

In Search of a Circular Supply Chain Archetype – A Content-Analysis Based Literature Review

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This paper addresses questions of how extant research discourses concerning the sustainability of supply chains contribute to understanding about circularity in supply chain configurations that support restorative and regenerative processes, as espoused by the Circular Economy ideal. In response to these questions, we develop a content-based literature analysis to progress theoretical body of knowledge and conceptualise the notion of a circular supply chain. We derive an archetypal form from four antecedent sustainable supply chain narratives - 'reverse logistics', 'green supply chains', 'sustainable supply chain management' and 'closed-loop supply chains'. This paper offers five propositions about what the circular supply chain archetype represents in terms of its scope, focus and impact. Novel insights lead to a definition of circular supply chain and a more coherent foundation for future inquiry and practice.

Keywords: circular supply chain, circular economy, sustainability perspectives of supply chains, restorative processes

1. Introduction

Over the past few decades, sustainability issues concerning supply chain operations have gradually occupied a more prominent space within the wide spectrum of managerial topics addressed by academics, practitioners and policy makers (Carter and Liane Easton 2011). The growing number of studies in this field has created a substantial body of literature in which four sustainability narratives of supply chains have emerged, namely: **reverse logistics**, **green supply chains**, **sustainable supply chain management (SSCM)** and more recently, **closed-loop supply chains**.

At a generic level of analysis, it is possible to associate these narratives with specific emphases, regarding the notion of 'circularity' in supply chain operations research. Govindan and Soleimani (2016) and Govindan, Soleimani, and Kannan (2015), for example, point out that **reverse logistics** is usually associated with supply chains that enable products to flow back into corporate operations, minimising the flows to landfill waste. **Green supply chain** research is particularly associated with a strong emphasis on reducing environmental and ecological impacts of product/process design and development. **Sustainable supply chain management (SSCM)** engages broader corporate governance and management of social responsibility issues for supply chain operations. Finally, **closed-loop supply chains** are associated with ideas that simultaneously consider forward and reverse supply chain operations.

A problematic aspect concerning these four sustainability narratives of sustainable supply chains is a general lack of conceptual distinction and in particular, in relation to restorative and/or regenerative outcomes. They largely overlap in many of the phenomena they address, to the extent that scholars refer to them interchangeably and studies consider reverse, green and close-loop aspects synonymously under a wider SSCM perspective (Seuring and Müller 2008; Carter and Rogers 2008; Walker and Jones 2012).

Glover et al. (2014, p103) point out that “*sustainability is a concept that is vague, ambiguous, pluralistic, contested, and grounded in different value systems*”. A potential problem with the ambiguities concerning the ‘sustainability’ notion of supply chains is the difficulty that practitioners face to design clearly sustainable supply chain processes and networks (Eskandarpour et al. 2015).

The recent economic perspective of the Circular Economy, is strongly grounded on social, economic and environmental sustainability values, calls for further considerations of the sustainability of supply chain operations (Genovese et al. 2017). By definition the Circular Economy refers to industrial production systems that are restorative and regenerative in purpose, where products, components and materials are kept in the market at their highest utility and value in the long term (Webster 2015). This fundamental principle posits a crucial importance on supply chains supporting circular production models that extend the life cycle of products, components and useful waste outputs. The so-called circular business models are shaping the growth of secondary goods markets supported by ‘circular’ supply chains where organisations from diverse sectors engage more collaboratively (Gurtoo and Antony 2007).

The transition to a Circular Economy predicated on business models facilitating reverse cycles, cascading of products, by-products and waste outputs, requires a refreshed appreciation to explore circular supply chain form(s) and their embedded circularities (Dervojeda et al. 2014; World Economic Forum 2014). The increased complexity and expanded scope of circular supply chains and their role as enablers of business responses to the sustainability imperatives of the Circular Economy deserve a more comprehensive understanding (Batista, Bourlakis, and Maull 2016; Smart et al. *Forthcoming*).

There is momentum for progressing theory by revisiting existing sustainable supply chain research in the light of Circular Economy ideal espoused on the global stage. Accordingly, this paper analyses extant literatures on sustainable supply chain by considering the main restorative processes underlying the ‘circularity’ features of business models in the Circular Economy. The following research questions are to be addressed:

RQ1: What extant body of knowledge on sustainable supply chains contributes to our understanding of the circular supply chain phenomenon of interest as espoused by the notion of a Circular Economy?

RQ2: What distinctive ‘form(s)’ of a circular supply chain enable restorative and regenerative processes in Circular Economy business ecosystems?

In response to the research questions, we conduct a content-based systematic literature review (Gosling et al. 2016; Jia et al. 2014; Seuring and Gold 2012) of sustainable supply chain research. We subsequently develop a conceptualisation of a circular supply chain archetypal form along with related propositions concerning fundamental aspects of circular supply chains.

The remainder of this paper is organised as follows. In the next section we highlight core restorative and regenerative processes of business models in the Circular

Economy and the enabling role of supply chain operations. This provides a basis for exploring ‘circularity’ within supply chains aspects that we seek to identify in the literature review. In the third section of this paper, we develop a content-based review of the literature, describing the methodology adopted for the selection and analysis of academic papers on sustainable supply chains. In the subsequent section, we introduce a conceptualisation of a circular supply chain archetype. Finally, the concluding section summarises the contributions of the paper and suggest directions for future research.

2. Restorative characteristics of the Circular Economy and the enabling role of supply chains

A growing body of literature is debating the philosophical paradigm of the Circular Economy, establishing the theoretical and practical foundations that place ‘triple bottom line’ sustainability as an inherent aspect of production systems (Lovins and Braungart 2014, Elkington, 2004). The strong emphasis on the sustainability capabilities of organisations is driving the market logic for businesses and the way they operate in the economy (Lacy and Rutqvist 2015; Preston 2012, Hart, 1995).

The call for a more sustainable economy is not new [see for example the works of Giarini and Stahel (1989) and Daly (1996)]. There is however an unprecedented favourable alignment of technological, political and social factors that are enabling an effective transition to a Circular Economy (BEIS Industrial Strategy Green Paper; Ellen MacArthur Foundation, 2012). This economic landscape is paving the way for business model innovations that aim to maximise societal and environmental benefits without detriment to economic benefits. Some of the dominant characteristics of productive systems in the Circular Economy are (Lacy and Rutqvist 2015; Webster 2015):

- The creation of closed-loop systems where waste to disposal processes are minimised through reusing, repairing, remanufacturing and recycling processes;
- The emphasis is on delivery of functionality and experience (value in use), rather than product ownership;
- Management approaches that build upon collaborative or shared consumption model.

