Product design and business model strategies for a circular economy

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Abstract

There is a growing need for and interest in the business concept of a circular economy. The move to a circular economy brings with it a range of practical challenges for designers and strategists in businesses that will need to facilitate this transformation from a linear take-make-dispose model to a more circular model. This paper seeks to develop a framework to guide designers and businesses strategists in the move from a linear to a circular economy. The following research question is addressed: What are the product design and business model strategies for businesses that want to move to a circular economy model? Building on Stahel (1994, p. 179) he terminology of slowing, closing and narrowing resource loops is introduced. A list of product design strategies and business model strategies for strategic decision-makers is introduced based on this to facilitate the move to a circular economy.

1. Introduction

Governmental organisations as well as business representatives report an increasing pressure on our global resources and the climate due to human activity (WBCSD, 2014; IPCC, 2014). The circular economy is viewed as a promising approach to help reduce our global sustainability pressures (European Commission, 2014; Ellen MacArthur Foundation, 2014). The Ellen MacArthur Foundation (2014) has helped popularise the move to a circular economy with businesses. Europe (European Commission, 2014) and China have adopted Circular Economy principles as part of their future strategies (Su et al., 2013). For example, the move to a more circular economy for Europe is associated with strategies such as: boosting recycling and preventing the loss of valuable materials; creating jobs and economic growth; showing how new business models, eco-design and industrial symbiosis can move us towards zero-waste; and reducing greenhouse emissions and environmental impacts (European Commission, 2014).

The idea of a circular economy is not new and was given a theoretical foundation in the field of industrial ecology in the early 1990s (Allenby et al., 1994; Su et al., 2013). Robert Ayres (in Allenby et al., 1994) introduced the idea of industrial metabolisms: “At the most abstract level of description, then, the metabolism of industry is the whole integrated collection of physical processes that convert raw materials and energy, plus labour, into finished products and wastes in a (more or less) steady-state condition” (p23). The ambition level of an industrial ecology is to achieve an ideal state, one which resembles nature most. Such a system would be characterised by “complete or nearly-complete internal cycling of materials.” Ayres also observes that such a closed cycle of flows can only be sustained as long as its external energy supply lasts. According to Ayres, a logical consequence of striving to create closed loop systems is that there are only two possible long-run fates for waste materials: either recycling and reuse, or dissipative loss (for resources such as for lubricants or detergents).

The circular approach contrasts with the traditional linear business model of production of *take-make-use-dispose* and an industrial system largely reliant on fossil fuels, because the aim of the business shifts from generating profits from selling artefacts, to generating profits from the flow of materials and products over time (Bakker et al., 2014). Circular business models thus can enable economically viable ways to continually reuse products and materials, using renewable materials where possible.

Since the first use of the concept of the circular economy the terminology around the ‘circular economy’ has been diverging rather than converging and the terms closed loop and ‘circular’ economy are often used in parallel. Although these terms might be used synonymously, in this paper, the terminology of a ‘circular economy’ is used. It is argued that at the product design level and the strategic level of business model innovation, a more coherent

terminology is appropriate and desirable to facilitate the move of businesses to a circular model. In this paper, a range of strategies for product design and business model innovation for a circular economy are developed based on the literature to give clarity and direction to designers and strategic decision makers in businesses wanting to pursue a circular business model. The following research question is addressed: *What are the product design and business model strategies for businesses wanting to move to a circular economy model?*

2. Literature review on circular design and business model strategies

The literature review brings together the relevant literature on circular product design and circular business models to develop a terminology and a framework of strategies for closed loop design and business models for a closed loop.

2.1 Resource cycles: Slowing, closing and narrowing loops

This section introduces the terminology of slowing, closing and narrowing resource loops. To distinguish circular economy models from linear models, we categorize the design and business model strategies according to the mechanisms by which resources flow through a system, building on Stahel (1994). When discussing closed loop systems, Stahel (1994, p. 179) distinguishes two fundamentally different types of loops: (1) reuse of goods, and (2) recycling of materials. “The reuse of goods means an extension of the utilisation period of goods through the design of long-life goods; the introduction of service loops to extend an existing product’s life, including reuse of the product itself, repair, reconditioning, and technical upgrading, and a combination of these. The result of the reuse of goods is a slowdown of the flow of materials from production to recycling. ... Reusing goods and product-life extension imply a different relationship with time.” (ibid.) The second loop is related to recycling: “The recycling of materials means simply closing the loop between post-use waste and production. Recycling does *not* influence the speed of the flow of materials or goods through the economy.” (ibid.).

