Archetypical consumer roles in closing the loops of resource flows for Fast-Moving Consumer Goods

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Abstract
After the depletion of their consumable components, Fast-Moving Consumer Goods (FMCGs) become obsolete. In an attempt to close the loop of resources (i.e. products, components or materials) FMCGs can be designed with revalorisation services. In these product-service systems (PSSs) consumers are assigned a key role in closing the loops of resource flows. To understand and define this role, we dissected eighteen examples of PSSs. From this analysis, four dimensions emerged that characterise distinct aspects of the PSSs: the form of obsolescence; the change of resources from obsolete to operative or recoverable; the prerequisite activities required of consumers for revalorisation; and the facilitators of activities (i.e. investments and incentives). These dimensions were used to model four data-driven archetypical roles of consumers named after the interaction between consumers and the resource in the obsolete state, namely *keep*, *bring*, *consign* or *abandon* obsolete components. The research concluded that revalorisation always takes place in designated locations. The roles that consumers fulfil in closed-loop PSSs involve carrying out activities to position resources in such locations. The roles always come at a cost, but PSSs can be designed to reduce it. PSSs can also be designed to induce a perceivable value of obsolete resources, which can be used to increase role fulfilment. This research presents a comprehensive understanding of the roles of consumers in the specific context of closed-loop FMCGs, identifies tactics to increase the fulfilment of these roles and suggests further research on behaviours and PSSs to understand the roles of other stakeholders in various type of PSSs.

1. Introduction

The consumption of Fast-Moving Consumer Goods (FMCGs) threatens the environment as it contributes to global waste issues and to the depletion of resources leading to future shortages (Ellen MacArthur Foundation, 2017). FMCGs, e.g. packaged food and beverages, are repeatedly purchased products, that conveniently but temporarily satisfy continuous user needs. After satisfying these needs, the remaining resources, e.g. empty packaging, are

typically thrown-away, which results in a linear resource flow. There is a need to make the consumption of FMCGs more circular (Charnley et al., 2015; Haffmans et al., 2018) so that resources can flow continuously (Ellen MacArthur Foundation, 2017).

In a circular economy it has been suggested to design systems e.g. product-service systems (PSSs) (Ellen MacArthur Foundation, 2015) that allow to dematerialise consumption, intensify resource use, and recover resources (Bakker et al., 2014b, 2014a; Mont, 2002; Stahel, 2013; Tukker, 2004), and at the same time consider the impact of changes on interrelated business models (Bocken et al., 2016). PSSs can constitute a revalorisation service, which *'includes offers that aim at closing the product material cycle by taking products back, reusing usable parts in new products and recycling materials if reuse is not feasible'* (Mont, 2002, p. 241). An example of a common revalorisation service is the kerbside collection of recyclables such as plastic packaging. Despite the existence of such services only 2% of plastics globally used in packaging are estimated to exist in closed-loop recycling (Ellen MacArthur Foundation, 2016). Collection rates of obsolete resources are one of the main determinants of flow continuity (Breen, 2006; Corvellec and Stål, 2017; Gelbmann and Hammerl, 2015; Peeters et al., 2017; Williams, 2007), and consumers are known to have a key role to enable effective collection.

Recent studies of PSSs have highlighted that circular design has implications on the roles and behaviours of consumers (Baxter et al., 2017; Boks and Daae, 2017; McAloone and Pigosso, 2018; Mugge, 2017). More specifically, it is acknowledged that consumers are assigned an active role in closed-loop systems (Charnley et al., 2015; Steg and Vlek, 2008; Wastling et al., 2018). In common household recycling programmes, consumers are required to carry out activities such as sorting, storing and separating. It was found that *how* these activities are carried out impacts the quality of the revalorised resources (Nassour et al., 2017; Rousta and Dahlén, 2015). Materials, components and products can, in fact, only be taken through multiple lifecycles once they are effectively collected (Den Hollander et al., 2017). Thus, to establish a continuous flow of resources it must be understood *if* all the key activities that constitute the role of a consumer are carried out.

To improve the fulfilment of the role of consumers in the revalorisation of FMCGs, tactics and influencing factors have been studied. For example, previous behavioural studies have investigated: the reasons for poor recycling behaviour (Guagnano et al., 1995); how to increase the number of recyclers (Domina and Koch, 2002; Tonglet et al., 2004); how to improve recycling practices (Angeles et al., 2010; Derksen and Gartrell, 1993; Magnier and Schoormans, 2015); and how to encourage the uptake of reusable facilitating components over single-use ones (Lofthouse et al., 2009; Poortinga and Whitaker, 2018; Ritch et al., 2009). Examples of influencing factors are: infrastructure and technical facilities, which have shown to be supportive of the fulfilment of these roles (Poortinga and Whitaker, 2018; Steg and Vlek, 2008) and can increase the levels of recycling (Derksen and Gartrell, 1993); and product features such as geometry, which were found to impact disposal behaviour (Baxter et al., 2016).

