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Business Models in the Circular Economy and the Enabling Role of Circular Supply Chains

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1 Introduction

As a response to climate change regulations, the rising costs of raw material acquisition and the environmental impact of by-products and waste disposal processes, over the past decade organizations have been

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systematically implementing business models to extend the life cycle of products, components and useful waste outputs (Lovins & Braungart, 2014). Business initiatives in this direction typically involve the conservation of materials by taking products, components, by-products and waste back into further production and commercial cycles through reusing, remanufacturing and recycling processes for as long as possible (EM Foundation, 2012). Such a market trend represents a key principle of the circular economy, which advocates production systems that are restorative by purpose, shifting product value chains from linear ("cradle to grave") to circular ("cradle to cradle") cycles (Webster, 2015).

A fundamental feature of business models in a circular economy is therefore their capability to implement circular value chains that maximize resource efficiency. This is possible through reducing primary extraction processes and minimizing disposal activities in which valuable resources leak out of the economy.

Reducing primary extraction and disposal activities requires prolonged use of materials. This can be achieved through businesses models that involve the design of products with higher durability and reparability features. Other business models involve the implementation of restorative processes where value is created via product reuse, product remanufacturing (i.e. renewing of products) and recycling of by-product and waste materials (Lovins & Braungart, 2014).

In a wider context, circular economy business models may involve complex networks of organizations that generate new economic value through the continuous exchange of resources (e.g. cascading of materials across firms). This is facilitated by innovative technologies and supply chain ecosystems (Dervojeda, Verzijl, Rouwmaat, Probst, & Frideres, 2014; Genovese, Acquaye, Figueroa, & Koh, 2017) that enable product-service offerings and industrial symbiosis initiatives linking organizations across different sectors of the economy (Chertow, 2007; Sarkar, 2013).

Although the circular economy concept has gained increasing prominence in academic, practitioner and policy circles, its actual enactment is still limited and fragile (Gregson, Crang, Fuller, & Holmes, 2015). The transition to a circular economy based upon restorative design, production involving reverse cycles, cascading processes, and cross-sector collaborations beyond traditional supply chain boundaries (Crowther & Gilman, 2014; Dervojeda et al., 2014) requires a more comprehensive understanding of the "circularity" features of business models. In this context, the increased complexity and expanded scope of "circular" supply chain operations and their role as enablers of circular economy business models also deserves a better understanding.

More specifically, there is growing recognition of the benefits promoted by new business initiatives in the circular economy and their potential to drive growth and productivity with the basis on economic, social and environmental sustainability imperatives (Preston, 2012). However, little is currently understood about the eco-innovative features representing "circularity" aspects of business models in the circular economy and the enabling role and fundamental characteristics of "circular" supply chains. Important questions emerging in this context are: what are the key "circularity" features of business models implementing circular economy praxis? How do they enable prolonged circulation of resources? What are the enabling roles of "circular" supply chains? What are the fundamental characteristics of a circular supply chain archetype?

This chapter addresses the issues above by presenting key theoretical and practical aspects underlying circular economy business models and related supply chain systems shaping the circular economy. The chapter is organized as follows. In the next section, we highlight core restorative aspects of business models in the circular economy and the enabling role of supply chain operations. This is followed by the presentation of fundamental aspects of a circular supply chain archetype. In the sequence, illustrative business cases are briefly presented and discussed in the light of the core restorative processes they implement and the role of related supply chains enabling the circular flows of materials. We conclude the chapter by summarizing its contributions and suggesting directions for future research.

2 Restorative Aspects of Circular Economy Business Models

There is a growing body of literature shaping 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 and the economy as a whole. The strong emphasis on the sustainability capabilities of organizations is driving the market logic for businesses and the way they operate in the economy (Lacy & Rutqvist, 2015; Lovins & Braungart, 2014; Preston, 2012).