In alignment with Stahel, the following two fundamental strategies towards the cycling of resources are introduced in this paper, as a high-level way to distinguish between the different interpretations of “closing the loop” and approaches for a linear economy, illustrated in Figure 1:
1) Slowing resource loops (i.e. reuse): Through the design of long-life goods and product-life extension (i.e. service loops to extend a product’s life, for instance through maintenance, repair) the utilisation period of products is extended, resulting in a slowdown of the flow of resources.
2) Closing resource loops (i.e. recycle): Through recycling, the loop between post-use and production is closed, resulting in a circular flow of resources.
These two approaches are distinct from a third approach towards reducing resource flows**: 3) Resource efficiency or narrowing resource flows,** aimed at using fewer resources per product**.** In the 1990s the influential book “Factor Four” was published, authored by von Weizsäcker and Mr. and Mrs. Lovins. It introduced the idea of *resource productivity* (defined as “reduction of environmental impacts per unit of economic output”; ibid.). Resource productivity was introduced as a way to decouple the link between resource use and environmental degradation. For product designers, resource productivity is often treated as an indicator of resource efficiency (using fewer resources to achieve the same purpose). Resource efficiency is not aimed at the cyclic use of products and materials, but an approach to reduce resource use within the product and production process. This approach is different from approaches for slowing resource loops, as it does *not* influence the speed of the flow of products and does not involve any service loops (e.g. repair). Resource efficiency has been applied successfully within a linear business model, and existing strategies for resource efficiency can be used in conjunction with both product-life extension and recycling within a circular system, an approach that can be characterized as ‘narrowing resource loops’. As narrowing resource flows does not address the cycling of goods, this strategy is not addressed further in this paper.

The detail of the product requirements and business model options building on Figure 1 are based on the literature and relevant product/ process standards and are described in the

subsequent sections. In the subsequent sections, the product design and business model strategies for a circular economy are described according to the above categorization.

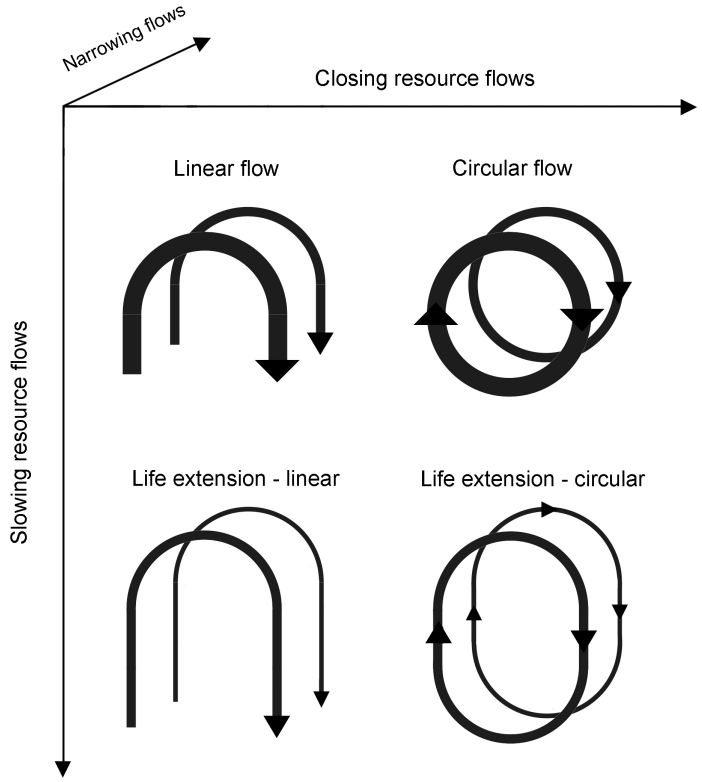

Figure 1: Categorization of linear and circular approaches for reducing resource use. Based on, and expanded from (Stahel, 1994; Braungart et al., 2008).