Despite these efforts to understand how the role of consumers impacts resource flows and why the role is not fulfilled, it is still unclear what exactly the role entails; and which tactics can be used most effectively to increase fulfilment. In fact, the key activities that constitute

the role of consumers are commonly overlooked in the design processes of circular packaging (De Koeijer et al., 2017). This work aims to understand and define the role of consumers in PSSs that revalorise FMCGs. Such understanding is important as it has the potential to successfully integrate consumers in PSSs, for example, when aiming to improve collection rates in recycling programmes. In addition, novel PSSs for circular consumption of FMCGs are emerging and research on the role of the consumer and the fulfilment of this role is needed to help companies modify their business models and interactions with consumers (Charnley et al., 2015).

The remainder of this article is structured as follows. In Section 2, we define FMCGs and obsolescence, and their relation to consumers and resource flows. Section 3 explains how we selected, dissected and systematically compared eighteen PSSs consisting of FMCGs and revalorisation services. In Section 4, we present archetypical roles that we modelled using dimensions that emerged from the analysis. We present three key insights and discuss their implications for the design of closed-loop PSSs in Section 5. We discuss limitations and further research in Section 6. In Section 7 we conclude on the contributions of this research.

2. Revalorisation of FMCGs

2.1. Fast-Moving Consumer Goods

FMCGs are everyday products that fit in categories such as food and beverages, personal care, baby care, home care and office supplies. Many FMCGs emerged from luxury goods that transformed into basic necessities (Maycroft, 2009), corroborating the view that FMCGs exist in or can emerge from other product categories. For example, consumer goods labelled as fast-moving increasingly include electronics and fashion (Charnley et al., 2015; Haffmans et al., 2018). FMCGs satisfy universal needs justifying the production of mass-volumes of inexpensive products (Braungart and McDonough, 2008). These needs, however, are typically only satisfied until the consumable components are depleted and the goods become obsolete.

The time from the moment in which a good is released for use until the moment in which it becomes obsolete, is defined as the product use cycle (Den Hollander et al., 2017). Although obsolescence can be overcome, allowing resources to go through multiple successive product use cycles (Den Hollander, 2018), most FMCGs only perform in a single short product use cycle. Its duration is determined by the minutes, days or weeks it takes to deplete the consumable components. Whether obsolete resources become waste or continue to flow in a closed loop, thus, depends on what happens in the moment in which they become obsolete.

2.2. Obsolescence and its role in closed-loop resource flows

Consumers are inherently linked to obsolescence

Obsolescence is typically used by business to influence consumer behaviour. It has a negative connotation due to the term ‘planned obsolescence’. Planned obsolescence, when used in business strategy, suggests that the goods that consumers constantly need are designed to become obsolete rapidly (Andrews, 2015), triggering constant replacement purchases. This strategy was implemented as early as in the 1900s when some of the first

FMCG businesses were founded. At that point in time, an international cartel agreed on a lifetime of 1500 hours for lightbulbs (Andrews, 2015) and DuPont designed stockings in a format prone to laddering (Agrawal et al., 2016). Earlier designs of these products were longer-lasting but did not deliver continuous revenues. Product use cycles where shortened through design-decisions such as the use of inferior materials to impact durability and reliability of components (Maycroft, 2009). In other variants of planned obsolescence the resource itself remains intact, but due to 'built-in obsolescence' manufacturers anticipate that consumers will get tired of them (Papanek, 1985). As a result, continuous consumer needs are merely satisfied temporarily.

Obsolescence can also be influenced by consumers. There are numerous forms of obsolescence described in the literature, see Table 1. The forms are structured in two groups, namely relative and absolute obsolescence. Relative obsolescence occurs when consumers decide to stop using a product (Burns, 2010; Cooper, 2004) and thus results in a resource that is no longer used or needed. In these cases obsolescence could be caused by changes to the product (e.g. aesthetic) or changes in the context of use (e.g. societal, economic, technological, ecological, psychological), which give consumers reason to stop using a resource.

Absolute obsolescence is related to the failure of a physical product after consumption, e.g. when a product technically breaks down (Cooper, 2004). This definition, however, captures only one absolute cause for obsolescence. Other causes are when a product still operates as intended, but the functions of components are no longer used (Bartels et al., 2012) e.g. when consumables are depleted and packaging is empty. Obsolescence can also result from the lack of availability of support (technological) or availability of components (logistical) (Feldman and Sandborn, 2007). As such, absolute obsolescence occurs when a resource can no longer be used by consumers.

Table 1. Forms of obsolescence.

Obsolescence		References	Causes
Relative	**Aesthetic**	(Burns, 2010; Van Nes et al., 1999; Wilson et al., 2015) *also: desirable (Packard, 1960)*	• Changes in appearance of resources, e.g. fading, dirty, worn out, making the product less desirable. • Loss of cosmetic and decorative value. • When a product is found to be out of fashion.
	Societal	(Burns, 2010)	• Societal changes that impact needs. • Legislation that sparks behavioural changes.
	Economic	(Burns, 2010)	• When (up)keeping products becomes too costly (e.g. maintenance and repair costs).
	Technological	(Burns, 2010; Cooper, 2004) *also: functional (Packard, 1960)*	• When a newer version becomes available that performs the function better.
	Ecological	(Wilson et al., 2017)	• A new product with a less harmful impact on the environment is available.
	Psychological	(Van Nes et al., 1999)	• Emotional value to favour a product over another product e.g. gift.
Absolute	**Qualitative**	(Packard, 1960) *Also: absolute (Cooper, 2004)*	• Break down or wear of products.
	Functional	(Bartels et al., 2012; Feldman and Sandborn, 2007)	• The functions of components are no longer used.
	Technological	(Bartels et al., 2012; Feldman and Sandborn, 2007)	• When an older version is no longer supported.
	Logistical	(Bartels et al., 2012; Feldman and Sandborn, 2007)	• When products or components are no longer available to procure.

