Logistics in the Circular Economy: Challenges and Opportunities

Strategic Decision Making for Sustainable Management of Industrial Networks

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Chapter 1
Logistics in the Circular Economy: Challenges and Opportunities

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Abstract Circular economy (CE) is a concept that has gained considerable attention in recent years, particularly in the domain of *Industrial Ecology*. CE requires products to be easily repaired, refurbished, remanufactured, and eventually recycled. The transition to a CE creates distinct material flows that have to be managed in an efficient and sustainable manner. Existing studies on CE tend to focus on product design, material use, and the market potential of CE products with little attention paid to the logistics challenges associated with such developments. From a logistics perspective, CE can be seen as the integrated management of forward and reverse flows of products in a supply chain. In the operations and supply chain management literature, a large body of knowledge on how to operationalize closed-loop supply chains (CLSCs) already exists and is a starting point for understanding logistics in the CE context. As with traditional forward supply chain network design, CLSC and CE supply chains also require decisions on the role of facilities, their location, their capacity allocation, and their demand and supply allocation. The CE concept does however introduce new challenges especially as circular business innovations converge to increased servitization and to more collaborative and open business models. The transition towards circular business models requires businesses to position themselves according to three key strategic decision-making problems, namely, (1) the extent to which the logistics network is centralized, (2) the extent to which the product is servitized, and (3) the extent to which logistics services are coordinated. This chapter presents a theoretical overview of the three trade-offs and what their potential implications are.

Keywords Logistics · Circular economy · Closed-loop supply chain · Product design · Supply chain network design

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1 Introduction

The circular economy (CE) is both a critique of what its advocates refer to as the 'linear economy' and a concept that promotes the preservation of the natural environment by minimizing resource extraction and waste generation. As opposed to disposing of products at the end of their use, CE seeks to extend the life of products and the materials embodied in products. Products that reach the end of their use-phase should then be re-used, remanufactured, and recycled as far as possible to prevent or postpone eventual incineration and landfilling. According to the Ellen MacArthur foundation (2015), re-use should be prioritized over remanufacturing which in turn should be prioritized over recycling. In other words, a hierarchy of product end-of-life processes exists, with the intention of preserving the embedded effort in the original product and the embedded energy in the material composition of the original product.

Circular business models recover value from used products and the materials embodied in products. This circular view on product manufacturing, product use, and end-of-life return options is illustrated in the Ellen MacArthur butterfly diagram (2015), shown in Fig. 1.1. As can be seen in Fig. 1.1, a distinction is made between the biological cycle (on the left) and the technical (on the right). The biological cycle includes products created from materials derived from living organisms but not fossil resources. The biological cycle is synonymous with the biobased economy.

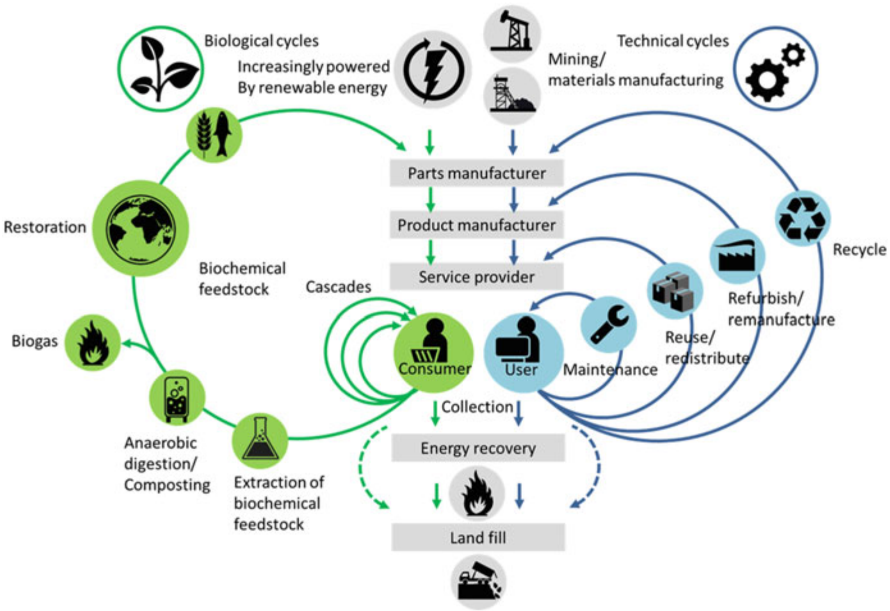

Fig. 1.1 Butterfly diagram illustrating a circular economy. (Adapted from the Ellen MacArthur Foundation 2015)

The technical cycle, however, includes products created from metals and minerals that initially need to be extracted from the subsurface. Ideally, circular products should all be derived from biological sources although this is not possible for many technologies.