2.2 Circular product design strategies

Integrating circular economy concerns at an early stage in the product design process is important, because once product specifications are being made, only minor changes are usually possible - it is difficult to make changes, once resources, infrastructures and activities have been committed to a certain product design (Bocken et al. 2014a). This section describes the product design strategies relevant to slowing and closing loops, and provides an overview of the terminology of relevant terms as described in the literature.

2.2.1 Design strategies for slowing resource loops

Slowing resource loops or extending the utilisation period of products helps to avoid the manufacture of new products and its associated resource and energy use. Slowing resource loops is about keeping the products we have in use for longer. As argued by John Donahoe, CEO of eBay Inc.: "The greenest product is the one that already exists, because it doesn't draw on new natural resources to produce" (eBay Inc, 2014).

Table 1 includes the typical design strategies to slow resource loops: creating long-life products (see Moss, 1985; Chapman, 2005) and extending the product's life, once in use (British Standard, 2009; Bakker et al., 2014). Long-life product design is supported by design for reliability (Moss, 1985) and by design for both emotional and physical durability (Chapman, 2005). Design or product life extension can be facilitated through maintenance, repair, upgrading and remanufacturing (see British Standard, 2009; Linton and Jayaraman, 2005). Table 1 includes the terminology for these strategies.

Strategies & terms	Definition
Designing long-life products	Ensuring an extended / long utilisation period of products by designing products for reliability and durability (physical and emotional)
Reliability	The probability that a product manufactured to a given design will operate throughout a specified period without experiencing a chargeable failure, when maintained in accordance with the manufacturer's instructions. (Moss, 1985; p. 17)
Durability - Emotional - Physical	Durability can relate to *physical* durability, e.g. the use of corrosion resistant materials, and *emotional* durability, a situation where "users and products flourish within long-lasting empathic partnerships" (Chapman, 2005).
Design for product-life extension	Extension of the use period of goods through the introduction of service loops to extend product life, including reuse of the product itself, maintenance, repair, and technical upgrading, and a combination of these.
Maintenance	The performance of inspection and/or servicing tasks (technical, administrative, and managerial; EFNMS, 2014) to retain the functional capabilities of a product (Linton and Jayaraman, 2005, p. 1814) or restore it to a state in which it can perform its required function (EFNMS, 2014).
Repair (recondition, reworking or refurbishment are forms of major repair)	Repair is about restoring a product to a sound/ good condition after decay or damage (Linton and Jayaraman, 2005, p. 1813). After repair, the product is expected to be in a usable state, but assurances of performance are generally limited to the repaired part. (British Standard, 2009). Reconditioning is concerned with rebuilding or repairing major components close to failure, even where there are no apparent faults (ibid.).
Upgrade	The ability of a product to continue being useful under changing conditions by improving the quality, value and effectiveness or performance (…) (based on Linton and Jayaraman, 2005, p. 1814).
Remanufacture	Returning a used product to at least its original performance with a warranty that is equivalent or better than that of the newly manufactured product. From a customer viewpoint, the remanufactured product can be considered to be the same as the new product.(British Standard, 2009)

Table 1. Overview of design strategies to slow resource loops, including terminology

2.2.2 Design strategies for closing resource loops

The Cradle to Cradle design philosophy, propagated by McDonough and Braungart (2002), has inspired many companies and designers to apply an ambitious circular approach to product design (Bakker et al. 2010, de Pauw et al. 2013). With the introduction of design strategies aimed at circular flows of materials, a more detailed understanding of the concept of recycling has been propagated. According to Ayres (1994), there are only two possible long-run fates for waste materials: either recycling and reuse, or dissipative loss (e.g. lubricants or detergents). McDonough and Braungart (2002) developed this into a design concept with distinct strategies for the two resource routes, in which dissipative losses are to be made compatible with biological systems (fit for the biological cycle); and other materials to be completely recycled (fitting a technological cycle). Products that mix materials of both cycles and thereby inhibit the recovery of the materials are referred to as 'monstrous hybrids' (ibid.). In addition, to allow circular flows of resources, the authors distinguish between primary recycling and downcycling (see Table 2), to demonstrate that downcycling does not enable a cyclical flow of resources, but only delays the linear flow of resources from production to waste. Likewise, processes such as quarternary recycling, or thermal recycling (conversion of waste into energy) do not fit within a circular approach to product design.

Table 2 summarises the strategies to close resource loops, including the terminology used for these strategies.