Obsolescence is a moment in the resource flow

The moment in which resources become obsolete is key in the flow of resources. Flows and stocks of resources are to be considered in the design of systems (Ellen MacArthur Foundation, 2013). The value of the resources in a flow is kept at its highest level if they are uncontaminated (Ellen MacArthur Foundation, 2015; Stahel, 1994). The value is also influenced by flow continuity (Allwood, 2014; Breen, 2006; Zeeuw van der Laan and Aurisicchio, n.d.; Zink and Geyer, 2017), which is dependent on the quality of the recovered versus the original resources and whether there is a market for the recovered resources (Bocken et al., 2016; Zink and Geyer, 2017). Further, the value of resources can be preserved if resources are timely and effectively managed and moved (Wilson et al., 2017) to establish a continuous flow that satisfies resource demand and diverts from sourcing new resources. This conceives the idea that the value of resources is subject to timing and location and reinforces the importance of understanding the moment in which resources become obsolescence.

Understanding how and where resources become obsolete can be used to exert control over resource flows. Although the planning of obsolescence is criticised for negatively

impacting the environment by producing short flows, depleting resources and inducing the rapid turnover of resources (Burns, 2010; Packard, 1960), the definition of an appropriate lifetime is suggested to make consumption more sustainable and produce extended loops (Bakker et al., 2014b; Burns, 2010; Den Hollander, 2018). Appropriate lifetimes, for example aiming at extending the life of resources by postponing obsolescence, can delay the turnover of resources to balance the environmental impact. Avoiding or postponing obsolescence, however, does not solve the lack of consideration of where obsolete resources should go (Papanek, 1985).

Planning-for obsolescence (Burns, 2010) captures the notion of positively impacting the environment, for example, by timely offering services that prevent leakage of resources (Breen, 2006; Ellen MacArthur Foundation, 2016; Sinha et al., 2016) in order to avoid the disruption of resource flows due to obsolescence (Choi et al., 2018; Macleod, 2017; Oguchi et al., 2010; Wilson et al., 2017). Resisting, postponing and reversing obsolescence through recovery operations were found to preserve product integrity and extend resource lifetime (Den Hollander, 2018). Further understanding of the causes of obsolescence (Burns, 2010; Longmuss and Poppe, 2017) and a specified lifetime (Zeeuw van der Laan and Aurisicchio, 2017, n.d.) are thus likely to favour the closure of resource loops.

2.3. Consumers as key stakeholders

Consumers of FMCGs are key stakeholders in the flow of resources because they own the resources in the moment in which resources become obsolete. The role of 'resource owners' in a circular economy has been studied in the literature (Bocken et al., 2016; Boks and Daae, 2017; Dewberry et al., 2017; Lofthouse and Prendeville, 2017; Stahel, 2010; Tukker, 2004; Wastling et al., 2018) and its criticality was stressed (Agrawal et al., 2015; Breen, 2006; Shih, 2001) as it determines the success of a circular system (Breen, 2006).

The activities required of consumers in revalorisation services are comparable to those in reverse logistics systems i.e. acquisition of obsolete goods; collection; inspection and sorting; and disposition (Agrawal et al., 2015; Shih, 2001). In reverse logistic systems, obsolete resources move from business-to-business (B2B) (Agrawal et al., 2015) in the opposite direction for the purpose of recapturing value or facilitating proper disposal (Breen, 2006; Östlin et al., 2008; Souza, 2013). Responsible stakeholders typically sign a contract that outlines roles and responsibilities regarding the ownership and movement of resources. Although contracts are sometimes also used in business-to-consumer (B2C) consumption systems (e.g. leasing) to increase control over resources (Souza, 2013), contracts do not guarantee the return of obsoletes (Breen, 2006). Despite the fact that the roles of stakeholders in B2B and B2C imply similar activities, the dynamics between service providers and consumers in closed-loop FMCGs differ. Therefore, their specific and critical roles in closing loops requires further investigation (Charnley et al., 2015; Den Hollander, 2018; McAloone and Pigosso, 2018; Zeeuw van der Laan and Aurisicchio, n.d.).

3. Method

This work intends to understand and define the role of consumers in closing the resource loops of FMCGs. We aim to derive this role by studying the activities that consumers are required to carry out in PSSs.

3.1. Data selection

We composed a dataset of PSSs that consist of a FMCG and a revalorisation service. The PSSs involved a tangible FMCG that was purchased by a consumer. The FMCGs are consumed rapidly, i.e. in minutes, days, weeks, and are prone to be re-purchased after consumption. The revalorisation service intends to close the loops of products, components or materials. We selected PSSs directed at consumers, which we identified by conducting searches in the World Wide Web. We first searched for FMCGs in the categories described in section 2.1, i.e. food and beverages, personal care, baby care, home care and office supplies. We then searched for revalorisation services for short-used products and assessed whether the products were fast-moving. A total of eighteen PSSs were selected.

