for the creation of materials' standards and information flow in the circularity and allows stakeholders to work together within an industry sector or between different sectors to achieve common goals (Geng and Doberstein, 2008; Hu et al., 2011; Preston, 2012).

Value #14. *Shift to renewable energy* highlights the ability of the CE to reduce the energy usage per unit of output and accelerates the shift towards renewable energy by design, treating the economy as a valuable resource (Pinjing et al., 2013; Ma et al., 2015; Pan et al., 2015).

Value #15. *Environmental consciousness* promotes the conservation of environmental resources and reduction of environmental impacts by adhering to environmental regulations (Hongchun, 2006; Zhu et al., 2010; Pinjing et al., 2013; Su et al., 2013; Hollander et al., 2017).

4.1.5 Mapping the Circular Economy Values

The last stage is ***mapping/grouping***. It is used to evaluate the 15 values of the CE that have been formulated before. The regrouping was done to find the consistency of the definition of CE values reformulation, the sequence between one item and others, and the implementation of the values in specific cases. The 15 items need to be classified with an appropriate name into some layers of the values of the CE. The layers are classified into: *principle*, *intrinsic attribute*, and *enabler*. **The first** layer indicates the essential activities/values/rules that should be followed to implement a CE. **The second** layer describes the internal CE characteristics as natural elements. **The third** layer is about some external aspects surrounding the CE that will support the practicality, possibility, and continuity in the implementation of a CE.

Based on the classifications above, each layer can be explained. The meaning of each layer is taken from dictionary definitions, where a *principle* is generally intended as a fundamental truth that serves as the foundation of a system, or as a basic idea or rule that explains or controls a system. A CE principle, could mean the essential characteristics that should exist when developing, creating, designing, etc. the CE systems. It is also indicated as being impossible to be ignored, as a clear activity, as active action, as an absolute value (measurable). An *intrinsic attribute* is generally defined as an essential natural element of a concept or system. Through this basic definition, the intrinsic attribute in the context of the CE can be defined as the natural available attribute for use in the implementation of a CE. The attributes will emerge within the natural elements of the system itself. It is indicated by a noun. An *enabler* is to make a system, operation, etc. possible, practical or easy. It could be a culture, a technology, or an infrastructure, etc. It is indicated by a noun.

Having identified the layers of CE items, the next step was to classify the items into layers based on the above-mentioned definitions and characteristics. To facilitate the classification or grouping into the appropriate layer, the following phrases were applied. The phrases describe the characteristics of each layer.

1. First layer (a principle)

(A1) A noun that emphasises reusability

(A2) A noun that relates to the environment

(A3) A noun that relates to the economy

(A4) A noun that can be measured and controlled

2. Second layer (an intrinsic attribute)

(A5) A noun that connects with the nature of the CE

(A6) A noun that mentions an internal, genuine CE characteristic

(A7) A noun that mentions advancement and achievement

(A8) A noun that can motivate the CE implementation

3. Third layer (an enabler)

(A9) A noun that has a role as assistant/facilitator

(A10) A noun as an element from the external environment

(A11) A noun that supports at the operational level

(A12) A noun that describes external facilitation

Based on the phrases above, the classification was done by analysing both the characteristic and value, then a classification was produced. The *first layer* consists of six items: maximising retained value, cascades/reverse cycle orientation, economic optimisation, environment consciousness, leakage minimisation, and waste elimination. The *second layer* consists of circularity, built-in resilience, collaborated network, system thinking, and optimisation of change. The *third layer* includes three enablers: technology, innovation, and market availability (see Figure 4).