Strategies & terms	Definition
Design for a technological cycle	Design products of service with materials or products ('technical nutrients') that can be continuously and safely recycled into new materials or products (McDonough and Braungart 2002).
Primary recycling (NB. upcycling is concerned with retaining or *improving* the properties of the material the latter concept being relatively new and underexplored;	The conversion of waste into material having properties equivalent to those of the original material (Aström, 1997). Recycling in which resources retain their high quality in a closed-loop industrial cycle (McDonough and Braungart, 2002),

see e.g. McDonough and Braungart, 2013)	
Tertiary recycling (depolymerisation & re-polymerisation)	The structural breakdown of materials into their original raw core components (for instance depolymerisation) and consecutive buildup (repolymerisation) of material with properties equivalent to the original material (Kumar et al., 2011)
Design for a biological cycle	Design products of consumption with safe and healthy materials ('biological nutrients') that create food for natural systems across their life cycle (McDonough and Braungart 2002).
Biodegradation and composting	Biodegradability is the capability of being degraded by biological activity (Vert et al., 2012); composting is a related process, in which organic matter is biologically decomposed, performed by microorganisms, mostly bacteria and fung (Vert et al., 2012).
Design for recycling strategies that only fit a linear economy	Design products of which the materials can be applied again in new products with loss of material quality, or can be burned while recovering part of the energy content.
Downcycling / secondary recycling	Material is reprocessed into a "low" value product, such as industrial grade rubber being reprocessed into a general grade rubber (Lee et al., 2001)

Table 2. Overview of design strategies to close resource loops, including terminology

2.3 Circular business model strategies

This section discusses the potential business model strategies for a circular economy. It should be noted that the examples given in Table 3 do not all necessarily present *full* business model innovations, but rather, elements of business model strategies that contribute to a circular business.

Business models define the way a firm does business (Magretta, 2002) and they are viewed as an important driver for innovation (e.g. Teece, 2010; Chesbrough, 2010; Yunus et al., 2010). Business model choices define the architecture of the business and expansion paths, but once established, companies often encounter great difficulty in changing business models (Teece, 2010). As Chesbrough (2010) observes: companies commercialise product and technology innovations through their business models and while they may allocate extensive investments to this, they often have limited capability to innovate the business models through which these innovations will pass. Following 'dominant business model logic' can lead firms to miss valuable uses of an innovation (Chesbrough, 2010; Prahalad & Bettis, 1995). The same technology or product innovation pursued through different business models will yield different economic outcomes (Chesbrough, 2010). Hence, according to Teece (2010), every new product development effort should be coupled with the development of the business model, which defines its 'go to market' and 'capturing value' strategies, because technology or products by themselves do not guarantee business success.

The move to a circular economy model is an example of a radical change, which will require a new way of thinking and doing business. The more radical the technical or product innovation, the more challenging and the greater the likelihood that changes are required to the traditional business model (Teece, 2010). Based on the business model frameworks of Bocken et al. (2014a) and Bakker et al. (2014), key business model strategies are identified, in Table 3, that fit the approaches of slowing and closing resource cycles.

	Business Model Strategies	**Definition**	**Business model elements**
Business model strategies to slow product loops			
1	Access and performance model	Providing the capability or services to satisfy user needs without needing to own physical products	**Value proposition:** delivery of the service (access and performance rather than ownership) **Value creation & delivery:** The 'hassle' of service and maintenance is taken over by the manufacturer or retailer. The user can enjoy the benefits of performance and access to a service (e.g. car sharing, launderette) **Value capture:** pricing per unit of service (e.g. time, number of uses, performance)
2	Extending	Exploiting residual	**Value proposition:** manufacturers exploit the residual