We narrowed the scope to selecting PSSs serving the European market, which is representative of high-income markets. When identical PSSs were found for common schemes, only one was selected. For example, bottle deposit schemes are used in several European countries and their working mechanism was found to be the same. Grolsch' beer bottles in The Netherlands were chosen to represent these schemes.

PSSs were only selected if they were direct-to-consumer offers and were in operation at the time of the research (between April and May 2018) to allow collection of accurate information on the services. For example, Heineken's Forwardable Bottle is a promising concept, but at the time of the research was only available in bars and restaurants which manage the obsolete bottles. The revalorisation service in this PSS is directed to businesses rather than consumers and therefore it was not selected.

Only FMCGs that are part of PSSs were included. For example, FMCGs raising awareness of environmental issues such as Head&Shoulders' beach plastic bottle and Ecover's ocean plastic bottle do not include revalorisation services. Emerging reusable coffee cups and water bottles are rarely offered with services. The Keepcup, for example, can be used at any coffee company and it does not provide a specialised service. In contrast, Dopper's refillable water bottle is part of a PSSs in which an application provides a service to locate public water refill points.

Some PSSs were dropped as the services offered were not sufficiently product-specific. For example, take-back schemes of fashion brands are often operated by one of few third parties (Stål and Corvellec, 2018). They intend to collect any discarded piece of garment by placing drop-off points in stores of 'fast-fashion' brands. As such, this service aims at intercepting obsolete garments to extend the value of materials. However, we regard this as a stand-alone waste collection service in-store rather than a purposely designed PSS.

3.2. Data collection

All PSSs required consumers to carry out activities to make use of the services. To understand the role of the consumer, we aimed to expose each of the activities that are required of consumers. All revalorisation services in PSSs were offered either by the manufacturer of the FMCGs or by third parties. The websites of these companies included dedicated pages and FAQs to inform consumers on the activities required of them. We collected this data at the time of research and used it to identify the activities that consumers must carry out to use the revalorisation service.

3.3. Data analysis

This section presents the methods used to analyse and compare the eighteen PSSs. First, we analysed the FMCGs to understand their components. Second, we focussed on characterising the revalorisation services offered for the FMCGs. Third, we developed a Customer Journey Map (CJM) to dissect each PSS systematically. The CJMs included touchpoints and activities, which were both categorised to conduct a systematic comparison of each PSSs and create new understanding the role of consumers in closing loops.

3.3.1. Fast-Moving Consumer Goods

We categorised the FMCGs' components as presented in Table 2. All FMCGs are constituted of *consumable components*, which determine the overall functional value of the products (De los Rios and Charnley, 2016). Consumable components are: used-up, such as the water in Dopper, or the detergents in Splosh; removed, such as the content in a Repack envelope; or worn-out such as the razor blades in Boldking or the coffee grounds in Nespresso capsules. After the depletion of the consumable components, the FMCGs become obsolete. Differently from the other cases, Kartent has only a consumable component and its residue is what becomes obsolete. All other FMCGs have a second type of component, which delivers or presents consumable components to users. Such *facilitating components* typically exist after consumption and may even remain intact when FMCGs have become obsolete.

This study focused on the facilitating components linked to the revalorisation services only. Other type of components can be identified for some of the eighteen FMCGs. For example, BIC, Fuji, HP, Boldking and Preserve have packaging components, which are not categorised as facilitating components in Table 2, because the revalorisation service does not apply to these components. Components used for the consumption of FMCGs were also not considered, excluding the Nespresso coffee machine used to consume the capsules; Boldking's razor handle used to assemble the cartridges; Drinkfinity bottle used to assemble pods; and the HP Printer used to print the ink from cartridges.

3.3.2. Revalorisation services

Many of the manufacturers of FMCGs manage their own revalorisation service, but some work with a third partner. Terracycle emerged as a significant third-party company that provides revalorisation services for multiple PSSs in the dataset. The majority of the revalorisation services are take-back services. However, in some PSSs the offer of other types of service resulted in closed loops of components and materials. The services are presented in Table 2. We also characterised the revalorisation service based on the type of resource linked to revalorisation i.e. components or materials; and the resources provided to collect and/or return obsolete FMCGs.

Finally, for each PSSs a location was identified that was designated to kick-start the revalorisation of the resources. The types of location varied, although there were also similarities between the locations. For example, resources often have to be deposited in accessible and regularly visited locations such as public post boxes or drop-off boxes in schools. In some PSSs, however, consumers have to deposit obsolete resources or obtain

consumable components in locations that are more exclusive such as a brand-specific store, a photo-developing store or selected retailers. Designated locations were also identified nearer to the consumer, for example, by using the consumer's own doorstep at specific times. In some cases, the designated location coincides with the location where resources are consumed and become obsolete, such as a music festival site where obsolete components are left behind and a home where consumable components are delivered directly.