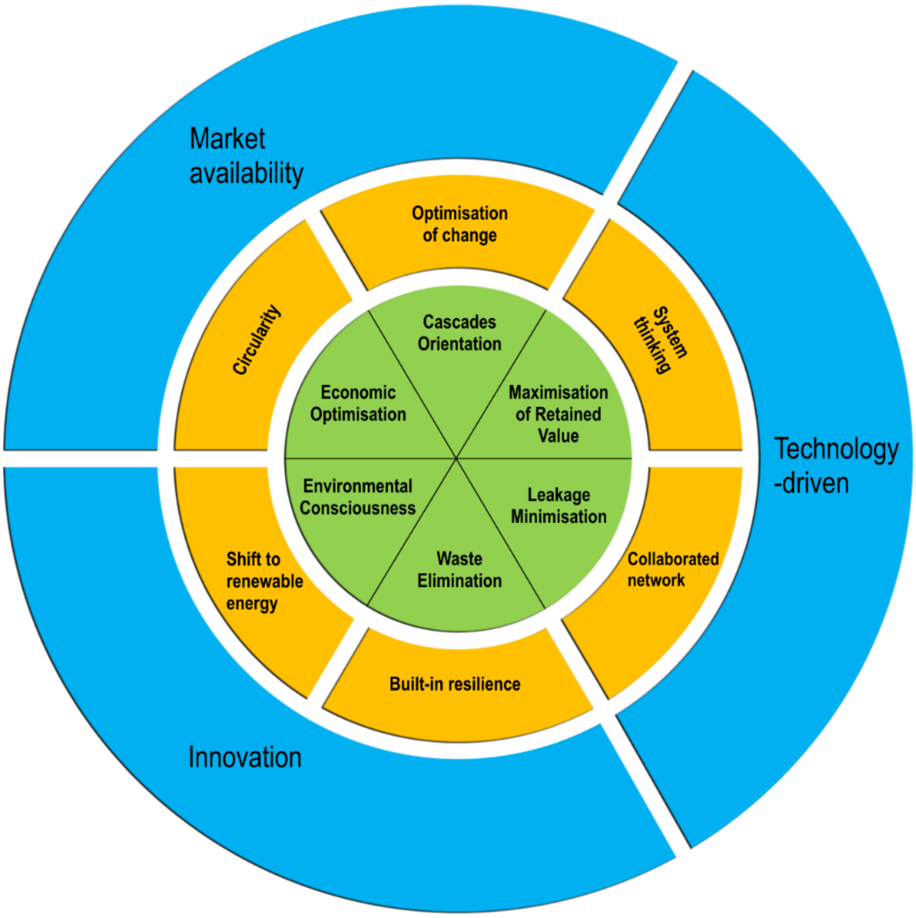

Figure 4 Circular economy values classification

5. Discussion

5.1. Circular Economy (CE) Values

The CE is a concept that has a wide coverage area: economy, ecology, social, technology aspects, etc. Within these areas, there are many activities from flow of raw material to becoming a product and vice versa. Each flow distinguishes the type of material (biological/technical). The flow also consists of some processes such as collection, maintaining, redistributing, or cascading. All of the processes are done to support regenerative and restorative determinants that can systematically support the balanced life system. This concept also has the general purpose of contributing to global economic opportunity. The understanding of a concept is needed to be able to implement the concept within the real system. By formulating CE principles in an available format, the adopting and understanding processes of the concept will be made easier. The principle is defined as a fundamental truth that can reveal the basis of this concept.

In this research, 15 CE principles have been reformulated from the literature as the CE values. This paper argues that the values themselves can be further grouped into the intrinsic attributes, enablers as well as principles. Whilst the principles of the CE are referred to as the fundamental truth or basic ideas or rules that explain or control a system, the **intrinsic attribute** is hereby defined as the natural available attribute for use in the implementation of the CE concept, and the **enabler** allows a system, an operation, etc. to practically and feasibly exist, and these could be a culture, a technology, an infrastructure, etc.

Pearce and Turner (1990), Kneese et al. (1970) in Andersen (2007), Park et al. (2010), Hu et al. (2011) and EMF (2012; 2013a), to some extent, proposed some principles of the CE but they did not provide a detailed process regarding how CE principles were formulated. Through this available method, the opportunities to discover or modify the new principles/values are wide open as the values are not prescriptive. The adaptability of this method is high because the user does not necessarily need to obtain many CE sources or read the vast amount of information related to the CE concept, as they have been well represented through the reformulated CE values.

The benefits from the reformulation of the CE principles create a readily available format that can easily be implemented in the design of specific cases, such as reverse logistics operations or product recovery. This study found that there are some CE values that are familiar to many researchers, for instance, system thinking. In the process of system development, each aspect will influence the others. Through this value, all aspects must be consistent and committed to both the implementation and the goals. ***Waste elimination*** means all the processes in the CE must aim to eliminate the amount of waste. ***Oriented to cascades/reverses cycle*** distinguishes the different types of material (biological and technical) and treats end-of-life products properly. ***Shift to renewable energy*** promotes the use of renewable energy whereas ***built-in resilience*** is related to the robustness a CE system to recover quickly from various disturbances, so it will contribute to the quality of the system being designed. ***Economic optimisation*** is a consideration for all aspects within the CE. The term optimisation is carefully chosen to emphasise the fact that maximising profit is not the only goal of CE; other aspects would need to be considered too.