	product value	value of products - from manufacture, to consumers, and then back to manufacturing - or collection of products between distinct business entities	value of products and are able to deliver the customer an affordable 'as new' product through remanufacturing, repair and other product life extension design strategies (see Table 1) **Value creation & delivery**: take-back systems and collaborations (e.g. with retailers, logistics companies and collection points) to be established to enable consistent product returns (e.g. a deposit system at retail, as in the case of soda bottles) **Value capture:** reduced material costs (while potentially increasing labour and logistics cost) can lower overall cost and make this an attractive option for manufacturers
3	Encourage sufficiency	Solutions that actively seek to reduce end-user consumption through principles such as durability, upgradability, service, warrantees and reparability and a non-consumerist approach to marketing and sales (e.g. no sales commissions).	**Value proposition:** the manufacturer creates high quality durable products and offers high levels of service (reparable, reusable over time) and has a non-consumerist approach to selling – fewer high-end sales rather than 'build-in obsolescence' **Value creation & delivery**: non-consumerist approach (e.g. no overselling, no sales commissions, conscious buying) to sales. Only sell what is 'needed' **Value capture:** Often a premium model, where a high price per product can justify lower volumes. Another example includes ESCOs (energy service companies) often subsidised by governments to incentivise users to reduce energy use in the home
Business model strategies to close resource loops			
4	Extending resource value	Exploiting the residual value of resources: collection/ sourcing of otherwise 'wasted' materials / resources/ energy to turn these into new forms of value	**Value proposition:** Exploiting residual value of resources, potentially making the product more appealing to certain customers (e.g. those with a 'green' interest), while reducing material costs and the overall product price. **Value creation & delivery**: New collaborations and take-back systems to be put in place to collect/ source materials. **Value capture**: Use otherwise 'wasted' resources to turn these into new forms of value
5	Industrial Symbiosis	A process- orientated solution, concerned with using residual outputs from one process as feedstock for another process, which benefits from geographical proximity of businesses	**Value proposition**: A process- orientated solution, concerned with using residual outputs from one process as feedstock for another process, across geographically close businesses. The proposition for the business network is a reduction in overall operating cost and risks (e.g. environmental fines). **Value creation & delivery**: collaborative agreements to reduce costs across the network, by for example sharing communal services (e.g. cleaning/ maintenance, recycling) and exchanging by-products. **Value capture**: joint cost reduction and potential creation of new business lines based on former waste streams (see e.g. AB Sugar; Short et al., 2014)

Table 3. Business model innovations to slow and close resource loops. Developed from Bocken et al. (2014b); Bakker et al. (2014).

2.3.1 Business model strategies for slowing resource loops

In line with the Section 2.2, business models to slow resource loops encourage long *product* life and reuse of products through business model innovation. Three key models are described: access and performance, extending product value, and sufficiency (Table 4).

	Business Model	Examples of cases
1	Access and performance model (or, PSS; Tukker, 2004; or Functionality not Ownership; Bocken et al., 2014)	- Car sharing - Launderettes - Document Management Systems (e.g. Xerox, Kyocera) - Tuxido hire - Leasing jeans - Leasing phones
2	Extending product value	- Automotive industry – remanufacturing parts - Gazelle offering consumers cash for electronics and selling refurbished electronics (gazelle.com) - Clothing return initiatives (e.g. H&M, M&S' Shwopping).
3	Encourage sufficiency	- Premium, high service and quality brands such as Vitsœ (Evans et al., 2009) and) and Patagonia (Chouinard & Stanley, 2012) - Energy Service Companies (ESCOs)

Table 4. Models to slow resource loops. Adapted from Bakker et al. (2014) and Bocken et al. (2014b)

The 'access and performance model' (Bakker et al., 2014) is concerned with providing the capability or services to satisfy users' needs without needing to own physical products. Similar terms include "Product Service Systems (PSS)" (e.g. Tukker, 2004), a combination of products and services that seek to provide this capability or functionality for consumers while reducing environmental impact is often used to refer to this type of business model (Goedkoop, et al., 1999) and "deliver capability rather than ownership" (Bocken et al., 2014b). Examples include launderettes, car clubs and clothing hire models (e.g. tuxedo hire). The advantage of the Access & Performance strategy is that it can introduce economic incentives for slowing resource loops, both with manufacturers (increasing profits from e.g. durability, energy efficiency, reusability, reparability) and users (reducing costs when reducing use, e.g. thinking before using a car) and potentially reduces the total need for physical goods. In this way, this type of business model can contribute to slowing resource loops.

'Extending product value' is concerned with exploiting the residual value of products. The ideal business model might be the case where the remanufacturing operation would simply recover products which have ceased to function, with no new net consumption of materials, other than those consumed during transport and processing (Wells & Seitz, 2005). In this type of business model, remanufacturing typically becomes the activity of the original manufacturer. Refrigerators and other white goods in the EU are examples of products whose development is driven by Extended Producer Responsibility and the WEEE Directive.