Traditional linear product supply chains are often designed without taking the handling and disposal of products into account. The traditional product has a definite beginning, which is the sourcing of raw materials and the manufacture of the product. This can be referend to as the ‘pre-use phase’. The customer uses the product, the ‘use-phase’, before the product is disposed of. The end of the product life can be referred to as the 'post-use phase'. In the CE, the end-of-life or post-use phase is the point at which the product or material is returned to the manufacturer so that it can be repaired, remanufactured, or recycled and then redistributed. In principle the sourcing of new materials for new products are displaced. It is important to point out, however, that according to the second law of thermodynamics, waste streams can be minimized but as long as the system is not isolated, there will always be a waste fraction that can no longer be recycled. This fraction will eventual need to be replaced by virgin materials. What can no longer be recycled can be sent energy recovery or used as construction material.

The role of designers and material engineers in the CE is to develop robust products that:

1. Extend the product use-phase for as long as possible to reduce the need for maintenance and the need for replacing products. In turn longer lasting products avoid all the associated environmental burdens (such as the depletion of limited resources and emissions) of collecting and processing used products and all the environmental burdens associated with manufacturing and distributing replacement products.
2. Maximize the potential for re-use, remanufacturing, and eventual recycling so that waste is essentially designed out of the system.

The role of logistics and supply chain management is to facilitate the efficient flow of materials in a circular economy. In other words, logistics and supply chain management provides the framework upon which every step in the life of the product either side of the use-phase can be optimized. The framework enables strategic decision-making with regard to:

(a) Material sourcing decisions, collaborating with manufactures of other products and utilizing their waste streams as inputs
(b) Typical facility location-allocation problems as well as the location-allocation of facilities for reverse logistics, maintenance, reprocessing, and redistribution
(c) Routing of distribution, collection, and redistribution networks
(d) Determining the scale at which product revenues exceed costs

The evolution of circular product design, new product life cycle management approaches, and various product recovery options has led to many structural changes in logistics processes. This chapter provides a logistics and supply chain perspective on the transition to a CE. The following sections explain the interconnectivity of circular product design and supply chain network design with reference to three key logistics and supply chain strategic decision-making problems relevant for the design and operation of circular businesses.

2 Logistics in the Circular Economy

A supply chain consists of all parties involved, directly or indirectly, in the flow and transformation of goods and services from the origin of the product through to the customer. Logistics involves the business activities required to match the consumer demand for products from businesses with the supply of products. These activities span throughout product supply chains, from raw material extraction through to final product delivery. The collection and processing of used products and waste also falls within the definition of logistics. Logistics does not only involve transport but also relates to (1) strategically designing a supply chain in terms of the scale and location decisions, (2) the matching of supply and demand with the resulting networks, and ultimately (3) the detailed planning of the flow of products through the supply chains. In other words, logistics deals with getting the right product at the right place, at the right time, in the right amounts, and of the right quality.

The hierarchy of end-of-life processes (repair, re-use, refurbish, remanufacture, recycle, waste-to-energy, and landfilling) can be understood from these perspectives. Firstly, the potential for a product to be re-used, remanufactured, or recycled falls within the domain of circular product design, and it is essential that circularity is already considered in this early stage. Secondly, for products that have a significant use-phase, there is emphasis on optimal use of the product during its life cycle and possible extension of this life cycle. Maintenance or repair activities can reduce overall material requirements. Thirdly, all materials in products, whether designed for prolonged use, remanufacture, or recycling, will eventually be disposed of. The re-use, remanufacture, and recycling of products simply acts as a buffer, delaying the point in time when the materials will be unusable. The disposal of materials has traditionally been the responsibility of local governments, who either disposed of waste themselves or outsource waste collection and disposal activities to waste management companies. The end-of-pipe solutions used for disposal include dumping, sanitary landfill, and incineration. Energy in the form of biogas can be harvested from sanitary landfills. The preferred alternative to landfilling is incineration that recuperates energy, also referred to as waste-to-energy. As society shifts towards circularity, especially with longer-lasting products that can be re-used, the quantities of waste managed by municipalities and waste management companies will decrease. Finally, logistics determines how the materials required for the product are brought together, how the product is brought to the consumer, and how used products are either brought back to the manufacturer or disposed of. These perspectives on the circular economy are also represented by Achterberg et al. (2016) in the Value Hill, which illustrates the transition from a linear economy to a circular economy. The Value Hill includes life cycle extension in the use phase, the many