Other values have been indirectly discussed by several authors. ***Circularity,*** for instance, means that the consequences of the adoption of the CE concept will create a circularity model naturally. All of the components will undergo circulation by using this model. It will keep the value longer by using suitable treatments, such as reuse, remanufacture, recycle, etc. ***Innovation***, this idea as an important aspect in the CE, and can be present in all the activities of CE. For example, in the design process of an electronic product, such as a laptop, to minimise the amount of waste and increase the functionality of the product, the design of the laptop is made modular. This process can be a standard for all laptop companies. ***Technology-driven,*** this value is needed to support the competitiveness of modern needs.

Regarding ***market availability***, a market is needed as a place in which to put the result of the system. Furthermore, concerning ***leakage minimisation,*** the possibility of a number of leakages identifies that this value should be exposed as an independent value, even though the activities could embed within other activities, such as in cascades/reverse cycle. ***Collaborated network,*** almost all values here need to collaborate with other companies/nodes or across industries, and this value is a control in the implementation of the CE itself. ***Environmental consciousness***, environmental consciousness is the basic goal in implementing the CE, this value needs to be explored in the process of implementing the CE.

In addition, in this research there are two new values that have been discovered as the most prominent: ***maximisation of retained value*** and ***optimisation of change***. This discovery may be the most significant contribution in this research. By comparing CE themes and values, it can be stated that those values have not yet been discussed explicitly by researchers. The value ***maximising retained value,*** will increase functionally and economically the value of used product before going back to landfill or incineration. The value will also provide some structural processes to increase the value of the product. ***Optimisation of change*** provides opportunities to optimise the circle that is concerning on where it could provide another opportunity.

Within the reformulation process of the 15 CE principles, it was found that not all of them could be categorised as principles; some were termed as intrinsic attributes, which were the natural characteristics of the CE; and enablers, which was identified as the operational drive to make a system easy. To cover all of the terms that have been found, another term such as value is needed. The word value was chosen to cover the 15 CE items, including principle, intrinsic attribute, and enabler.

5.2. Implications for Logistics and Supply Chain Management (SCM)

The CE principles reformulation can potentially be used in the supply chain particularly into a more circular, closed-loop supply chain. The closed-loop supply chain has two distinct flows – forward flows aiming to minimise services and cost, and reverse flows (also known as reverse logistics) to recover the unwanted, broken or end-of-life products from customers for return to the manufacturers. The complexity of products, services, and processes in the closed-loop supply chain increase as the business models of the CE grow. The business models require the supply chain to handle the transition in an agile manner, and in this respect, CE values can support this transition. As the CE focuses on keeping products, components, and materials at their highest utility and value at all times, this will affect the upstream processes in the supply chain, right from the process of manufacturing raw material to become products, until the products are received by customers. As mentioned above, in a closed-loop supply chain, the return management and reverse logistics services play an important role in handling returned or end-of-life products. Product returns have increased in recent years, along with changes in the scope and choice of product and services, and also trade-offs (Weetman, 2017) and therefore the return management and reverse logistics need to be handled properly. This can possibly be done by embedding the CE values into the design of a reverse logistics process that optimises the supply chain operations in general.

Embedding CE values can start by applying **system thinking** and **optimisation of change** right from the very beginning of the system design. Those values are an entry point to support the implementation of modern SCM. System thinking can also holistically analyse and consider all of the elements/components in a system. Optimisation of change is thus an important value that is capable of coping with dynamic problems in a system or business. In this way, all of the values of the CE can support the modernisation of SCM towards a circular initiative.

The **Supply Chain Operations Reference (SCOR)** model supports business activities in re-engineering, benchmarking, and measurement of the supply chain (Huang et al., 2005). The model comprises a number of activities, namely plan, source, make, deliver, and return (Stephens, 2001). Those activities need to be linked to one another to satisfy the customer demand. The return activity, in particular, is worth noting because it covers product return and receiving product, and post-delivery customer support. Linked to all of the echelons in the supply chain (suppliers, management and customers), the return activity influences all of the business activities in this model. The return activity, therefore, has an important role, especially in the planning activity.

Logistics management, a critical component in SCM, concerns the physical movement of materials and products in the whole supply chain (Langley, 1986; Lambert and Stock, 1993), whose goals include the provision of rapid response capability; minimum variance; minimum inventory expenses; consolidated shipments; high quality, and product life cycle support. Logistics also share the goal of SCM to meet customer requirements. Those aims of logistics are integrated, mutually influential, and share similar challenges to the supply chain in terms of scope and choice of products and services, and trade-offs that affect, for instance, the design of distribution networks. CE principles that support the distribution of network design well are, for example, collaborative network, leakage minimisation, market availability, and economic optimisation. Furthermore, one of the goals of logistics is **supporting the product life cycle**, meaning that logistics management concerns regarding life cycle mode and consequently the circular initiative model in logistics management is required.