'Encourage sufficiency' includes solutions that actively seek to reduce end-user consumption, in particular through a non-consumerist approach to promotion and sales (e.g. not overselling, no sales commissions) (Bocken et al., 2014b). The main principle of 'encourage sufficiency' is to make products that last and allow users to hold on to them as long as possible through high levels of service. Although they do not need to be, sufficiency based business models are often *premium business models* – they are high end and the price premium justifies 'slower sales' and higher service levels. Examples of premium business models include that of the furniture company Vitsœ (Evans et al., 2009) which developed a video 'against obsolescence' (Fablemaze Weather, 2014) and Patagonia (Chouinard & Stanley, 2012) who developed the iconic "Don't buy this jacket" advertisement (Patagonia, 2011) to support the launch of its Common Threads Initiative to encourage repair and reuse of its products. Positive impacts of encouraging sufficiency include the reduction in the consumption of resources, sustainable living and long-term customer loyalty, and new repair and service markets. Businesses may benefit from premium margins on high quality products and high levels of customer loyalty. The principles of longer use and repair and service are aligned with the principles of a closed loop economy.

2.3.2 Business model strategies for closing loops

Closing loops in business model innovation is about capturing the value from what is considered in a linear business approach, as *by-products* or *'waste'.* These strategies may be 'micro' in scope, for example when materials are reused in manufacturing processes within a production facility (Wells & Seitz, 2005), or more 'macro' when products are eventually disposed of and the content may be recycled via an entirely independent network. This business model is already profitable for some materials such as aluminium where the energy

costs of creating the material are higher than re-melting (ibid.). Table 5 summarises the business model strategies that economically enable closing of resource loops.

"Extending resource value" is about the collection/ sourcing of otherwise ' wasted' materials and resources to turn these into new forms of value. An example of this is InterFace Net-Works ^{TM} – a programme that sources fishing nets from coastal areas to clean up oceans and beaches while creating financial opportunities for people in impoverished communities and serving as a source to create recycled into yarn for Interface carpet (InterFace, 2008).

Similar to this, industrial symbiosis is a process-orientated solution, concerned with turning waste outputs from one process into feedstock for another process or product line (Ayres & Simonis, 1994 & Chertow, 2000). An innovative business model example of internal symbiosis practices is the case of AB Sugar, who managed to reinvent its business model focused on sugar refining through internal practices, described by Short et al. (2014). This paper discusses a range of business model innovations of industrial symbiosis, such as the creation of a new business line producing animal feed from by-product bagasse (a common by-product of sugar refining) and the use of latent heat and CO_2 from sugar refining to heat greenhouses and grow tomatoes near its sugar refining facilities (ibid.). These internal practices where value is created from 'waste' are not uncommon, the Guitang Group in China being another example of a sugar refiner developing new business lines based on 'waste' streams (Zhu et al., 2007).

Whereas industrial symbiosis practices often take place at the process and manufacturing level and benefit from businesses located closely within a geographical area, 'extending resource value' often happens at the product level and may happen across geographical areas (see e.g. the Interface example).

	Business Model	**Definitions**	**Cases**
1.	Extending resource value	Collection/ sourcing of otherwise ' wasted' materials / resources/ energy to turn these into new forms of value (e.g. products and services)	- Interface – collecting and supplying fishing nets as a raw material for carpets - RecycleBank – providing customers with reward points for recycling and other environmentally benign activities (recyclebank.com)
2.	Industrial Symbiosis	A process- orientated solution, concerned with turning waste outputs from one process into feedstock for another process	- Kalundborg Eco-Industrial Park (http://www.symbiosis.dk/en) - Symbiosis across business lines (e.g. Zhu et al., 2007) - AB sugar – internal 'waste=value' practices (Short et al., 2014)

Table 5. Business model strategies for closing resource loops. Developed from Bocken et al. (2014b)

3. Conceptual frameworks to support the move to a circular economy

Building on the product design and business model strategies to enhance a circular economy, this section proposes a simple circular economy strategy framework to help facilitate the move to a circular economy (Figure 2).