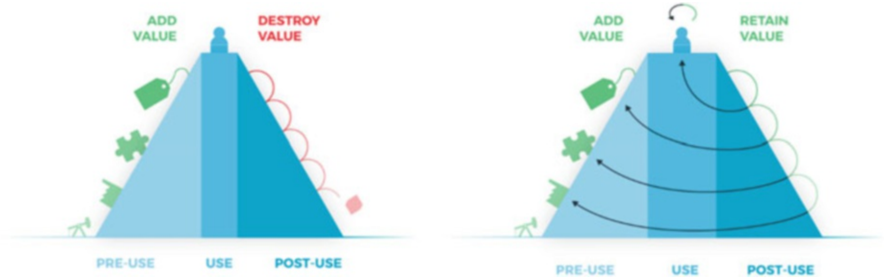

Fig. 1.2 Value Hill diagram by Achterberg et al. 2016. The pyramid on the left represents the linear economy where value is destroyed post use. The pyramid on the right represents the circular economy where value is retained post use. The greatest value retention occurs at the pinnacle where only maintenance is required

reverse flows in the post-use phase, as well as an emphasis on organizing logistics and supply chain activities across the different phases (Fig. 1.2).

3 Circular Product Design and Supply Chain Network Design

The basis of designing circular supply chains is similar to that of conventional supply chains. The basis of supply chain network design requires making decisions within each of the following four categories (Chopra and Meindl 2016): facility role, facility location, capacity allocation, and demand and supply allocation. The facility is where products are produced or where materials are stored or transferred. Each type of facility in the chain needs to be determined. For circular products, this may also include collection hubs, refurbishment facilities, and disassembly facilities. The locations of each type of facility need to be determined. Transporting materials and eventual products is an expense, and whether the product is circular or not, the distance between facilities should be as short as possible. There is, however, a trade-off that needs to be made between short network distances and the extent to which facilities can be decentralized. For each facility and location, the capacity needs to be defined. The capacity of each facility is also a function of how many facilities are in the supply chain network.

Designing the supply chain also requires determining the share of each market serviced by each facility. Retailer chains, for example, need to understand the size of the catchment area that each of their stores are servicing. The catchment size in turn, also determines the capacity at which the nodes upstream should be operated at. This also concerns the supply side, especially when production is based on reusable or recyclable material. On the supply side, the catchment area represents the material supply base.

Conventional supply chains can be referred to as open-loop supply chains and involve the flows of material and eventual products from the producer to the

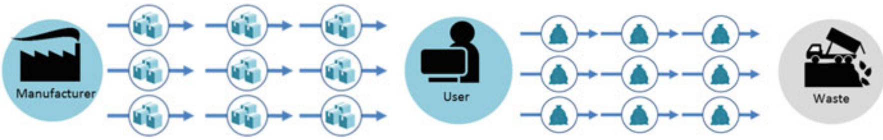

Fig. 1.3 Linear economy product life cycle from manufacture, through use to disposal

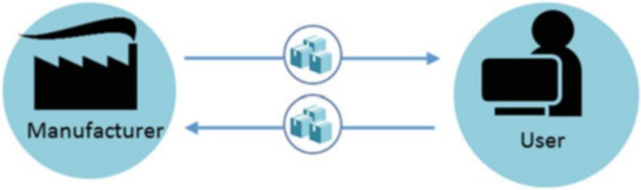

Fig. 1.4 Circular network design principles to reduce resource use (adapted from Bocken et al. 2016). Circular products last longer and therefore need to be replaced less often. Circular products are made from materials, which have less of a burden on the environment. Finally, circular products are returned to the manufacturer as opposed to being disposed of

customer. The supply chain is open because the product leaves the initial supply chain once it reaches the customer. At the end of the product's use-phase, it is then collected and either re-used, remanufactured, recycled, or disposed of via a different supply chain to the supply chain which delivered the product in the first place. If the supply chain also includes the collection of the used products, then it is referred to as a closed-loop supply chain.