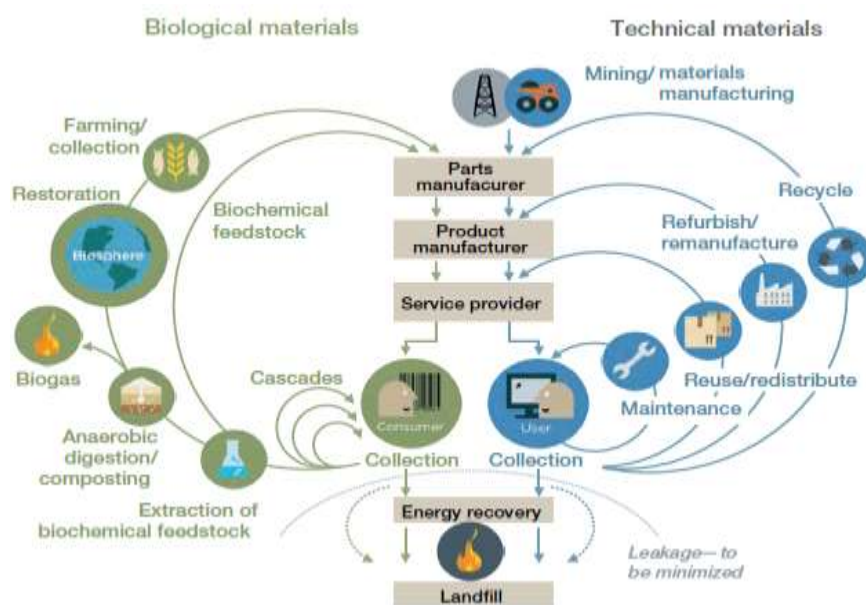
Such aspirations entail business model innovations that are aimed at extending the life of products (Bocken et al. 2014; Lovins and Braungart 2014), such as: (1.) minimisation of product replacement processes through reuse, repair or remanufacture activities and maintenance of stock value through service-life extension activities; (2.) goods are sold as services – ‘utilisation value’ replaces ‘exchange value’; and (3.) achievement of higher materials efficiency through shared utilisation of goods. In essence, these aspects represent restorative and regenerative capabilities of business models, i.e. their capacity to **restore** (impart new life and vigour, promote recuperation) and **regenerate** (recuperate to a new, usually improved, state) materials (Esty and Simmons, 2011). Both concepts entail the ‘recuperation’ or recovery of materials for further use. As the particular focus of this paper is on specifying an archetypal circular supply chain enabling the recovery of materials in general, for simplification we will use the terminology ‘restorative’ to also refer to the ‘regenerative’ capabilities of organisations and related supply chain operations.

A practical translation of the Circular Economy places emphasis on the purposeful design of the restorative and regenerative capabilities of business models and related supply chain operations (Dervojeda et al. 2014; Lovins and Braungart 2014; Murray, Skene, and Haynes 2017), i.e. a circular economy is restorative and regenerative by intention and design (EM Foundation 2012; Webster 2015). We draw on the idea of purposeful design in operations management research (Brown, Bessant, and Lamming 2013), which conventionally recognises that design can involve the design of a product, the design of a process, and the design of a supply chain. This three-level stratification offers a helpful basis to distinguish the restorative opportunities within complex productive systems that seek overall net positive sustainability impact. More specifically, we imply that the restorative and regenerative opportunities and practices of new business models in a Circular Economy context can be purposefully designed at three distinct levels as follows:

- (1.) *At the level of the product:* This level refers to the physical features of products that allow life expansion and restoration, such as modularity, reparability options, upgradability, and recyclability attributes (EU Commission 2015);
- (2.) *At the level of the organisation:* This level suggests restoration processes that take place in an organisation, such as reusing, repairing, reconditioning, refurbishing, remanufacturing, and recycling processes. The All-Party Parliamentary Sustainable Resource Group (APSRG) differentiates these processes as follows (APSRG 2014):
 - *Reusing:* Simple reuse of a product, with no modifications;
 - *Repairing:* Simple fixing of a fault, with no guarantee attached to the product as a whole;
 - *Reconditioning:* Adjustments made on a product's components in order to bring it back to working order, but not necessarily to a 'like-new' state;
 - *Refurbishing:* Large aesthetic improvements on a product, which may bring it to a 'like-new' state, but with limited functionality improvements;
 - *Remanufacturing:* A series of manufacturing activities on an 'end-of-life' part or product, in order to bring it to a 'like-new' state that may involve improved functionalities;
 - *Recycling:* Transformation of a product's materials into raw materials for use in new products.
- (3.) *At industry level:* This level suggests restoration through cascading of used materials and renewable resources between firms, engagement in waste and by-product synergy systems, sharing of resources and infrastructure, and involvement in industrial symbiosis processes across diverse organisations (Chertow 2007; EU Commission 2015).

The aspects described above are represented in Figure 1, which illustrates that restorative value chains can take place to recover two generic types of materials, namely: Biological materials (from bio-organic nature) and technical (not bio-organic) materials. An important aspect of these value chains is the expanded complexity of the supply chains they involve. For instance, the circular cycles in restorative value chains are enabled by supply chains that implement material flows from consumption points to production points. This is typical of reverse logistics approaches; however, it is not necessarily the case of Circular Economy supply chains, as the loop flows may not involve returns to the focal company. This expanded scope of supply chain operations in the Circular Economy calls for further theoretical considerations, as discussed in the following sections.

Figure 1. Restorative value chains in the Circular Economy.
Source: World Economic Forum (2014)



It is important to understand the implications of the circular flows advocated by the Circular Economy ideal to the implementation of sustainable supply chains. As mentioned previously, supply chain configurations associated with sustainability matters have evolved from reverse logistics models, going through green supply chain concepts, to more recent closed-loop supply chain models.

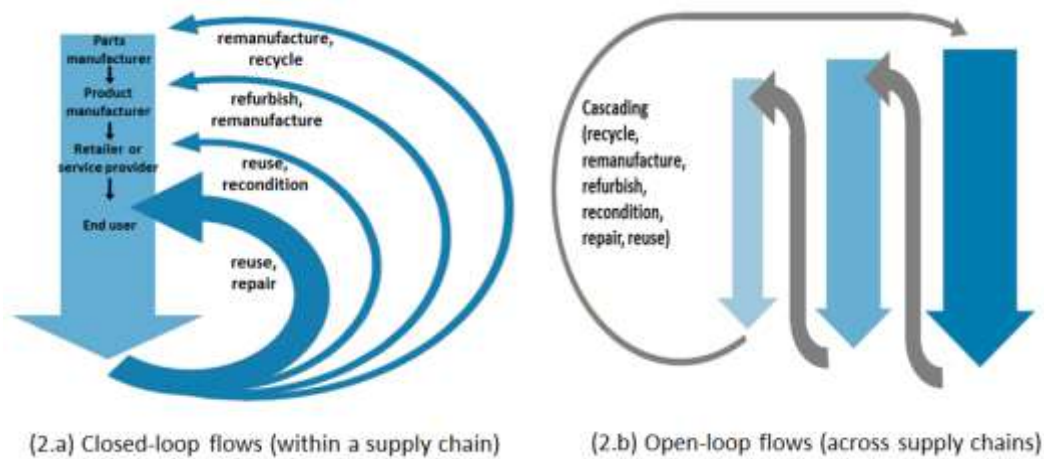
The design of supply chain operations that encourage the flow of products back into productive systems has reignited research on reverse logistics and its role on enabling business sustainability (Loomba and Nakashima, 2012; Beh et al., 2016; Jalil et al., 2016; Parry et al., 2016). Despite enabling reverse flows, we argue that the reverse supply chain narrative is insufficient to address the wide scope of restorative and regenerative processes and related supply chain configurations that might occur in the Circular Economy. For instance, it may also be the case that circular flows through which products, components and materials are fed forward into further production processes. ‘Circular’ flows can comprise reverse (closed-loop) flows as well as forward (open-loop) flows of products, components and other materials, such as by-products and

waste. We therefore imply that circular supply chains refer to logistics and supply chains implementing closed-loop and/or open-loop flows inherent in the restorative processes of organisations.