Figure 2 visualises a range of product design strategies and business model strategies available to businesses wanting to move to a circular economy model based on the review in Section 2. In this paper, it is argued that for such strategies to become successful, the business needs to implement or already have in place, an overall goal or vision focused on 'circularity', so that innovators in the business are empowered and are motivated to act upon this new way of thinking. To fully capture the business potential of the circular economy within the overarching objective of the circular economy to reduce sustainability pressures (Lovins et al., 2014, p. 4-5), the product and business model strategies are to be implemented within the light of this overarching visionary statement or goal.

To provide an example of a business which such an overall vision: Vitsœ aims to make durable timeless products which will last a lifetime or longer (Evans et al., 2009) and seeks to

challenge 'planned obsolescence' in design through the way it does business (FableMaze Weather, 2014). It encourages reparability, upgradability, and emotional and technical durability in design, which are important strategies to slow resource loops (Table 1). A second example of such a visionary company is Patagonia, which has a mature view on 'sustainability' and wants to challenge unsustainability and over-consumption through the way business is done (Chouinard & Stanley, 2012). Similar to Vitsœ, Patagonia has taken action to create awareness about the unsustainability of overselling and over-consuming, through its one-off "Don't Buy This Jacket" advertisement (Patagonia, 2011), which can be viewed as a business model strategy to slow resource loops ("encourage sufficiency"; Table 3). Patagonia through the Common Threads Partnership with eBay (eBay inc., 2014) encourages people to reuse clothes and buy second hand, and pledges to support product repair and make durable products, which are strategies to 'slow' resource loops.

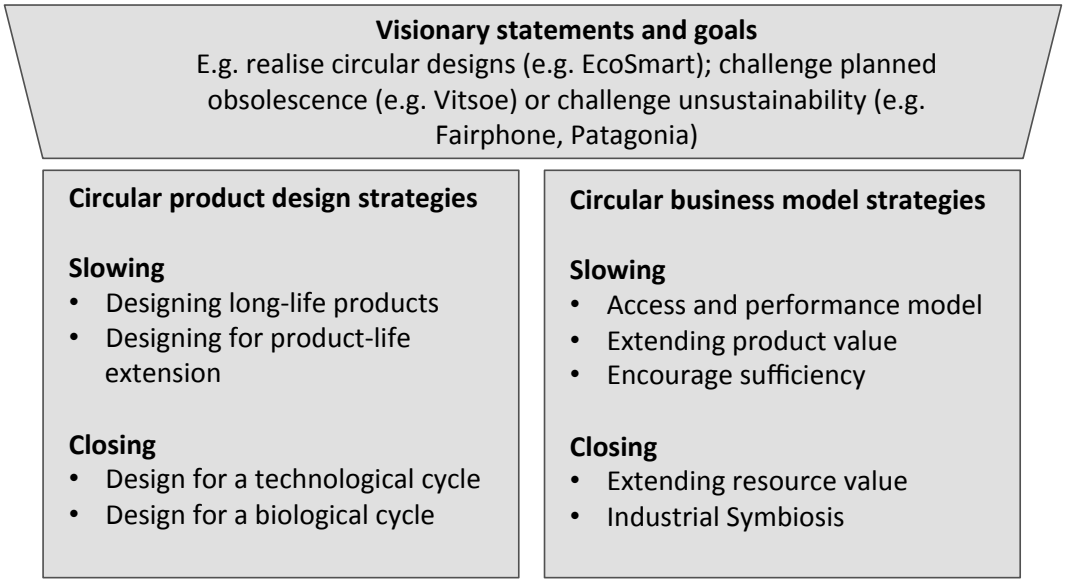

Figure 2. Circular economy product and business model strategy framework

4. Discussion and conclusions

This paper has sought to give insights in the product and business model strategies suited for the move to a circular business. The taxonomy of slowing, closing and narrowing resource loops was introduced building on Stahel (1994), as can be found in Figure 1. The aim of slowing resource loops is to extend the utilisation period of products, whereas the purpose of closing resource loops is to close the loop between post-use and production (i.e. recycling). Second, a simple circular economy strategy framework (Figure 2) was developed to provide a conceptual overview of the possible design and business model strategies for a circular economy.

This work has focused on design and business model strategies. Future work will need to include other essential elements such as the supply chain and enabling technologies and infrastructure. Future work includes the development of case studies to test the proposed strategies. Finally, methods for assessing the environmental, social and economic sustainability of circular business models will need to be developed.

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