From a logistics perspective, CE can be seen as the integrated management of forward and reverse flows of products in a supply chain. In the quantitative operations and supply chain management literature, a large body of knowledge on how to operationalize closed-loop supply chains (CLSCs) already exists. CE literature, mostly from *Industrial Ecology*-based journals, prescribes sets of principles predominantly focused on the design and material composition of products. Less emphasis is placed on supply chain network design. Bocken et al. (2016) do however describe three design principles that could underpin the circular products supply chain network design, namely, (1) slowing, (2) narrowing, and (3) closing (material) loops. Figures 1.3 and 1.4 illustrate the three principles. Figure 1.3 is of the traditional linear economy product, which is manufactured, delivered to the consumer and disposed of when the product reaches its end-of-life. The product is also replaced multiple times. From a logistics perspective, this product supply chain can be referred to as open loop. Figure 1.4, depicts a circular product supply chain or in logistics terms, a closed loop supply chain. The circular product lasts longer and therefore does not need to be replaced. The transport of the product has a smaller impact on the environment because it is constructed out of lighter (as well as more environmentally friendly) materials. Finally, the circular product is returned to the manufacture at its end-of-life, for refurbishing, remanufacturing, or recycling.

Slowing material flows involves product life cycle extension. In other words, designers should design products that are durable and last longer and allow for the possibility of servicing, repair, and remanufacture. Longer-lasting products implies that the need for replacing products is reduced. From a logistics perspective, on the one hand, this means less deliveries and less transport of new products. On the other hand, the need to transport new products would be replaced by the reverse flows of products requiring maintenance, repair, and remanufacturing. Waste collecting and processing will also be reduced by extending the life of products (including packaging). In many cases, product ownership will also change; it will be retained by product manufacturers who simply lease their products to their customers. In other words, 'product-as-a-service' will replace customer product ownership. This development is called servitization and incentivizes longer-lasting products and the efficient maintenance of products on the side of the product owner (the manufacturer).

Narrowing material flows also starts with the product designer, designing products in such a way as to minimize material inputs. This could include fewer materials used in the manufacturing of the product and less energy required in the operation of the product after manufacture. In other words, the products are environmentally less damaging or "lighter." Part of this discussion is the possible minimization of transport distances of the resources chosen by the product designer. CE principles generally also advocate reducing dependencies on imports (Geissdoerfer et al. 2018), since such dependencies present resource security risks. Stahel (2013) also argues that the repair, remanufacture, and recycling flows should be kept small and local in order to avoid products being transported back and forth over long distances.

Closing material flows begins with a switch from landfilling and incinerating products and residual waste to the separation of waste streams and recycling. Ultimately, recycling should be replaced by reverse logistics, and every product manufacturer will therefore have to have a closed-loop product system. From a supply chain perspective, reverse logistics has already been studied for many years (e.g., Govindan et al. 2015; Govindan and Soleimani 2017), and many opportunities to apply and extend this knowledge base exist. Closing loops can also be extended across different supply chains, where products or waste streams are not necessarily re-used in their own supply chain, but by another stakeholder that can make use of the material. An example of such re-use is industrial symbiosis, which is the use of another company's waste flows as a feedstock (see also Herczeg et al. 2018).

In the current transition towards the CE, many circular business models are being initiated by start-ups and by existing businesses that traditionally provided waste management services. Initiatives range from growing mushrooms on collected used coffee grounds to the production of biogas from collected municipal organic waste. Circular companies that are able to valorize waste or side streams need to be able to compete in the market with producers that use conventional feedstock and fossil fuels. Whether or not these circular businesses can compete in terms of price per unit is to a large extent dependent on whether logistics and production costs can be kept low enough to achieve a competitive market price for the product being made. Three strategic decision-making problems specific to circular businesses need be considered in achieving an optimal supply chain.

4 Key Logistics Strategic Decision-Making Problems in a Circular Economy

The optimal supply chain network configuration for circular products requires companies to consider their positioning on the following three strategic decision-making problems:

1. Centralized versus decentralized production and logistics
2. Product-oriented versus service-oriented sales
3. Coordinated versus collaborative organization

Each of the three strategic decision-making problems is explained in the following subsections.