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 favorable alignment of technological, political and social factors that are enabling an effective transition to a circular economy (EM Foundation, 2012). This economic landscape is paving the way for business model innovations that maximize societal and environmental benefits without detriment to economic benefits. Some of the key aspects of productive systems in the circular economy are (Lacy & Rutqvist, 2015; Webster, 2015):

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

The aspects above can be translated into practical features of business model innovations that are mainly aimed at extending the lifespan of products (Bocken, Short, Rana, & Evans, 2014; Lovins & Braungart, 2014). This can be achieved through: (1) minimization of product replacement processes through reuse, repair or remanufacture activities; maintenance of stock value through service-life extension activities; (2) goods are sold as services; "utilization value" replaces "exchange value"; and (3) achievement of higher materials efficiency through shared utilization of goods.

In essence, these aspects represent restorative and regenerative capabilities of business models, i.e. their capacity to **restore** (impart new life and vigor, promote recuperation) and **regenerate** (recuperate to a new, usually improved, state) materials (Esty & Simmons, 2011). As both concepts entail the "recuperation" or recovery of materials for further use, for simplification we will use the terminology "restorative" to also refer to the "regenerative" capabilities of organizations and related supply chain operations.

By definition the circular economy refers to an economy that is restorative by purpose, in which products, components and materials are kept in the economy at their highest utility and value in the long term (Webster, 2015). This fundamental principle underlies the business features mentioned above, positing a critical importance on the restorative capabilities of businesses. It also implies that the restorative capabilities of a business model can be purposefully designed.

Thus far, the existing circular economy literature does not specify what constitutes the restorative capability of a business. To address this issue we draw on the notion of purposeful design from an operations management perspective (Brown, Bessant, & Lamming, 2013), which conventionally recognizes 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 conceptual basis to distinguish the restorative capabilities that can be implemented by new business models in the circular economy. More specifically, we imply that the restorative capabilities of circular economy business models can be purposefully designed at the level of the product, the process and the industry. Hence, by making linkages with restorative features of products, processes and industry, we specify the following "circularity" capabilities of businesses at three levels:

1. *At product level*: This level refers to physical features of products that allow life expansion and restoration, such as reparability, durability, upgradability and recyclability attributes (EU Commission, 2015);
2. *At firm level*: This level refers to restorative processes that take place in an organization, 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):

    (a) *Reusing*: Simple reuse of a product, with no modifications;
    (b) *Repairing*: Simple fixing of a fault, with no guarantee attached to the product as a whole;
    (c) *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;

(d) *Refurbishing*: Large aesthetic improvements to a product, which may bring it to a "like-new" state, but with limited functionality improvements;
(e) *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;
(f) *Recycling*: Transformation of a product's materials into raw materials for use in new products.

3. *At industry level*: This level refers to 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 symbiotic processes across diverse organizations (Chertow, 2007; EU Commission, 2015).

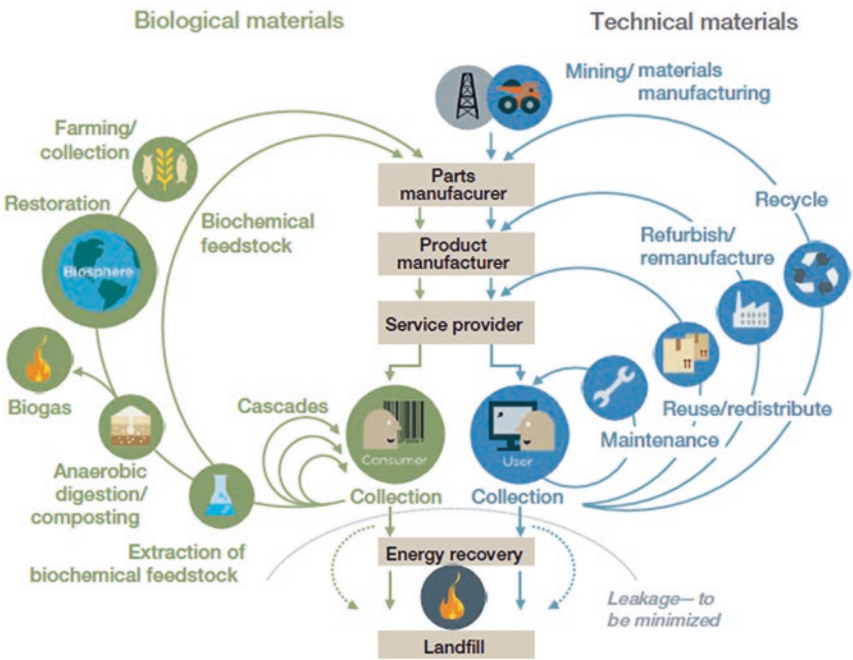

Fig. 7.1 Restorative value chains in the circular economy (WEC, 2014)

The aspects described above are embedded in Fig. 7.1, which shows that restorative (circular) value chains can take place to recover two generic types of materials: biological and technical.