Figure 2 below illustrates the well-known Ellen MacArthur Foundation (EMF) depiction of potential restorative flows enabled by circular supply chains in the context of a Circular Economy idealisation. The Figure shows that restorative processes may comprise closed-loop flows which refer to reverse flows involving organisations **within** a supply chain of a focus company (Figure 2.a). These flows may also be cascaded through forward open-loop flows linking organisations **across** other supply chains from other organisations (Figure 2.b). This extended scope of the circular supply chain concept encompasses all supply chain loops implementing the restorative flows a business model implements. This view allows a more structured characterisation of the complex mix of restorative supply loops supporting Circular Economy business models.

Figure 2. Restorative flows enabled by circular supply chains.

Source: EM Foundation (2014).



3. Content-based systematic literature review

3.1. Methodology

Our initial objective was to identify how reverse, green, closed-loop and SSCM perspectives relate to sustainability and circular supply chain features enabling restorative processes such as reuse, repair, remanufacturing, recycling and cascading. This provided the basis for the development of an archetypal model of a circular supply chain, which is further characterised by formal elaborations of fundamental propositions underpinning its core aspects as well as structured logical linkages with its antecedent perspectives. In methodological terms, this followed a process of theory building based on knowledge emerging from a backward-oriented integration of previous evidence (Hoon 2013).

A content-based systematic literature review comprised the main methodological approach of the study. This method relates to systematic literature review (Tranfield, Denyer, and Smart 2003) approaches involving a more orderly and consistent method to map, consolidate and identify gaps in an existing body of

knowledge (Gosling et al. 2016; Jia et al. 2014; Seuring and Gold 2012). Indeed, this method provided an efficient process to address the first research question, for which the systematic review allowed a more focused identification of ‘circularity’ features of supply chains that emerge from main sustainability perspectives of supply chains, namely: (1.) reverse logistics, (2.) green supply chains, (3.) closed-loop supply chains and (4.) wider SSCM views. In practice the ‘circularity’ aspects of supply chains represent circular supply chain designs and processes supporting the circular flows of materials enabling the restorative capabilities of businesses (Dervojeda et al. 2014; Lovins and Braungart 2014; Webster 2015), as described in the previous section.

The content-based approach allowed the capture of the main ‘circularity’ narratives emerging from extant sustainable supply chain research and body of knowledge. The approach is a specific branch of systematic literature review that focuses on qualitative content/narrative analysis (Gosling et al. 2016; Jia et al. 2014; Seuring and Gold 2012). This method of systematic literature search and analysis has been applied in recent supply chain related studies involving theoretical reviews (Appolloni et al. 2014; Gosling et al. 2016; Jia et al. 2014).

In general, systematic content-based analysis of literature within empirical social science can be developed through a quantitative approach where meta-analysis quantitatively describes the manifest content of communication (Seuring and Gold 2012), or a qualitative approach where specific content is identified and interpreted with basis on theory-driven analysis of fixed communication (Schreier 2014). Given that the heterogeneity of the subject –in our case, sustainable supply chain perspectives– diminishes the applicability of meta-analysis as a method for synthesising knowledge (Tranfield, Denyer, and Smart 2003), we have adopted the qualitative approach to develop the content-based analysis. Seuring and Gold (2012) describe the main steps involved in this method, as follows:

- (1.) *Material collection*: Delimitation of the material and unit of analysis;
- (2.) *Descriptive analysis*: Initial descriptive analysis of the material;
- (3.) *Category selection*: Selection of the collected material according to specific analytic categories or dimensions;
- (4.) *Material evaluation*: Theoretically-based analysis of the material according to the categories previously specified.

This selective approach provides a helpful methodological basis for the examination of research work in a systematic way, allowing convergence of focus only on the works considered most significant and relevant to the theoretical aspects being reviewed.

Accordingly, the selective approach was implemented with basis on the three search streams (A, B and C) shown in Table 1. Search stream A selected from research publications on sustainable supply chains perspectives comprising reverse, green, closed-loop and SSCM perspectives, including direct references to ‘circular’ and ‘open loop’ supply chains. Search stream B selected from research publications on core supply chain functional areas. These search streams were further combined with search stream C, which selected from publications on key restorative processes enabled by supply chains. Table 1 shows a detailed list of the search streams and related search strings adopted in the literature selection process.

Table 1. Search streams and related search strings (full/truncated)

A. Sustainability perspectives of supply chains	B. Supply chain functional areas	C. Restorative processes
“reverse” “green” “closed loop” “sustainable” “circular” “open loop”	“supply chain*” “logistics” “transport*” “sourcing” “purchasing” “procurement”	“reuse” “repair*” “recondition*” “refurbish*” “remanufactur*” “recycl*” “cascad*”

To ensure that as many relevant articles as possible would be included in the selection process, we applied the search strings in titles, keywords and abstracts of manuscripts from relevant publication sources. Peer-reviewed articles published in English language journals were considered as the unit of analysis, as they represent a major communication means among researcher communities. The selection process was conducted in two stages. First, interfaces between ‘sustainability perspectives of supply chains’ and ‘supply chain functional areas’ (i.e. search streams A ‘AND’ B shown in Table 1) were initially selected. Then, the initial selection was narrowed down through a refined selection of papers from this group which addressed key restorative processes advocated by the Circular Economy (i.e. research streams A ‘AND’ B ‘AND’ C).

We have applied the selection criteria shown in Table 2 to select papers from two major academic source databases that provide access to full text publications, namely:

- *EBSCO (Business Source Premier)*: It provides full text coverage for more than 2,300 journals, including over 1,100 peer-reviewed titles;
- *PROQUEST (ABI/INFORM Global)*: It is one of the most comprehensive business databases on the market, including in-depth coverage from thousands of publications, most of them in full text.