4.1 Centralized Versus Decentralized Production and Logistics

The centralized production or processing of materials, whether that be for forward logistics (supply new products to customers) or reverse logistics (collecting used products), is generally more efficient than smaller decentralized facilities. Depending on the type of processing technology required, a larger facility that handles more product has lower start-up or fixed costs than multiple facilities handing the same quantity of product. The efficiency achieved with larger facilities can be described as *economies of scale*. Larger facilities with larger throughput allow for gains in economic efficiency by decreasing average total costs per unit produced in the long run. The gains in efficiency are due to greater labor and managerial specialization as well as allowing assets like machinery to be utilized continually, as opposed to intermittently or lying idle. Large-scale production also allows for bulk purchasing of inputs, which also reduces average total costs per unit.

The greater efficiency of centralized processing and production, as opposed to smaller-scale decentralized production, comes at the cost of a more sparsely distributed network and therefore greater transport costs. For example, having multiple warehouses in a decentralized network, as opposed to a single warehouse in a centralized network, from which to distribute products to retail outlets in a city, reduces the transport distances between the warehouses and the retail outlets. The same principle applies to processing facility for the reserve flow of products. A single biogas plant, invariably, requires greater transport distance than a more distributed or decentralized network of smaller digesters. Designing the optimal network requires finding a balance between the fixed costs of each facility and the variable costs of transport to and from each facility.

Other important considerations, which are particularly relevant to end-of-life processes (re-use, remanufacture, recycle, waste-to-energy, and landfilling), are the quantities, values, and geographic dispersion of the used products or waste streams. The more value retained in the used product, the greater the distance over which it can be transported, and the smaller and more geographically dispersed the products can be. For example, used precious metals retain their value, and therefore the cost of transport is relatively lower than, for example, manure, which has very little value. In other words, the value of the used product should cover the transport costs, and if this margin is very small, then a more decentralized network might be necessary.

Chen et al. (2012) evaluated 88 recycling projects in 23 towns in Japan to draw conclusions about the optimal scale of production for different value streams. They concluded that materials, such as oil, metals, plastics, paper, and Waste Electrical and Electronic Equipment (WEEE), could be handled across a dispersed regional network of recycling and reprocessing facilities, since the market value of the materials cover the transport costs. Organic waste, mixed municipal solid waste (MSW), and demolition waste are however of relatively little value per unit of mass, and therefore only a more local decentralized network of recycling and processing can allow for the transport costs to be covered.

Finally, product quality concerns might also impact the level of centralization; in the case of biological materials, there might be limited time in which the disposed products have to be processed, or its value might be lower (and, for instance, only be suitable for a waste-to-energy treatment).

The opportunity for logistics sector lies in designing networks that strike a balance on the continuum between centralized production with economies of scale on the one hand and decentralized production and transport cost minimization on the other hand.

4.2 Product-Oriented Versus Service-Oriented Sales

The circular economy literature discusses a change in traditional business operating models, from the business-to-customer transfer of product ownership to firms keeping ownership of products and instead providing the service that the product would otherwise deliver. The transition typically involves a switch from delivering value in the form of a finished product to delivering value in the form of performance-based services (Reim et al. 2015). As opposed to the customer buying a product and owning it until its end-of-life, the firm retains ownership of the asset and receives revenue for the value delivered by the asset to the customer. The firm, is therefore, incentivized to operate and maintain the asset as efficiently as possible. The transition goes beyond Extended Producer Responsibility (EPR) schemes, in which the producer is merely responsible for product's end-of-life but instead businesses define their business model according to the extended life of assets

(Van Engeland et al. 2018). The new type of business models is defined as 'product-as-a-service', 'product-service', or product service systems (Reim et al. 2015; Annarelli et al. 2016; Franco 2017; Geisendorf and Pietrulla 2018)

Businesses are also therefore required to balance the trade-off between extending the life of existing assets and replacing existing assets with new more efficient technology. A classic example of the product-as-a-service operating model is the leasing of photocopy machines, where the leasing company is responsible for maintenance and the continuous operation of the photocopy machines. Instead of the customer buying a photocopy machine, they are 'paying per use'. The business model can be referred to as 'use-oriented'. As with all assets, over time, it might be more economical to replace existing machines with newer technology. The firm is incentivized to carefully weigh up the cost and benefits of maintaining existing assets against new investments, and in this sense, the onus of the material efficiency of products or assets remains with the initial manufacturer. The question is how incumbent firms ought to make this transition and where the relevant opportunities are for the logistics sector.