An important aspect of the circular flows shown in Fig. 7.1 is the expanded complexity of the supply chains involved. In practice, the circular flows 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 and closed-loop supply chains. However, it is not necessarily the case of circular supply chains, as the restorative loops may not involve "returns" to the focal company. Rather, they may involve forward loops (open-loops) comprising an alternative circular flow of materials. This expanded scope of supply chain operations in the circular economy calls for further theoretical considerations, as discussed in the following sections.

3 Enabling Role of Supply Chains

It is essentially important to understand the wider implications of circular economy business models to supply chain operations. From a simplistic point of view, supply chains tend to be thought of as primarily "linear" structures, where products flow from one organization to another and eventually to an end user. Research on supply chain management has evolved from linear supply chain perspectives to include multiple and overlapping relational linkages in complex business networks in which firms are embedded—see the supply chain configurational perspectives discussed by Srai and Gregory (2008) and Pathak, Wu and Johnston (2014).

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 in enabling business sustainability (Beh, Ghobadian, He, Gallear, & O'Regan, 2016; Jalil, Grant, Nicholson, & Deutz, 2016; Loomba & Nakashima, 2012; Parry, Brax, Maull, & Ng, 2016). Despite enabling reverse flows, we argue that the reverse logistics narrative is insufficient to address the wide scope of restorative processes and related supply chain configurations that occur in the circular economy. For instance, in some cases the circular flows of products, components and materials are enabled by forward-feeding flows into further production processes external to the focal organization. "Circular" flows therefore 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 organizations.

Figure 7.2 illustrates potential restorative flows enabled by circular supply chains in the context of a circular economy idealization. The figure shows that restorative processes may comprise closed-loop flows which refer to reverse flow of materials involving organizations **within** the supply chain of a focus company (Fig. 7.2a). Other flows may involve cascading of materials through forward open-loop flows linking organizations **across** other supply chains comprising other organizations (Fig. 7.2b). This extended scope of the circular supply chain concept encompasses all supply chain loops implementing the restorative flows a business model can implement. This view allows a more structured characterization of the complex mix of restorative supply loops supporting circular economy business models.

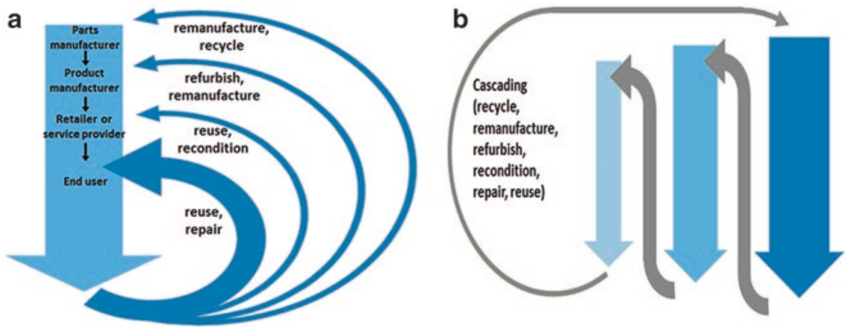

Fig. 7.2 Restorative flows enabled by circular supply chains (EM Foundation, 2014). (a) Closed-loop flows (within a supply chain), (b) open-loop flows (across supply chains)

4 Theoretical Antecedents of Circular Supply Chains

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 & 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**.

In general, it is possible to associate these narratives with specific emphases regarding the notion of "circularity" in supply chain operations. Govindan and Soleimani (2017) 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, minimizing 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 concerning supply chain operations. Finally, closed-loop supply chains are associated with approaches that simultaneously consider forward and reverse supply chain operations.