Table 2. PSSs of FMCGs with revalorisation services.
(F) : facilitating components; (C) : consumable components

	PSSs	FMCG *(components)*		Revalorisation service *(B2C)*			
		Consumable (C)	*Facilitating (F)*	*Service*	*Collect-and-return*	*Location*	*Close loops of*
Food and beverages	**Dopper**	Water	Reusable bottle	App locates water points		Refill point	Components (F)
	Drinkfinity	Concentrated flavourings	Pods	Take-back	Terracycle post label	Post box (or Terracycle drop-off point at retailer)	Materials
	Grolsch	Beer	Glass bottle and crown cap	Take-back	Grolsch crate	Retailer's reverse vending machine	Components (F)
	Jacob's	Biscuits	Wrapper	Take-back	Terracycle post label	Post box (or Terracycle drop-off point at retailer)	Materials
	Milk&More	Milk	Glass bottle and foil cap	Take-back		Doorstep	Components (F)
	Nespresso	Coffee grounds	Single-use capsules	Take-back	Nespresso envelop or post label	Nespresso in-store drop-off point (or post box)	Materials
Home care	**Ecover**	Detergent	Reusable bottle	Refill station		Refill station at retailer	Components (F)
	Splosh	Detergent	Reusable bottle	Refill delivery		Home	Components (F)
Office	**BIC (pen)**	Ink	Pen components	Take-back	Terracycle post label	Terracycle drop-off point at schools	Materials
	Fuji (dispo camera)	Film	Camera components	Photo development		Photo developing shop	Components (F)
	HP	Ink	Cartridge components	Take-back	HP envelope	Post box	Materials
	Repack	Various e-commerce	Reusable envelope	Take-back	Repack address label (part of envelope)	Post box	Components (F)
Outdoor	**Kartent**	Cardboard tent		Collection		Music festival site	Materials
Personal care	**Boldking**	Metal blades	Cartridge components	Take-back	Boldking envelope	Post box	Materials
	Garnier	Cosmetic	Plastic bottles	Take-back	Terracycle post label	Post box (or Terracycle drop-off point at retailer)	Materials
	Lush	Cosmetic	Plastic pots	Take-back		Lush store	Materials
	MAC	Cosmetic	Plastic pots	Take-back		Mac store (or post box)	Materials
	Preserve	Bristles	Handle	Take-back	Preserve post label	Post box	Materials

3.3.3. Customer journey mapping

A CJM is a visual representation of an individual's experience with products and services over time (Crosier and Handford, 2012; Shih, 2001; Stickdorn et al., 2016). CJMs can be used to present all the steps that customers go through (Bellos and Ferguson, 2017) and have already been used to understand the role of stakeholders in circular business models (Antikainen and Paloheimo, 2017; Sinclair et al., 2018; Stål and Corvellec, 2018). The main actor in our CJMs is the consumer. CJMs are often used to represent a first encounter with a product (Bettencourt and Ulwick, 2008; Crosier and Handford, 2012; Johnston and Kong, 2011; Shih et al., 2006) but we used them to map the consumer's common and repeated journey. The journey included the FMCGs' complete use cycle split in three stages: purchase, use and disposal. This has allowed to observe whether early commitment was used to engage customers in revalorisation (Breen, 2006).

We used customer journey mapping to dissect the PSSs and expose the activities that consumers are required to carry out and the factors that influence engaging in them. The CJMs are *research-based* (Stickdorn et al., 2016) as they use the data collected from service providers' websites to identify the steps that consumers must go through. The steps in the CJMs represent the activities that are required of consumers. The activities are marked by touchpoints that indicate when consumers interact with products and services (Stickdorn et al., 2016). The activities and touchpoints of each PSS were mapped in a CJM as presented in Figure 1. This visual representation was performed systematically to allow for comparison of PSSs and identification of similarities and differences. The full set of CJMs is included in the Appendix.

Some PSSs offer multiple options to either purchase or revalorise the same item, in which case we selected one offer to be mapped. For example, Terracycle commonly offers both the delivery of items to one of their drop-off locations, or the assembly of a parcel and its shipping by post. If present, we mapped the post box option for Terracycle's take-back schemes, as their drop-off points seemed less widespread. For brand stores that offered post and in-store option, we mapped drop-off in brand stores. Further, we mapped the common journey of offline sales of FMCGs, except if the goods were only available through online channels (i.e. Boldking, Drinkfinity, Kartent, Milk&More, Repack, Splosh, Preserve).

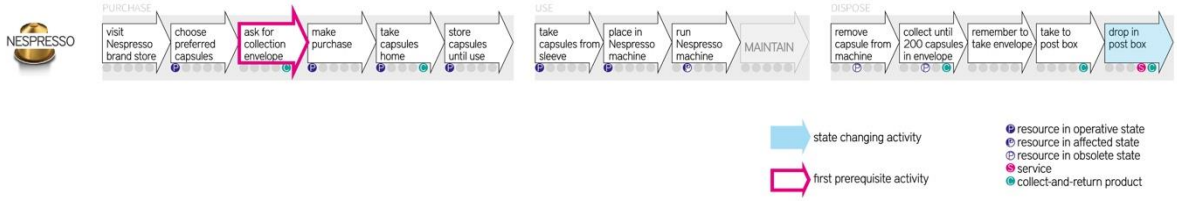

Figure 1. CJM constructed for Nespresso's revalorisation service.