Frishammar and Parida (2019) define a roadmap for firms to transform linear business models to circular business models. The roadmap is based on empirical observations of how eight existing firms, motivated by consumer interest in sustainable business practices on the side of firms, have made this transition. Frishammar and Parida (2019) were able to deduce a four-phase approach to transforming from typical linear business models to greater circularity. Phase 1 involves identifying the potential for adopting circular business principles and creating awareness regarding circularity amongst the existing customer base. If opportunities can be identified, then the phase 2 can be initiated in which the existing business model is exhaustively evaluated in terms of shortcomings, barriers, and potential circular business opportunities. This phase also involves creating awareness within the firm regarding the potential for circularity. The shortcomings and opportunities are the starting point for phase 3, in which the new circular business model is designed. Here, incumbent firms can draw from examples of case studies of other firms who have already made the transition. The firm in question needs to achieve internal alignment so that all the necessary departments in the firm are aligned in supporting the transition. The firm also needs to identify potential for collaboration with other firms or "ecosystem partners" and other network actors. Finally, the phase 4 involves validating the proposed transformation by introducing a pilot-scale prototype. The small-scale trial allows the firm to identify room for improvement and potential pitfalls of the circular business design before moving towards large-scale rollout.

The logistics sectors in many cases are ecosystem actors that provide the operational infrastructure for moving products between producer and customer. As firms continue towards increased servitization, the one-time flows of products to customer and from customers to end-of-life treatment (disposal, recycling etc.) will be replaced with products (or assets) remaining at customers for longer and servicing and maintenance of those assets. In other words, there will be less throughput of product and this will be replaced by the movement of service personnel and spare parts to and from customers. Logistics service providers have the opportunity to more efficiently manage maintenance scheduling. A further evolution towards circular economy would involve business-to-business servitization of assets, where firm share centralized production and manufacturing infrastructures. In this case, logistics services providers also stand to gain in terms of greater business-to-business flows between business locations.

4.3 Coordinated Versus Collaborative Organization

Collaborative logistics is the sharing of supply chain and distribution network infrastructures between multiple companies to reduce logistics costs. Collaborative logistics can be vertical or horizontal. Vertical collaboration involves different companies managing different consecutive stages along the same supply chain. Horizontal collaboration involves different companies that are usually competitors sharing each other's logistics infrastructure to reduce costs. Collaborative logistics can also include handing over logistics operations to an independent party that does not share sensitive operational information between the parties involved but ensures that the part of the supply chain it is responsible for operates optimally. Allowing such a fourth party to manage operations can be referred to as coordination and leads to developments like supply chain control towers. Beyond reducing logistics costs, companies who can share an existing network also improve the environmental performance of their products (e.g. reducing travel distances and truck utilizations and therefore the associated air emissions of the product).

Circular products can be placed on a spectrum between various different firms working together, either in sequence or within the same stage of the supply chain and a fully coordinated supply chain. In the CE context, traditional product manufacturing can consider shifting from an open-loop supply chain, to closed-loop supply chain, in which case the product is returned from the customer to the initial producer, when the consumer no longer needs the product or when the product reaches the end of its life. The expansion of the supply chain to include a take back program of the product can be described as integration, which can also be done vertically or horizontally. Integration of downstream supply chain activities, such as shifting from an open loop supply chain to a closed loop supply chain would be forward integration. Horizontal integration between a firm and other firms operating in the same supply chain stage that would otherwise be competitors is also possible in closed-loop context, especially in situations where the management of reverse flows is regulated on industry level. A well-known example is the collection of Waste Electrical and Electronic Equipment (WEEE). Integration is an important concept because it describes the transition of firms from open-loop supply chain towards closed loop supply chains; however, integration is not always synonymous with greater collaboration.

Kortmann and Piller (2016) describe two ways in which businesses are adapting to consumer and stakeholder demands for more sustainable, as well as open, business practices. By open business practices, they refer to firms being transparent