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

Overall, 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 recognize, 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 refers to 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, p. 130), 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, & Murtaza, 2015; Cannella, Bruccoleri, & Framinan, 2016; Khor, Udin, Ramayah, & Hazen, 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, & Jaber, 2016). In many cases, returned items are disassembled for the recovery of useful components that can be used in different restorative processes, after which products are introduced back into the market (Lai, Wu, & Wong, 2013).

The expanded scope of reverse logistics perspectives led to different sustainability narratives 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 et al. (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, Zelbst, Meacham, & Bhadauria, 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 & Çifçi, 2012; Dües, Tan, & Lim, 2013; Mishra, Kumar, & Chan, 2012).

Although the green supply chain narrative has considerable overlap with the **SSCM** narrative (Glover, Champion, Daniels, & Dainty, 2014; Wu, Ding, & Chen, 2012), it remains essentially narrower in scope (Ahi & 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 & Seuring, 2014; Fabbe-Costes, Roussat, Taylor, & Taylor, 2014). This aspect is acknowledged by Ahi and Searcy (2013, p. 339), 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.*

Differently from the 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 overlap significantly with the reverse logistics narrative discussed above. 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 & Soleimani, 2017). In other words, a 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, p. 10), 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, Sarkis, Dehghanian, Banihashemi and Rahman (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 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 the notion of "circular" supply chains, which assume 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 flows may be enabled by either 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, Genovese, Acquaye, Koh and Yamoah (2017) view such a 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.

Overall, although the literature indicates academic research with direct references to "circular" (or the idea of circularity) in supply chains, its characterization still remains a marginal venture in the field of supply chain operations management. There is indeed a lack of a conceptualization 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 constructed as a circular supply chain operation. However, the closed-loop narrative remains insufficient because it does not address wider post-production and stewardship operations espoused by the grand idealization of a circular economy, such as the supply chain operations supporting waste flows and by-product synergies linking organizations across diverse industrial 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 conceptualization of a circular supply chain archetype that integrates and builds upon core features of the supply chain narratives discussed thus far.

5 Fundamental Aspects of a Circular Supply Chain Archetype

In this section we introduce a conceptualization of a circular supply chain (CSC) archetype we developed in previous research (Batista, Bourlakis, Smart, & Maull, 2018). The research included a content-based literature review of the antecedent narratives discussed in Sect. 4 in order to specify a CSC archetype that takes into account the wide spectrum of restorative and regenerative flows advocated by the circular economy. We integrate the dominant features of the antecedent narratives (reverse, green, SSCM and closed-loop) to provide a more comprehensive and theoretically sound basis 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 emphasize 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 conceptualization of a "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-product synergies 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. We hence derive 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 a circular supply chain**, as follows:

> *The coordinated forward and reverse supply chains via purposeful business ecosystem integrations 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 organizations.*

Based on the definition above, we can infer that circular supply chains entail the integration of the main linear supply chain with additional restorative supply chains supporting the implementation of circular economy production ecosystems. The linear supply chain refers to the mainstream forward supply chain of new products produced by organizations. The restorative supply chains refer to two distinct restorative streams: (1) the reverse supply chains involving closed-loop cycles of products (returns) and components back to the organization in focus; and (2) the forward open-loop streams supporting cascading flows of materials to organizations outside the linear supply chain (Dervojeda et al., 2014; Krikke et al., 2004; Tahirov et al., 2016). This comprehensive supply chain configuration is illustrated in Fig. 7.3, which represents a generic **archetype of a circular supply chain** comprising the material flows previously mentioned. In the figure, the **primary materials** are the raw materials used in the production of products derived from primary resources. The **recovered materials** are the **returned** products, parts,