Although these two databases do not cover all business publications in the market, they provide access to a significant large number of top tier journals covering the business and economics areas, including industrial ecology and cleaner production perspectives of organisations. This allowed us to identify predominant features and viewpoints of different sustainability perspectives of supply chains derived from peer-reviewed research publications of high academic standard. From a methodological perspective, the selection of these two databases represented the application of convenience sampling, which is a sample selected by the researcher by virtue of its convenient availability and practicability (Bryman and Bell 2015). Practically, we adopted the rationale that using a reduced number of representative databases would facilitate the conduction of the study and the replicability of related outcomes in further research. To gauge the representativeness of these two databases, a trial applying search streams A and B on a third well-established database such as the *Web of Science* has produced a slightly higher number of outcomes than *EBSCO* and *PROQUEST*.

However, after application of the selective criteria in Table 2 the outcomes from the *Web of Science* have converged to results identical to the selections from across *EBSCO* and *PROQUEST*. We have therefore assumed that using these two databases only would not concede significant publication misses and together they would allow the capture of sufficient relevant publications on the subject area considered.

Table 2. Literature review selection criteria

Criteria	Inclusion	Exclusion	Rationale
1. Publication quality	Peer-reviewed articles	Not peer-reviewed articles	Selection of articles with high quality research and academic rigour
2. Publication language	Articles written in English	Articles written in other languages	Selection of articles written in a language that most researchers worldwide can read; English is a global language for academic publications
3. Publication length	Full-text articles	Summarised articles; abstract and citations only	Full-text articles allow more detailed content analysis
4. Publication type	Empirical and conceptual journal papers	General articles from magazines and newspapers, working papers	Selection of articles providing empirical evidence and theoretical contributions across scientific communications acknowledged by the academic community
5. Publication scope	Papers whose research addresses reverse, green, closed-loop and SSCM supply chains perspectives and related functional areas	Papers referring to reverse, green, closed-loop and SSCM perspectives of supply chains as a secondary subject superficially considered in a context addressing other organisational aspects / areas	Selection of articles whose main subject area encompasses one or more of the subject perspectives being considered in the research
6. Publication focus	Papers whose research addresses	Papers referring to restorative practices that were not	Selection of articles with specific focus on the subject areas that are of

	restorative processes directly related the reuse, repair, reconditioning, refurbishing, remanufacturing, recycling and cascading/open loop practices	considered within a supply chain perspective	particular interest of the research
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The selection criteria above specified was intentionally strict, with the purpose of narrowing down the body of literature into academic research that particularly contributed to the specific areas and aspects considered in this study. Criteria 1, 2, 3 and 4 above were implemented through the application of the selective option functions available on the *EBSCO* and *PROQUEST* search engine platforms. Duplicate papers listed by the two databases were identified through a cross-checking of publications' title, authors and journal name. Selection criteria 5 and 6 were applied via direct analysis of papers' abstracts and key words. Finally, we did not establish a start date for the selection process, leaving the publication period open for selection of the full range of publications that meet the selection criteria specified in Table 2.

The first search process considered publications selected according to search streams A 'AND' B (Table 1). This resulted in 457 papers listed by *EBSCO* and 567 papers listed by *PROQUEST*, making a total of 1024 papers selected. From this total, 289 papers were duplicates, i.e. listed by both databases. Therefore, after subtracting the duplicates we have identified a total of 735 papers selected in the first round.

We refined this initial selection by further selecting papers containing one or more of the search strings in stream C (Table 1). This process resulted in 220 papers. From this group, 99 were duplicates and 72 were out of scope (exclusion criteria 5 and 6, Table 2). After subtracting the duplicates and out of scope papers, we have finalised the selection phase with a total of 49 papers identified for final in-depth review. We drew from the 49 papers key aspects of the overlapping domains of supply chain sustainability perspectives, functional areas and restorative processes that supported the characterisation and the propositional fundamentals of a circular supply chain archetype that can be used as a basis for future empirical research.

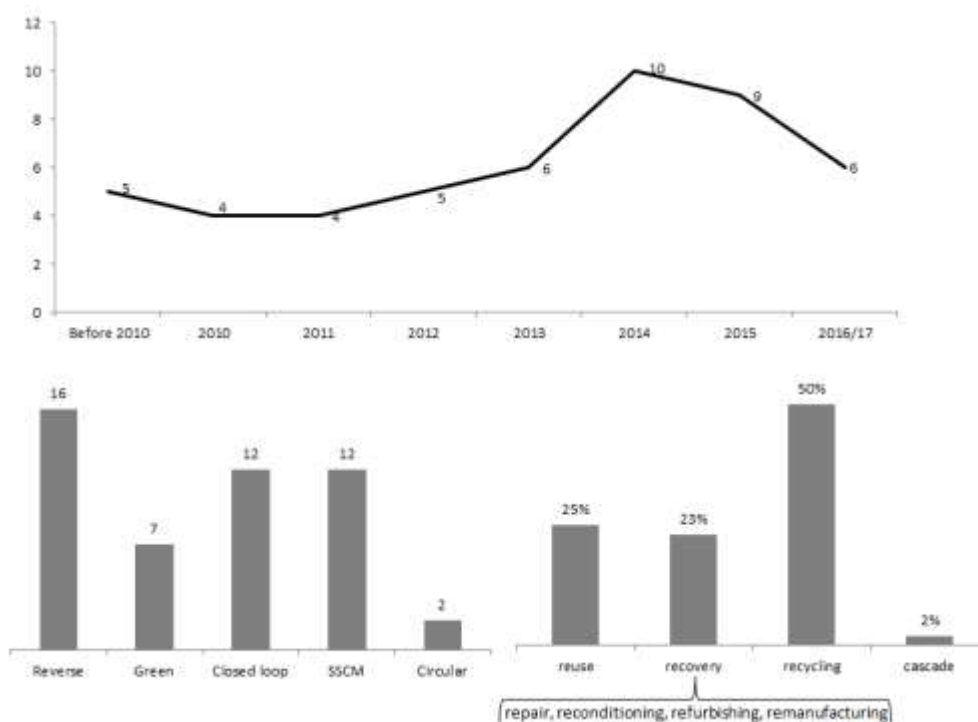
3.2. Findings

Figure 3 presents general descriptive statistics for the 49 papers selected for content analysis. The publications timeframe varies from 1992 to 2017, with a noticeable steady increase of publications after 2011. A growing political, social and scientific concern with the climate change over the last decade is likely to have influenced such an upsurge of publications on sustainability issues regarding supply chains.

The supply chain sustainability perspectives (stream A, Table 1) are fairly balanced between reverse, close loop and wide SSCM views, followed by green supply

chain perspectives. In terms of circular perspectives (stream C, Table 1) addressed by the publications, there is a predominant focus on recycling processes supported by supply chains (50%), followed by a balanced number of publications focusing on reuse (25%) and recovery (23%) processes, which include repair, reconditioning, refurbishing and remanufacturing. It is worth noting that the use of the term ‘circular’ remains minimal and little attention is paid to the role of supply chains in cascading processes. Only two papers selected develop a relative in-depth discussion of supply chains with close consideration of Circular Economy principles and related restorative processes. This outcome suggests an opportunity in the knowledge base aimed at understanding supply chains in circular economy terms.