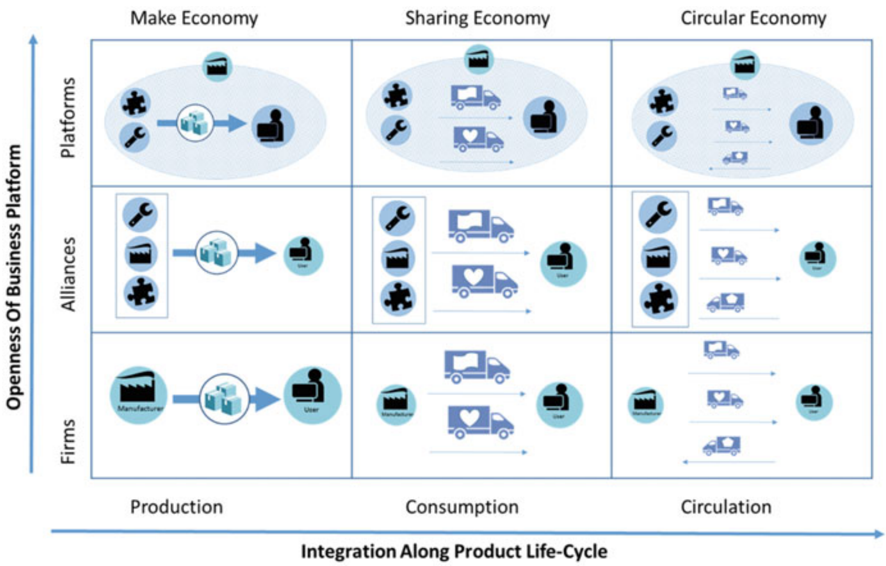

Fig. 1.5 Business model archetypes in the transition towards open and circular value chains. (Adapted from Kortmann and Piller 2016)

about business decisions and allowing stakeholders and customers to play a role in defining the business model. The shift towards greater sustainability lies in firms expanding the scope of the business operations to include taking back products from consumers (Fig. 1.5).

They map out nine archetypes of business models along two axes. The first or horizontal axis is the product life cycle continuum from the conventional forward value chain of linear business models towards the closed loop value chain of circular business models. The continuum is further divided into production, consumption, and circulation and in other words represents greater forward integration. The second or vertical axis is the business openness continuum from the conventional firm operating in isolation towards full collaboration and in other words greater horizontal integration. The continuum is divided into firms, alliances, and platforms.

From a logistics perspective, Archetype 1 is the traditional single actor, open-loop supply chain. Archetype 9, on the other side of both continuums, a circulation-platform operator, is synonymous with a fourth party responsible with cross-chain coordination. Kortmann and Piller (2016) show that firms need to cater to consumer demands for greater sustainability in terms or circulation and greater openness and this will also present opportunities for logistics sector.

5 Conclusions

This chapter provided an introduction to the circular economy concept and specifically what the concept entails regarding product design, product life cycle extension, as well as a hierarchy of end-of-life possibilities (re-use, remanufacturing, and recycling). From a logistics perspective, circular economy is predominantly about a shift that has been conventionally referred in logistics literature as open-loop supply chains, towards closed loop supply chains. In other words, the traditional life cycles of products from manufacturing, product use, to product disposal is being replaced with manufacturing, product use, and take back. In this sense, there is both a forward and reverse flow of products between producers and consumers. This also means less products will be treated as waste by local government, and instead manufacturers will displace landfill and incineration with longer lasting products, re-use, and remanufacturing schemes. The logistics sector will play a critical role in orchestrating the newly established flows between the different ecosystem actors.

The challenges that arise include:

1. Creating affordable reverse take-back programs and reverse logistics that support geographically dispersed materials and products
2. Reducing idle products and assets by firms that invest in product-as-a-service business models but also bear the risk of those products and assets becoming outdated
3. Sharing logistics networks with competitors at the risk of losing market share to competitors

The opportunities that arise including:

1. Sourcing cheaper material inputs locally that would otherwise be waste
2. Business-to-business servitization of assets reduces capital expenditure and therefore barriers to new markets for entrepreneurs
3. Circulation-platforms and open business models allow users to be directly inform product research and development

The perspective on how supply chain networks ought to be designed and operated differs between the strictly product design-oriented literature from the Industrial Ecology domain and the well-established knowledge of closed loop supply chains in the logistics domain. From a product design perspective (e.g., Stahel 2013; Bocken et al. 2016), flows should be slowed, narrowed, and closed. In other words, the flow of products should be reduced by designing products to last longer, using less environmentally intensive materials, and ensuring that products are returned to the producer at their end-of-life. From a logistics and (closed-loop) supply chain perspective, business models in the circular economy should consider three key strategic decision-making problems in the design and operation of their supply chain: (1) the extent to which the network is centralized or decentralized; (2) the extent to which a product is servitized; and (3) the extent to which the supply chain activities requires a collaborative effort. A perfect circular business model and corresponding production and logistics network does not exist, as many case-specific aspects need to be considered. The three strategic decision-making problems outlined in this chapter provide a framework for achieving greater circularity and supply chain integration.

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