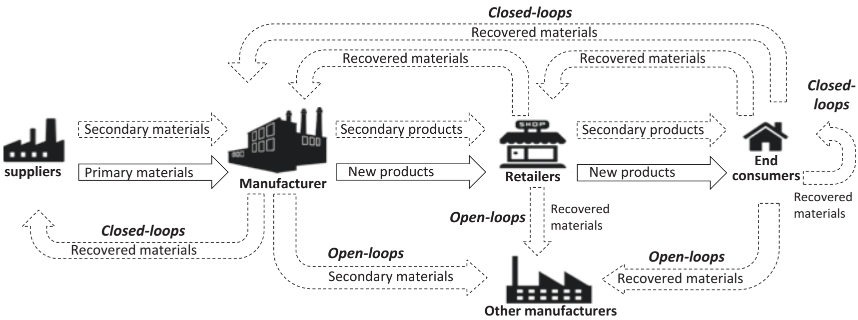

Fig. 7.3 A circular supply chain archetype

components, as well as by-products and waste that flow back as input materials for further production processes. The **secondary materials** are recovered materials that were processed to be used as feedstock for the production of **secondary products** (e.g. repaired, reconditioned, refurbished, remanufactured or recycled products), which do not necessarily present inferior quality.

The supply chain archetype in Fig. 7.3 points out distinct restorative loops inherent 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 in 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 minimize (re)processing of materials/resources.*

Therefore,

Proposition 5 *Circular supply chains should be designed to maximize 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 a 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.

In conceptual terms, "circular supply chain" should be considered as a collective term for the co-ordinated integration of 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 lifespan of products and enable core restorative and regenerative processes being implemented by business model innovations that aspire to circular economy ideas (Lovins & Braungart, 2014; WEC, 2014). The forward and reverse flows can be implemented through the concerted integration of traditional (linear) and restorative supply chains. To facilitate understanding, Fig. 7.4 provides a logically structured representation of the "traditional-restorative/forward-reverse" supply chain integrations that may take place in a circular supply chain.

We finalize our discussion by summarizing 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

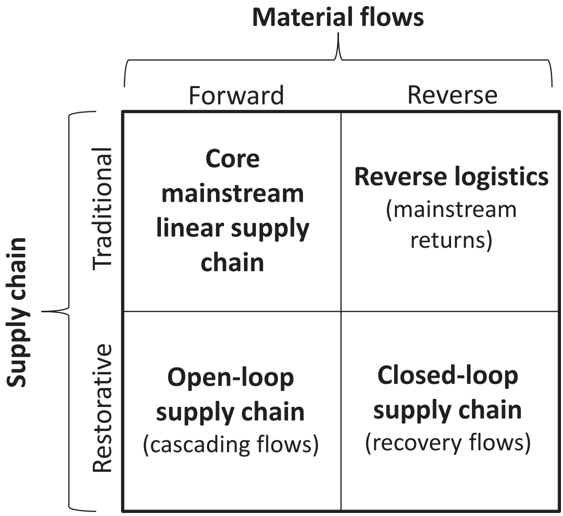

Fig. 7.4 Structured integration of component supply chains in the wide circular supply chain archetype

waste flows recovered from reverse or forward cascading chains. It involves a triple bottom line approach to improve the economic, social and environmental sustainability of organizations.

- *Augmented design complexity*: It requires coordinated integration of the traditional linear 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 favor restorative processes downstream.
- *Value chain composition*: It comprises traditional (linear mainstream) and restorative supply chains involving forward and reverse value chains of primary and secondary materials.

6 Business Model Initiatives Towards the Circular Economy

Business model initiatives towards the circular economy seek to incorporate a "triple bottom" line (economic, social and environmental) sustainability approach to the market by taking into account a wide range of stakeholder interests, including maximization of societal and environmental benefits, rather than economic gain only. To provide a practical perspective of the subject, we draw from secondary data some business cases that implement one or more of the restorative processes discussed above. The cases provide illustrative examples of circular economy business practice. In this section, we focus on the value creation dimension represented by the restorative capabilities of the business models considered.

The creation of "value" is a key feature of a business model. As defined by Baden-Fuller and Morgan (2010), a business model is the logic of the firm, the way it operates and creates value for its stakeholders. Osterwalder and Pigneur (2010) expand on this by defining the business model as the rationale of how a firm generates, distributes and captures value. They specify three fundamental dimensions of value creation:

1. *Value proposition*: Product and service features that aggregate value to stakeholders;
2. *Value delivery*: Key activities, resources and partners that operationalize the value proposition; and
3. *Value capture*: The cost structure and revenue streams of the business.