Figure 3. General descriptive aspects of the selected publications



We have analysed supply chain research papers in accordance with their sustainability narratives. In this respect, there is a substantial body of literature on reverse supply chains linking **reverse logistics** with sustainability issues. Such linkages can be identified in research published more than two decades ago. For instance, Pohlen and Farris (1992) developed a model of the reverse logistics channels used in recycling processes of plastics, in which they include restorative processes involving collection of recyclable material and retro-manufacturing (use of recycled commodities in manufacturing processes). From their point of view, reverse chains for recycling are mainly industry-led initiatives where customers play a more passive role. They recognise, however, that shifting responsibility for recycling within the channel and determining the role of the consumer are key areas where the channel efficiency and structure of the reverse logistics can improve.

A fundamental ‘circularity’ notion of reverse logistics is its role to implement the movement of materials from consumers back to producers. This is embedded in its

very definition, as described by Rogers and Tibben-Lembke (2001, p130), who define reverse logistics as:

“the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal”.

Besides recycling, over the years, researchers have been considering reverse logistics perspectives related to other alternatives to disposal processes such as reuse, repairing, reconditioning and remanufacturing (Agrawal, Singh, and Murtaza 2015; Cannella, Bruccoleri, and Framinan 2016; Khor et al. 2016). This expanded scope of restorative processes associated with reverse logistics represents a shift from the predominant focus on single products collected and recovered as a whole to wider reverse logistics perspectives that consider multiple products and related spare parts (Tahirov, Hasanov, and Jaber 2016). In many cases, returned items are disassembled for the recovery of useful components (a process also known as ‘cannibalisation’) that can be used in different restorative processes, after which products are introduced back into the market (Lai, Wu, and Wong 2013).

The expanded scope of reverse logistics perspectives led to different sustainability perceptions of supply chains, such as green, sustainable supply chain management (SSCM) and closed-loop views. The **green perspective** puts more emphasis on environmental issues concerning supply chains. For van Hoek (1999), the partial and fragmented contributions of reverse logistics research failed to address the application of value-seeking and proactive approaches to more ‘green’ supply chains. Other authors however do not see green approaches as a departure from reverse logistics perspectives. For instance, Tahirov, Hasanov, and Jaber (2016) see reverse logistics as an important component of green supply chains and the ‘green’ approach to managing supply chains implies a managerial integration of material and information flows throughout the supply chain to satisfy customer demand for environmentally friendly products and services.

By definition, green supply chains involve traditional supply chain management approaches with the additional ‘green’ component, which includes managerial practices such as green purchasing, green distribution, green manufacturing, eco-design, etc. which lead to improved environmental and economic performance (Green et al. 2012). Typical restorative processes such as recycling, repairing, remanufacturing, and so forth are studied from green supply chain viewpoints which usually involve broad perspectives of analysis (Büyüközkan and Çifçi 2012; Mishra, Kumar, and Chan 2012; Dües, Tan, and Lim 2013) as reflected in the managerial practices above mentioned.

Although the green supply chain narrative has considerable overlap with the **SSCM narrative** (Wu, Ding, and Chen 2012; Glover et al. 2014), it remains essentially narrower in scope and opportunity for innovation (Ahi and Searcy 2013). While the former has a predominant focus on the environmental dimension of sustainability, the latter extends the environmental perspective to include social and economic perspectives that, together, allow more comprehensive triple bottom line approaches to supply chain management (Beske and Seuring 2014; Fabbe-Costes et al. 2014). This

aspect is acknowledged by Ahi and Searcy (2013, p339), who define SSCM as the:

“creation of coordinated supply chains through the voluntary integration of economic, environmental, and social considerations with key inter-organizational business systems designed to efficiently and effectively manage the material, information, and capital flows associated with the procurement, production, and distribution of products or services in order to meet stakeholder requirements and improve the profitability, competitiveness, and resilience of the organization over the short- and long-term”.

Once again distinct from the broad narratives mentioned above, the **closed-loop narrative** is concerned with the appropriate logistics and supply chain structures to support forward and backward flows of products. The restorative flows of materials considered by this narrative overlaps significantly with the reverse perspectives above discussed; however, the reverse logistics and closed-loop perspectives of supply chains are fundamentally different in scope and opportunity for innovation. A primary notion is that while reverse logistics focuses on the reverse flows of materials from the point of consumption to the point of origin, closed-loop supply chains consider forward and reverse supply chains simultaneously (Govindan and Soleimani 2016). In other words, closed-loop supply chain combines forward and reverse supply chains to cover entire product life cycles from cradle to grave. This fundamental aspect is reflected in a classic definition provided by Guide and Van Wassenhove (2009, p10), who define closed-loop supply chain management as the:

“design, control, and operation of a system to maximize value creation over the entire life cycle of a product with dynamic recovery of value from different types and volumes of returns over time”.

Fahimnia et al. (2013) make an explicit link between the closed-loop narrative and restorative circular processes by stating that closed-loop supply chains incorporate reverse logistics systems designed to manage the flow of products or parts destined for reuse, recycling, remanufacturing or disposal. Das and Rao Posinasetti (2015) also connect the closed-loop narrative with restorative models that include reprocessing of end-of-life products and disposal of unusable parts. They also link the closed-loop idea with product recovery through refurbishing and repairing options, and materials recovery through recycling processes.

The closed-loop supply chain narrative is closely related to initial references regarding ‘**circular**’ **supply chains**, which assumes a broader agenda of product life cycles in order to include post-production stewardship. In this sense, circular supply chains entail integrated supply chain models in which product returns from end consumers go through recovery operations such as reuse, repairing, reconditioning, remanufacturing or recycling and are integrated back into forward supply chains (Genovese et al. 2017). According to Krikke, le Blanc, and van de Velde (2004), recovery options may be applied either in the original supply chain through closed-loop flows back to the supply chain of the focus firm or in alternative supply chains through open-loop flows into other forward supply chains. This forward feeding aspect is directly associated with the ‘open-loop’ feature of closed-loop supply chains. Nasir et

al. (2017) view such combination of closed and open loops as a ‘quasi-closed’ supply chain system in which the boundary of green supply chain management is extended to incorporate the Circular Economy principle of continuous circulation of resources.

Table 3 below provides a summary of relevant studies that contributed to the characterisation of predominant sustainable supply chain narratives. Many studies overlap in terms of the sustainability perspectives they address. In Table 3 we have grouped them according to the supply chain conceptualisations, scope and models they share around reverse, green, SSCM and closed-loop perspectives.