3.3.4. Activities

The activities in the three stages were coded and categorised as presented in Table 3. Activities always occurred in the sequence shown. In all PSSs, consumers 'become owner' and 'consume' but the other activities did not always occur. Several activities, however, were commonly required. For example, despite the variety of take-back service locations (e.g. post boxes, drop-off points) the activities required of consumers in the disposal stage of these PSSs always included 'stocking', 'preparing' and 'transiting'. Further, as can be seen

in Table 3, some activities reoccurred in multiple stages of the journey. For example, numerous activities in all three stages could be categorised as 'preparing' activities and all PSSs included such activity at least once in the journey. The CJM with detailed activities for each PSS can be found in the Appendix.

Table 3. Activities required of consumers in revalorisation services.

Activity	Possible touchpoints	Description
Purchase stage		
'visit (web)shop'	S	Visit a retailer, brand-specific store or access a web-shop online.
'choose product'	P S C	Select FMCG from the (online) offering.
'prepare'	P Ⓟ S C	Add a collection-and-return product or refill consumable.
'purchase'	P S C	Make payment.
'become owner'	P C	Take home, receive or go to FMCG.
'stock'	P	Keep inventory of operative resources.
Use stage		
'remove'	P C	Unpack for consumption (removed parts are not revalorised).
'prepare'	P Ⓟ	Assemble FMCG or refill consumable.
'consume'	Ⓟ S	Deplete consumable components.
'maintain'	Ⓟ	Extend lifetime of affected resources.
Disposal stage		
'remove'	Ⓟ	Disassemble and remove residue consumables (removed parts are not revalorised).
'stock'	Ⓟ C	Keep inventory of obsolete resources.
'prepare'	Ⓟ S C	Assemble parcels of obsolete resources and/or plan and remember to take them into transit.
'transit'	Ⓟ C	Move obsolete resources to designated locations.
'detach'	Ⓟ S C	Deposit or abandon obsolete resource.

3.3.5. Touchpoints

Touchpoints are direct and indirect interactions of consumers with products and services during activities. We categorised the touchpoints in the five categories presented in Table 4. Touchpoints could be identified for all activities but not all touchpoints were identified for each activity, see Table 3. The activities 'visiting (web)shops' and 'preparing' in the disposal stage are the only two that occurred without any touchpoints.

Touchpoints may be sensitive to atmosphere and time (Stein and Ramaseshan, 2016). Accordingly, the conditions of the FMCGs were found to change over time as a result of consumption. For example, FMCGs increasingly deteriorate in the course of their consumption until they become obsolete. In the literature it has been suggested that recovery operations can reverse obsolescence (Den Hollander, 2018). The conditions in which resources are considered obsolete are thus impermanent. In fact, obsolete resources were found to change into 'as new' resources through revalorisation services e.g. a refill service. We used the term *state* to categorise resources in three specific conditions. Resources in *operative state* are FMCGs equipped with both consumable and facilitating components with a value equal to a finished good. FMCGs can also be in a state in which

consumables are visibly diminished or there are signs of wear, but they are not yet obsolete. We named this the *affected state*. We assigned the *obsolete state* to resources that can no longer be used or are no longer needed.

The service touchpoints include a variety of services. Mapping the entire use cycle led to include service touchpoints that were contextual of the revalorisation services such as online sales channels or subscription services. Post boxes and offline sales in retail or brand-specific stores were, therefore, not marked with a touchpoint. The mapped service touchpoints include interactions between consumers and companies through the web, mobile applications, software, refill stations and drop-off locations.

The touchpoint named 'collect-and-return products' includes the resources that are provided to or acquired by consumers to make use of some of the take-back services. Common resources include containers, envelopes and post labels for a self-assembled parcel. Each type is indispensable to the use of the revalorisation service.

Table 4. Touchpoints.

Touchpoint		Description
Ⓟ	Resource in operative state	FMCG 'as new'.
Ⓟ	Resource in affected state	FMCG's state has changed due to consumption.
Ⓟ	Resource in obsolete state	FMCG can or is no longer used or is no longer needed.
Ⓢ	Service	Any service offered during the use cycle.
Ⓒ	Collect-and-return product	Items provided to consumers to make use of revalorisation services.

4. Characterisation of the role of consumers

Four archetypical roles of consumers were modelled using the four dimensions that emerged from the analysis of PSSs. The dimensions are: the form of obsolescence; the resource state change; the prerequisite activity; and the facilitators (i.e. efforts and investments) of activities. In the analysis, we aimed at identifying how resources in the PSSs flowed by investigating: why and how FMCGs change to the obsolete state; what activities consumers of PSSs must carry out to make resources lose the obsolete state; and what these activities entail. The archetypical roles and their variants are mapped against the dimensions in Table 5. The roles are named after the implied interaction between the consumer and the obsolete resource.

1) ***Keep* obsolete resources**. The depletion of the consumable components makes the facilitating components functionally obsolete, although they remain intact. Consumers *keep* the obsolete resources and replenish them with new consumable components so that they become operative again. Two variants of this role emerged based on when the prerequisite revalorisation activities must be carried out, when effort is invested by consumers, and what incentives exist.