To narrow down the discussion of the illustrative cases, from the three dimensions above we consider the value proposition and the value delivery aspects of the business models. We also emphasize the "sustainability value" inherent to those two value dimensions. In other words, we present the value proposition and value delivery of the business models in terms of the restorative processes they implement. Such processes represent the "sustainability value" a business model creates. For the circular economy, the sustainability value of a business model should be intrinsic to its value proposition and value delivery is implemented through the restorative processes a business carries out.

6.1 Case 1: Reparability and Durability Values

Fairphone (www.fairphone.com) is a social enterprise whose restorative capability is mainly centerd on the restorative features of its product: a mobile phone. The product was purposefully designed to have high durability and reparability. This enables the concentration of restorative cycles downstream in the supply chain, close to the end user.

To achieve high reparability value the Fairphone has a modular architecture that allows easy disassembly and assembly of its components. Such modularity enables the phone's electronic sub-systems (modules or parts) to be easily accessed, repaired and replaced. Most of the phone's modules were also designed with further modular construction techniques in order to allow reparability at a more granular level, with varying levels of complexity.

The repair process was also designed to allow access to the phone's components by the users themselves, without requiring advanced technical skills. For example, the display unit does not require a tool to be removed; it can be unclipped. Other components can be removed with the use of a single screwdriver and the screws that connect them to the phone's chassis are color-coded for easy matching with the specific areas they fit.

The phone's durability was designed with the aim of longevity. For example, the phone does not require users to add extra layers of protection to keep phones safe from the elements and accidental drops. The display unit is secured to the phone through a strong magnesium frame. The phone's outer shell is an integral part of the phone that acts as a protective case that is fully replaceable.

The Fairphone business model as a whole was built as a movement towards fairer electronics, including its supply chain. In order to minimize the social and environmental impact of its product, the company works closely with manufacturers who invest in the well-being of their employees. They also use as many recycled materials as possible, without compromising the durability aspects of the product. Finally, they favor suppliers that support local economies and source raw materials mined from conflict-free mineral areas.

6.2 Case 2: Remanufacturing Value

Caterpillar is a large corporation that manufactures heavy machinery such as construction and mining equipment, diesel and natural gas engines, industrial turbines and diesel-electric locomotives. The company has been developing its restorative capability through remanufacturing processes. Its "Cat Reman" unit is a business model with an emphasis on a component recovery program which is implemented in nine locations around the world, employing over 3600 people (APSRG, 2014).

The company has been increasingly designing products with components that are intended to be remanufactured a number of times. A typical Caterpillar product can have 10% of its components remanufactured. The company's ability to remanufacture at low cost and high quality allows it to provide the same warranty for remanufactured engines as for new ones (EM Foundation, 2012).

Caterpillar also implements the "value in use" proposition advocated by the circular economy through its "product as a service" offers, in which the company retains ownership of the products and their associated value. The company has embedded remanufacturing cycles in this type of service, this way increasing its profit margin by replacing products before they break and rebuilding them with a mixture of new and remanufactured parts.

Overall, as materials account for most of the company's costs, remanufacturing allows greater business advantage for the company over their competitors. The circular supply chain supporting the remanufacturing loops is sustained through a returns incentive scheme. By offering economic incentives for the return of used parts, the company ensures that a high percentage of core material is sent back for remanufacture.

The environmental benefits of Caterpillar's remanufacturing initiatives are significant. The company has calculated that remanufacturing a cylinder head allows reduction of greenhouse gases by 61%, water use by 93%, energy use by 86% and waste sent to landfill by 99% when compared to producing a new part (APSRG, 2014).

6.3 Case 3: Reuse Value

Collaborative consumption is a typical example of a business model whose sustainability value is based upon products reuse. Offering a compelling alternative to traditional forms of buying and ownership, the restorative capability of these models is the implementation of reuse cycles through systems of organized sharing, bartering, lending, trading, renting and swapping of products over time (Botsman & Rogers, 2010).

For example, Airbnb.com has implemented an online platform for a peer-to-peer market where people can rent their spare rooms. This online marketplace idea also applies to the facilitation of reuse cycles for resources such as parking spaces, cars, general goods, skills and services between individuals, who may be both suppliers and consumers (Barnes & Mattsson, 2016). From a supply chain point of view, collaborative consumption models can be seen as business models that facilitate the creation of circular supply chains which enable reuse cycles at the level of end users.