Table 3. Illustrative publications for sustainable supply chain operations

Sustainable supply chain narrative	Predominant considerations	Related academic articles
Reverse logistics	<ul style="list-style-type: none"> - Movement of materials from consumers to producers (i.e. reverse flows of materials); - Logistics role to support restorative processes such as repairing, reconditioning, remanufacturing and recycling, as well as disposal processes 	<p>International Journal of Physical Distribution & Logistics Management:</p> <ul style="list-style-type: none"> - Pohlen and Farris (1992) <p>International Journal of Production Economics:</p> <ul style="list-style-type: none"> - Lai, Wu, & Wong (2013); - Cannella, Bruccoleri, & Framinan (2016); - Khor et al. (2016); - Tahirov, Hasanov, & Jaber (2016) <p>Journal of Business Logistics:</p> <ul style="list-style-type: none"> - Rogers & Tibben-Lembke (2001) <p>Resources, Conservation and Recycling:</p> <ul style="list-style-type: none"> - Agrawal, Singh, & Murtaza (2015)
Green supply chains	<ul style="list-style-type: none"> - Emphasis on general environmental issues concerning supply chains; - Integration of green practices (e.g. green purchasing, green distribution, green manufacturing, eco-design, etc.) with traditional supply chain management practices; 	<p>International Journal of Production Research:</p> <ul style="list-style-type: none"> - Mishra, Kumar, & Chan (2012) <p>Journal of Cleaner Production:</p> <ul style="list-style-type: none"> - Dües, Tan, & Lim (2013) <p>Production Planning & Control:</p> <ul style="list-style-type: none"> - Büyüközkan & Çifçi (2012) <p>Supply Chain Management: An International Journal:</p> <ul style="list-style-type: none"> - van Hoek (1999);

	<ul style="list-style-type: none"> - Environmental accreditation of suppliers; - Supplier process improvement in terms of waste and CO₂ emission reduction 	<ul style="list-style-type: none"> - Green et al. (2012)
SSCM	<ul style="list-style-type: none"> - More comprehensive triple bottom line approaches to supply chain management; - Integration of environmental, social and economic capabilities that allow organisations and related supply chains to achieve long- term sustainability performance 	<p>International Journal of Operations & Production Management:</p> <ul style="list-style-type: none"> - Fabbe-Costes et al. (2014); - Zorzini et al. (2015) <p>International Journal of Production Economics:</p> <ul style="list-style-type: none"> - Wu, Ding, & Chen (2012); - Glover et al. (2014) <p>Journal of Cleaner Production:</p> <ul style="list-style-type: none"> - Ahi & Searcy (2013) <p>Supply Chain Management: An International Journal:</p> <ul style="list-style-type: none"> - Beske & Seuring (2014)
Closed-loop supply chains	<ul style="list-style-type: none"> - Logistics and supply chain structures and configurations to support flows of used and recovered products; - Integration of forward and reverse supply chains to cover entire product life cycles from cradle to grave; - Restorative supply chain models that include reprocessing of end-of-life products and disposal of unusable parts 	<p>California Management Review:</p> <ul style="list-style-type: none"> - Krikke, le Blanc, & van de Velde (2004) <p>European Journal of Operational Research:</p> <ul style="list-style-type: none"> - Govindan, Soleimani, & Kannan (2015) <p>International Journal of Production Economics:</p> <ul style="list-style-type: none"> - Das & Rao Posinasetti (2015) <p>Journal of Cleaner Production:</p> <ul style="list-style-type: none"> - Fahimnia et al. (2013); - Govindan & Soleimani (2016) <p>Operations Research Informs:</p> <ul style="list-style-type: none"> - Guide & Van Wassenhove (2009)

Overall, although the literature analysis indicates academic research with direct

references to ‘circular’ (or the idea of circularity) in supply chains, its characterisation still remains a marginal venture in the field of supply chain operations management. There is indeed a lack of a conceptualisation of what constitutes a ‘circular supply chain’ in the context of a Circular Economy ideal. Thus far, due to associations with restorative and regenerative processes, the reverse and closed-loop narratives offer useful contributions towards theoretical frames that link sustainable supply chain operations research with circular economy principles and praxis. By considering reverse and forward flows, the closed-loop supply chain narrative in particular offers a useful starting point to represent what might be construed as circular supply chain operations. However, the closed-loop narrative remains insufficient because it does not address wider post-production and stewardship operations espoused by the grand idealisation of a Circular Economy, such as for example the supply chain operations supporting waste flows and by-product synergies linking organisations from diverse sectors. This calls for a sustainable supply chain narrative that connects more adequately with the broader industrial ecosystem involving flows of products, by-products and useful waste. We address this deficiency in the next section, where we introduce a conceptualisation of a **circular supply chain archetype** that integrates and builds upon core features of the four supply chain narratives discussed in the preceding sections.

Further insights captured from the 49 selected publications are presented in Table 4, which provides a relative distribution of their focus in terms of three aspects: (1.) The category of the material (biological or technical) involved in the supply chains they consider; (2.) the range of the materials addressed (i.e. focus on a product only or focus on a product and related by-products/waste); and (3.) the predominant methodological approach they adopt.

Table 4. Further characterisation of the selected publications’ focus

		% of papers				
		Reverse	Green	SSCM	Closed loop	Circular
Restorative cycles	Biological materials	5%	30%	20%	25%	35%
	Technical materials	95%	70%	80%	75%	65%
Materials considered	Main product	95%	75%	75%	90%	--
	Main product, by-product & waste	5%	25%	25%	10%	100%
Methodological approach	Quantitative	90%	70%	50%	60%	--
	Qualitative	10%	30%*	50%	40%	100%*

*The qualitative approach usually involves some quantitative analysis within wider case study/LCA approaches

An interesting outcome suggests an overall emphasis on supply chain studies focusing on sustainability related issues concerning ‘technical materials’, particularly in reverse logistics publications (95% of the selected papers). There is a slight increase of studies considering ‘biological materials’ under the ‘green’, SSCM and ‘closed loop’ narratives, but these are still predominantly focused on technical materials. A plausible explanation for this might be that a number of restorative processes (e.g. reuse, repair, refurbishing and remanufacturing) are more naturally associated with non-biological materials. In what concerns restorative cycles of biological materials, these are usually considered under processes such as extraction of biochemical feedstock, anaerobic digestion / composting, generation of biogas, etc.

An important outcome reveals that the reverse, green, SSCM and closed loop narratives tend to focus on the flow of one main product only. This outcome provides a valuable insight regarding the characterisation of studies considering the sustainability of supply chains in the context of a Circular Economy. Due to the broad scope and stronger emphasis the Circular Economy posits on resource efficiency, the supply chains analysed from the Circular Economy perspective usually take into account a spectrum of restorative cycles involving not only the main products, but also the related by-products and useful waste. They also commonly consider the economic dimension of sustainability alongside with the environmental and the social dimensions. This augmented complexity might help to explain the preference for mixed method approaches in circular supply chain studies, where predominant case study approaches are combined or complemented by quantitative analysis.