2) ***Bring* obsolete resources.** Although a few facilitating components remain intact, they are mostly impacted or altered due to consumption or remain assembled to consumable components once they become obsolete. Consumers *bring* obsolete resources to designated locations where they deposit them without further ado.

Once deposited in the designated locations, resources can be intercepted by service providers and thus become recoverable. Four variants of this role emerged based on the different prerequisite activities for revalorisation, the investment of money or effort, and the existence or not of an explicit incentive.

3) ***Consign* obsolete resources.** Both the facilitating components and the residue of the consumable become obsolete but remain inseparable. Consumers see value in the residue of the consumable and, therefore, *consign* the obsolete resources to service providers who can retrieve the value for them. In contrast to *bring*, consumers who *consign* make certain that their deposit is received. Their invested effort moves the recoverable facilitating components to the service providers for interception.

4) ***Abandon* obsolete resources.** With absence of facilitating components, it is the residue of the consumable that becomes obsolete at the end of an agreed use cycle. Consumers *abandon* obsolete resources in designated locations at set times as the place and time for use are predefined. Consumers are incentivised by the convenience to leave behind the resources.

In Figure 2 the four roles are marked on the lifecycle of resources composed of origin, production, use and end of life phases. In the use phase consumers are involved in the flow of resources. Once the resources have become obsolete consumers actively contribute to establishing the flow of resources in one of two ways. Consumers who *keep* obsolete resources establish a closed-loop flow by changing obsolete resources into operative resources, essentially reusing components. Consumers who *bring*, *consign* and *abandon resources* establish a closed-loop flow by changing obsolete resources into recoverable resources. These will either be components that are reused or materials that are recycled.

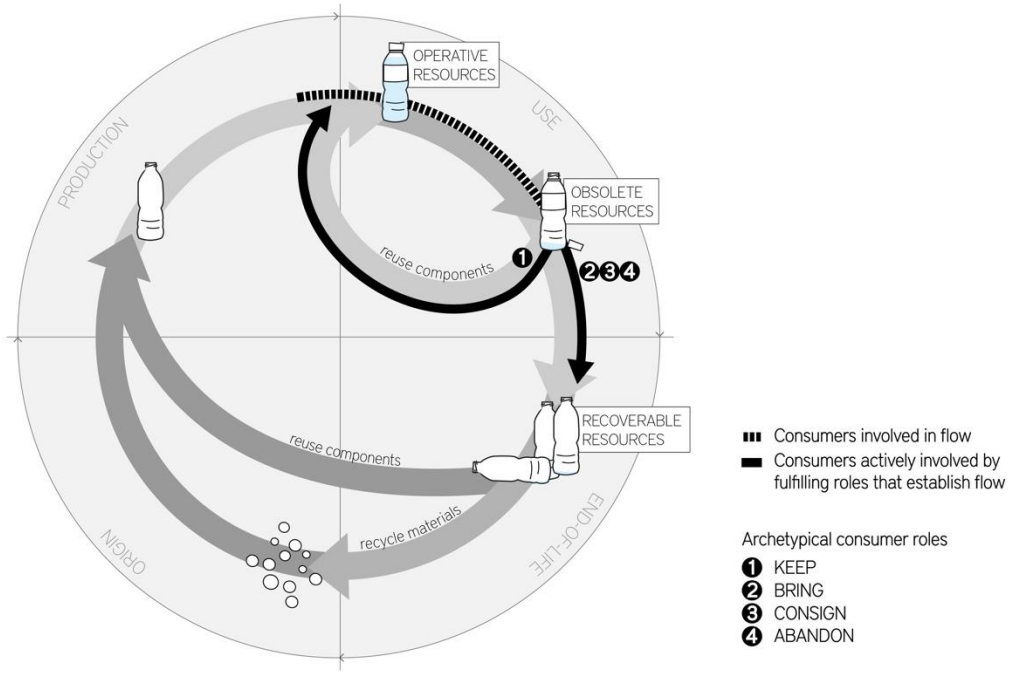

Figure 2. Representation of the resource lifecycle illustrating the involvement of consumers in the flow of resources and the influence of the four archetypical consumer roles.

As it can be seen from Table 5 the most common role is *bring* (13) obsolete resources followed by *keep* (3) obsolete resources, and *consign* (1) and *abandon* (1) obsolete resources. In the remainder of this section we elaborate on the dimensions and how they are used to model these archetypical roles.