In the Airbnb business model, on one side of the supply chain (upstream) are local people who have spare rooms and on the other side (downstream) are people looking for reasonably priced accommodations with the added benefit of local knowledge. Trust is built through rating systems profiling suppliers and users and it is up to the suppliers to determine if they want to host a guest. User guests can decide if they want to rent a room based on photos of the property, detailed profile of the hosts, and previous users' reviews. Airbnb also acts as a "trusted intermediary", providing a secure payment system through which guests make reservations using a credit card or PayPal account and hosts are paid in full 24 hours after a guest has checked-in.

The Airbnb business model has expanded far beyond the initial idea of a marketplace for spare rooms. Capitalizing on this emerging form of socio-economic collaboration, the collaborative consumption model implemented by Airbnb also enables the rent of tree houses, offices, boats, igloos, villas and even castles (Botsman & Rogers, 2010).

7 Conclusion

In this chapter we have introduced some conceptual propositions that provide useful theoretical foundations for a better characterization of the restorative capabilities of business models in the circular economy. We have also developed key theoretical foundations characterizing circular supply chains and the restorative loops and processes they enable.

By taking into account relevant actors in circular value chains, the chapter points out business model innovations that reinforce the transition towards a circular economy and better positions supply chain operations into the circular economy context, this way providing a more structured and up-to-date contribution to the wider debate on how operations and supply chains meet the challenges of sustainability.

The theoretical aspects here developed provide a coherent explanatory basis for the key questions set in the introduction above, which we briefly answer as follows:

- What are the key "circularity" features of business models implementing circular economy praxis?
- The circularity features represent the restorative capabilities of a business model. From an operations management perspective, they refer to an organization's capacity to recover products, by-products and waste that can be used in further production processes, this way enabling prolonged circulation of resources. Such capability creates sustainability value to stakeholders that are intrinsic to the value proposition of the business.
- How do they enable prolonged circulation of resources?
- This can be achieved at three levels: (1) at product level (i.e. products designed with recoverability features and less dependent on primary raw materials); (2) at process level (i.e. implementation of reusing, repairing, reconditioning, refurbishing, remanufacturing, or recycling processes); and (3) at industry level (i.e. implementation of recovering processes though cascading flows across organizations in diverse sectors).
- What are the enabling roles of "circular" supply chains?
- Circular supply chains enable and support the implementation of the recovery processes mentioned above, including cascading flows across

industrial sectors. This entails the integration of the main linear supply chain with additional restorative supply chains supporting the implementation of circular economy production ecosystems. The implementation of circular supply chains is intrinsic to the restorative capability of circular economy business models.

- What are the fundamental characteristics of a circular supply chain archetype?
- 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, they 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, they 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. In a circular supply chain, inner loops involve restorative and regenerative processes that minimize (re)processing of materials/resources. Therefore, circular supply chains should be designed to maximize restorative and regenerative processes downstream.

The theoretical fundaments introduced in the chapter were illustrated by a brief presentation of business model cases that provide real-life examples of circular economy practice. The cases presented in this chapter are far from covering the full range of circular economy business models being currently developed. For example, there is a growing number of businesses implementing restorative processes based on by-product and waste material synergies involving recycling through industrial symbiosis collaborations. Future research may want to discuss these business models and related supply chains in the light of the concepts introduced here.

The circular economy advocates a certain “resource efficiency” hierarchy for the restorative loops discussed in the chapter, claiming that “inner cycle” loops are where the circular economy can add most value, in other words the smaller the loop, the more profitable and resource efficient it is (Dervojeda et al., 2014). Although there is a coherent logic in this assertion, future research to confirm its validity is welcomed.

An in-depth discussion of the configurational perspectives of circular supply chains and the network of actors they involve in different restorative business models is also an important area calling 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. The business models in which they are involved comprise a wider set of stakeholders that necessitates a broader value-network perspective that takes into account the collaborative ties for implementing the restorative capabilities required by the circular economy.

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