4. Fundamental aspects of a circular supply chain archetype

In response to our second research question, we introduce a conceptualisation of a **circular supply chain archetype** that takes into account the wide spectrum of restorative and regenerative flows advocated by the Circular Economy idealisation. To this end, we integrate the dominant features of the existing sustainable supply chain narratives (reverse, green, SSCM and closed-loop) to provide a more comprehensive understanding of a circular supply chain.

The ‘closed-loop’ narrative provides a helpful perspective to represent key circularity aspects of Circular Economy business models. However, we should be mindful that its propositions tend to emphasise reverse (closed-loop) flows, even though ‘open-loop’ flows are also part of the ‘closed-loop’ narrative. Our view is that embedding ‘open-loop’ flows into the broader conceptualisation of ‘closed-loop’ supply chain may appear counter intuitive, undermining understanding and the accurate representation of the circularity features of the supply chains supporting Circular Economy business models.

In addition, the closed-loop narrative tends to focus more on the flows of main products, to the detriment of by-products and useful waste flows. This is evident in the definition of closed-loop supply chain management provided by Guide and Van Wassenhove (2009), who, as previously mentioned, point out that closed-loop supply chains support value creation systems derived from entire product life cycles and related returns. Following from this, we suggest that the fundamental distinction between the ‘closed-loop’ and the ‘circular’ supply chain perspective lies in the scope and the focus of their associated value chain systems. Hence, we suggest the following propositions:

Proposition 1: *Circular supply chains represent an expansion of the closed-loop narrative of sustainable supply chains in terms of scope and focus of the value chain systems they consider.*

In terms of scope,

Proposition 2: *Circular supply chains extend the boundaries of closed-loop supply chains by taking into account post-production stewardship to include forward feeding flows into alternative supply chains.*

In terms of focus,

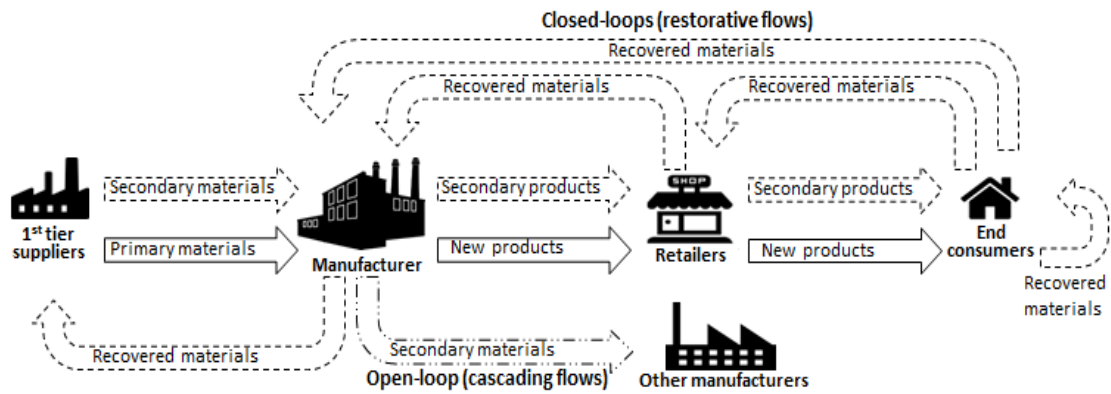
Proposition 3: *Circular supply chains support sustainable value chain systems derived not only from products and their end of life returns, but also from associated by-product synergies, services and waste flows.*

These fundamental propositions help us to specify a **definition of circular supply chain**, as follows:

The coordinated forward and reverse supply chains via purposeful business ecosystem integration for value creation from products/services, by-products and useful waste flows through prolonged life cycles that improve the economic, social and environmental sustainability of organisations.

Based on the definition above, we can infer that circular supply chains entail the integration of the main original supply chain with additional restorative supply chains supporting the implementation of materials recovery processes. The original supply chain refers to the traditional forward supply chain supporting core production processes of organisations. The restorative supply chains refer to two restorative cycles: (1.) The reverse supply chains supporting closed-loop cycles of products (returns) and components back to the organisation in focus, and (2.) the forward open-loop cycles supporting cascading flows of materials to organisations outside the original supply chain (Dervojeda et al. 2014; Krikke, le Blanc, and van de Velde 2004; Tahirov, Hasanov, and Jaber 2016). This scenario is illustrated in Figure 4, which represents a generic **archetype of a circular supply chain** and the different types of material flows it involves. In the figure, the **primary materials** are the raw materials used in the core production process of an organisation. The **recovered materials** are the returned products, parts, components, as well as by-products and useful waste that can be used as inputs in further production processes. The **secondary materials** are materials such as used products, parts, components, by-products and useful waste that can be used in restorative processes for the production of secondary products (e.g. repaired, reconditioned, refurbished, remanufactured or recycled products).

Figure 4. A circular supply chain archetype



The supply chain archetype above also points out typical product recovery loops in circular supply chains. A fundamental aspect to highlight here concerns the **peculiar aspects of the recovery loops** that take place at different levels, and involve different actors, across the supply chain. For instance, the loops downstream, particularly the ones at ‘end consumer’ level, typically involve product reuse (a subject largely discussed under the ‘sharing economy’ theme) and product repair initiatives. By their turn, remanufacturing processes usually involve loops linking consumers downstream with manufacturers upstream.

These loop differentiations are important because they are claimed to have different levels of ‘resource efficiency’ in terms of their impact in the context of a circular economy (Stahel 2010). That is, although all possible restorative and regenerative loops enabled by circular supply chains are important, the ‘inner loops’, i.e. the ones downstream the supply chain, are claimed to be the ones that generate less environmental impact because they require less reprocessing of materials (Dervojeda et al. 2014; Stahel 2010). We formally elaborate on this notion by suggesting the propositions below.

Proposition 4: *In a circular supply chain, inner loops involve restorative and regenerative processes that minimise (re)processing of materials/resources.*

Therefore,

Proposition 5: *Circular supply chains should be designed to maximise restorative and regenerative processes downstream.*

We state these propositions herein in a formal and explicit manner with the intention of building theory through a cumulative logic process (Hoon 2013) to provide novel contribution for a wider audience from distinct disciplines. Thus, our definition and propositions represent conceptual building blocks that aggregate fragmented ideas into formal and explicit explanations (Meredith 1993). In doing so our insights add to the growing body of knowledge in the field.

Table 5 connects the core circular flows in the specified archetypal model (Figure 4) with some specific studies considered in the literature analysed and related theoretical aspects.