As the closed-loop supply chain consists of two flows (forward logistics and reverse logistics), CE values can be embedded into the design of product recovery options (repair/reuse, refurbishment, remanufacturing, cannibalisation, and recycling). In the past, reverse logistics only focused on some keys logistics activities/roles, recovery/reuse activities, distribution channels, recapturing values reverse flow, and also cost. As the customer demand has increased, however, there is a greater need for the reverse logistics process to maximise the retained value of product/service, thus products will need to be cascaded in order to maintain them at their highest utility and value at all times.

5.3. Embedding CE Values in Logistics & Supply Chain Management

Embedding CE values can help facilitate a better understanding in designing, structuring, and evaluation of the supply chain, which are in fact values that the SCOR model aims to achieve. Embedding implies redesigning the business processes by including CE values, for example, circularity, collaborative network, cascades orientation, maximisation of retained value, into the reverse logistics and return management. Return management deals with **the return of product and the supporting services for customer post-delivery, which may involve** transportation, warehousing, 3rd and 4th party logistics, and reverse logistics itself. The circular initiative can be developed through embedding CE principles into these functions.

A robust strategy to plan and manage a supply chain is needed to address the complexity and issues in logistics and the supply chain in the context of the CE. Some of the issues include **facility, inventory, transportation, pricing, sourcing, demand forecast, obsolescence management** and **risks**. **Facility** issues are associated with the role, location, and capacity of repair, remanufacture, or part harvest activities in each echelon, such as supplier, manufacturer, and customer. These issues are therefore related to several CE principles such as circularity, built-in resilience, and collaborative network. In particular, facility location has a strong link with economic optimisation and market availability value. Capacity is another aspect in facility consideration that is closely related to, for instance, economic optimisation and collaborative network values. **Inventory** issues are related to the availability of spare parts. This means there is a strong need to engage the suppliers and partners within a collaborative network. **Transportation** is about creating a network to efficiently and effectively collect products from customers. The effectiveness and efficiency of the transport network may be affected by the values of innovation, technology-driven, market availability, collaborative network, and shift to renewable energy. **Pricing** is related to the product being sold. In determining a pricing strategy in the CE business, one should consider market availability, economic optimisation, and cascade orientation values. **Sourcing in-house/outsourced** processes to meet actual demand through procurement of goods and services engage the market availability and maximisation of retained values. **Demand forecast** could mean the management of demand that is based on availability, needs, and markets. This may, therefore, involve innovation, technology-driven, and market availability.

Ripanti (2016) described the embedding process of the CE for reverse logistics in six distinct steps: 1) deciding on reverse logistics operation options in order to have product recovery options; 2) identification of reverse logistics activities; 3) considering and reviewing circular economy values; 4) mapping reverse logistics options based on circular economy values; 5) identification of parameters of product recovery activities based on circular economy values; and 6) analysing parameters and decisions in the mathematical formulation. A similar exercise was also undertaken by Bernon et al. (2018) who embedded CE values into retail reverse logistics; they also found evidence of where reverse logistics practices were aligned with CE principles but had not been recognised as such by organisations.

6. Conclusions

Fifteen circular economy principles have been reformulated comprehensively by means of a systematic literature review. During the reformulation process of the CE principles, it was found that not all of them could be categorised as principles; some were termed as intrinsic attributes or the natural characteristics of CE, and enablers, which were identified as the operational drives to facilitate the operationalisation of a CE system. In this paper, the principles, intrinsic attributes and enablers are termed the CE values. The reformulation of CE principles that exist in the body of literature can also facilitate in the implementation of, for example, reverse logistics and closed-loop supply chains. Whilst some researchers previously described the CE principles at a conceptual level, this research has offered more detailed, operationalisation aspects of the CE via the three groups of CE values mentioned above.

The way the CE values have been formulated in this study opens up an opportunity to other researchers to continue to amend the collection of the CE values. Going forward, it is intended to develop a method that describes in detail the embedding process of CE values into product recovery. Imminent challenges in CE will continue to be unravelled, in particular related to the uncertainty aspects in product recovery, especially when the products have a long-life cycle.

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