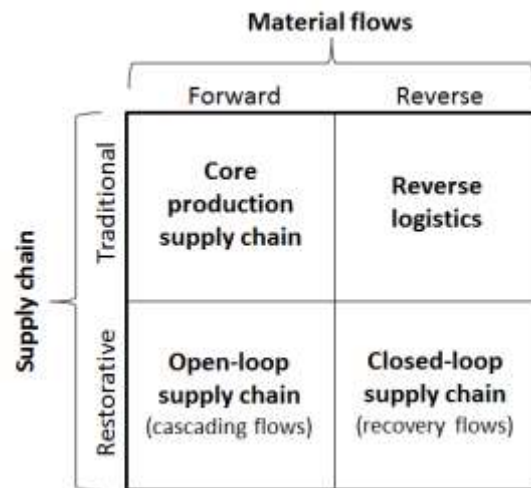
Table 5. Circular supply chain linkages with previous studies and related theoretical aspects

Archetypal element	Previous studies	Related theoretical aspects
Circular flow of recovered materials back upstream the supply chain	<ul style="list-style-type: none"> - Green et al. (2012) - Wu, Ding, & Chen (2012) - Lai, Wu, & Wong (2013) - Glover et al. (2014); - Das & Rao Posinasetti (2015) - Cannella, Bruccoleri, & Framinan (2016) - Khor et al. (2016) - Tahirov, Hasanov, & Jaber (2016) 	<ul style="list-style-type: none"> - Creation of reverse or closed-loop systems where waste to disposal processes are minimised through reusing, repairing, remanufacturing and recycling processes - Design of supply chains implementing flow of products back into productive systems - Environmental sustainability of supply chains
Circular flow of recovered materials at end consumers levels	<ul style="list-style-type: none"> - Rathore, Kota, & Chakrabarti (2011) - Sampson and Spring (2012) - Sigala (2014) - Kortmann & Piller (2016) 	<ul style="list-style-type: none"> - Productive systems that emphasise delivery of functionality and experience, rather than product ownership - Productive systems that build upon collaborative or shared consumption approaches - Achievement of higher materials efficiency through shared utilisation of goods
Cascading (forward flows) of secondary materials to other producers outside the supply chain in focus	<ul style="list-style-type: none"> - Park, Sarkis, & Wu (2010) - Rizzi et al. (2013) - Leigh & Li (2015) - Genovese et al. (2017) - Nasir et al. (2017) 	<ul style="list-style-type: none"> - Development of restorative capabilities of businesses at the level of industry - Involvement in industrial symbiosis processes across diverse organisations - Cascading of used materials and renewable resources between firms, engagement in waste and by-product synergy systems

Circular supply chain is considered a collective term for the coordinated forward and reverse supply chains, as indicated in the definition of circular supply chain proposed. More specifically, a circular supply chain comprises a series of supply chain processes which are expected to improve the life span of products and enable core restorative and regenerative processes being implemented by business model innovations that aspire to circular economy ideas (Lovins and Braungart 2014; World

Economic Forum 2014). The forward and reverse flows can be implemented through traditional and restorative/regenerative supply chains. To facilitate understanding, Figure 5 provides a logical, structured and holistic representation of the ‘traditional-restorative / forward-reverse’ supply chains that form in a circular supply chain.

Figure 5. Structured integration of component supply chains in the wide circular supply chain context



We finalise our discussion by summarising the fundamental premises concerning a circular supply chain archetypal form in terms of sustainability, design and value chain composition.

- *Sustainability*: It expands the closed-loop perspective of supply chains by considering value creation chains derived not only from products and related end of life returns, but also from by-products and useful waste flows recovered from reverse or forward cascading chains. It involves triple bottom line approach to improve the economic, social and environmental sustainability of organisations.
- *Augmented design complexity*: It requires coordinated integration of the traditional supply chain with restorative supply chains supporting the implementation of restorative processes involving forward and reverse flows. Furthermore, it may involve several loops of recovery materials for a number of different restorative processes (e.g. reuse, repairing, reconditioning, refurbishing, remanufacturing, recycling and cascading).
- *Downstream design*: In terms of resource-efficiency, circular supply chains should be designed to favour restorative processes downstream.
- *Value chain composition*: It comprises traditional and restorative supply chains involving forward and reverse value chains of primary and secondary materials.

5. Conclusion

This paper addresses the following two research questions: (1.) What extant body of knowledge on sustainable supply chains contributes to our understanding of the circular supply chain phenomenon of interest as espoused by the notion of a Circular Economy? and (2.) What distinctive ‘form(s)’ of a circular supply chains enable restorative and regenerative processes in Circular Economy business ecosystems?

In response to our questions, we conducted a content-analysis based literature review on existing sustainability narratives of supply chains and major restorative and regenerative processes advocated by the Circular Economy ideal. We derive an archetypal form from four antecedent sustainable supply chain narratives - ‘reverse logistics’, ‘green supply chains’, ‘sustainable supply chain management’ and ‘closed-loop supply chains’. We subsequently offer five propositions about what the circular supply chain archetype represents in terms of its scope, focus and impact. Novel insights lead to a definition of circular supply chain and a more coherent foundation for future inquiry and practice. In doing so, the paper contributes to a recent call by the academic community for the development of integrative theories surrounding sustainable supply chain management (Markman and Krause 2016).

The conceptual aspects here developed have practical implications. For instance, we emphasise the importance of coordinated integration of distinct value chains (traditional and restorative/regenerative) comprising a circular supply chain. It is also important to stimulate restorative processes downstream. This is possible by designing products that facilitative reuse and repair processes close to end consumers. Product modularisation in this context becomes an essential strategy (Mikkola and Skjøtt-Larsen 2004), which can be supported by the circular supply chain archetype characterised in this paper.

The research developed here is not exempt from limitations. The content-based method and related selective approach to developing the systematic literature review allowed us to focus on key contributions to the research topic. Nonetheless, the selection process may have been too strict and overlooked other key papers in the area, hindering a more comprehensive analysis. The papers here analysed are far from stressing the full range of contributions and different perspectives in the area. For example, there is a growing evidence of businesses implementing restorative processes based on by-product and waste material synergies involving industrial symbiosis collaborations. Future research may want to discuss these business models and related circular supply chains in the light of the conceptualisation and propositions here introduced.

The Circular Economy advocates a certain ‘resource efficiency’ hierarchy for the restorative loops discussed in the paper, claiming that ‘inner cycle’ loops are more environmentally friendly (Dervojeda et al. 2014; Stahel 2010). Although there is a coherent logic in this assertion (see propositions 4 and 5), future replication and validation studies are welcomed.

Another important topic for further research concerns the sustainability efficiency of ‘closed’ and ‘open’ loops. A key debate between proponents of the Circular Economy and other experts in the sustainability arena lies in the fact that not all ‘circular’ processes are more sustainable than ‘open loop’ processes and vice versa. The

archetypal circular supply chain model here developed provides a helpful frame of reference of closed and open loops to support future research addressing this debate from a supply chain angle.

An in-depth discussion of the configurational challenges of circular supply chains and the network of actors engaged in different restorative business models is also an important area for further research. As Bocken et al. (2014) point out, sustainability value is not created by firms acting in isolation, but by a group of actors acting together through formal and informal arrangements. Circular Economy business models and their related circular supply chains comprise a wide set of stakeholders that require a broader value chain outlook that take into account the collaborative ties for developing and enacting the restorative and regenerative capabilities espoused by the Circular Economy.

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