Table 5. Four archetypical roles and the dimensions used to model them. (p: purchase stage; u: use stage; d: disposal stage)

PSSs	Form of obsolescence	State change to	Prerequisite activity	Facilitators *Investments*	Facilitators *Incentives*
1) Keep obsolete resources					
Splosh	Functional	Operative	'purchase' (p)	Efforts (u)	Implicit
Dopper, Ecover	Functional	Operative	'prepare' (d)	Efforts (p)	Explicit
2) Bring obsolete resources					
Boldking	Technological	Recoverable	'prepare' (p)	Money	None
Grolsch, Milk&More, Repack	Qualitative *[Grolsch, Milk&More]* Functional *[Repack]*	Recoverable	'purchase' (p)	Money	Explicit
HP, Nespresso	Programmed	Recoverable	'unpack' (u) *[HP]* 'prepare' (p) *[Nespresso]*	Effort (d)	None
BIC, Preserve, Jacob's, Garnier, Lush, MAC, Drinkfinity	Technological *[BIC, Preserve]* Qualitative *[Jacob's]* Functional *[Garnier, Lush, MAC]* Programmed *[Drinkfinity]*	Recoverable	'stock' (d)	Effort (d)	Explicit
3) Consign obsolete resources					
Fuji	Programmed	Recoverable	'prepare' (d)	Effort (d)	Implicit
4) Abandon obsolete resources					
Kartent	Situational	Recoverable	'purchase' (p)	Effort (p)	Implicit

4.1 Form of obsolescence

Resources in the obsolete state and the manifestation of this state were studied in-depth to diagnose the form of obsolescence in each PSS. We distinguished indicators of obsolescence and the condition of the resource in the obsolete state as presented in Table 6. Three forms of obsolescence were identified in line with those described in the literature: technological, qualitative and functional obsolescence. Two additional forms have been named *programmed* and *situational* obsolescence.

Table 6. Causes of obsolescence identified in the PSSs linked to the forms of obsolescence.

Resource in obsolete state		**Indicators**	**PSSs**	**Cause**	**Obsolescence**
Facilitating components assembled	Residual consumable	Wear and tear	BIC, Boldking, Preserve	• A newer version is available that performs the function better.	**Technological** (relative)
Facilitating components impacted	Consumable used-up	Clearly visible	Grolsch, Jacob's, Milk&More,	• Break down or wear.	**Qualitative** (absolute)
Facilitating components intact	Consumable used-up	Clearly visible	Dopper, Ecover, Garnier, Lush, Mac, Repack, Splosh	• The functions of components are no longer used.	**Functional** (absolute)
Facilitating components altered and assembled	Residual consumable	Clearly indicated	Drinkfinity, HP, Fuji, Nespresso	• *There is a threshold to the number uses.*	***Programmed*** (absolute)
	Residual consumable	Clearly indicated	Kartent	• *The duration of the use cycle and the location of use are fixed.*	***Situational*** (absolute)

Technological obsolescence

Some consumable components of FMCGs are sensitive to wear and tear such as Boldking's razor blades and Preserve's toothbrush bristles. The worn-out components cannot be easily disassembled from the unaffected facilitating components, which might explain why only the materials are revalorised. Consumers are likely to use affected resources until the experience becomes too unsatisfying compared to consuming the identical but new and better-performing resources in the operative state. Consumers' final decision to replace the resource is subject to the availability of the new resources. The value consumers can perceive of FMCGs is thus influenced both by the performance of the FMCG as well as by the presence of its replacement.

Qualitative obsolescence

Consumption can damage facilitating components causing them to break-down. Damage to components devalue them as it compromises the ability to reuse components such as for Jacob's wrappers, Grolsch' crown cap, and Milk&More's foil cap. Nevertheless, some of the facilitating components might remain undamaged and can become operative again albeit after expert processing and replacement of the damaged components such as for Grolsch' and Milk&More's bottles.

Functional obsolescence

With consumable components used-up, functions of facilitating components such as containing, preserving and transporting are no longer used making these components obsolete. All PSSs in which we identified functional obsolescence involved packaging and the facilitating components remained intact. This form of obsolescence is suitable for *keep*, as undamaged components demonstrate potential value to consumers, exemplified by the reusable bottles of Dopper, Ecover and Splosh. Functional obsolescence is also appropriate if providers intend to revalorise components rather than materials such as Repack for *bring*.

Programmed obsolescence

Although not grounded in the literature, the term programmed obsolescence has occasionally been used in the biology literature to describe the ageing of cells (Fragala, 2015; Orgel, 1973). Cells, such as those in the human body, are suggested to have an intrinsic biological or molecular clock that counts a predetermined and finite number of cell divisions, after which they become obsolete (Blythe and Macphee, 2013). The term is used here because a similar threshold was observed for the number of uses of FMCGs: Nespresso's capsules and Drinkfinity's pods can be used once; Fuji's cameras count-down 27 photos; and HP's software sets a predetermined threshold for the use of a cartridge. Once the threshold is reached, the FMCG is unable to deliver the initial value again. Further uses are prevented because consumable components are depleted, or consumption has altered the facilitating components. The alterations to facilitating components are not necessarily irreversible, but their recovery generally requires specialist disassembly from the residue of consumable components.

Situational obsolescence

If the use cycle of a resource is agreed on with the consumer, the resource can no longer be used by or deliver value to the consumer after the agreed use time or outside the agreed location. The resource thus becomes obsolete because the duration of the use cycle and location of use are fixed. This form of obsolescence was identified only for Kartent, who defined use time as the duration of the festival and the location of use as the festival site.

4.2. Resource state changes

A variety of offerings were identified as revalorisation services, including refill stations and take-back services. All services were found to close resource loops by permitting resources to lose the obsolete state. Obsolete resources changed either to the operative state, in which they instantly became 'as new', or to the recoverable state, in which they were recovered through further processing steps. The two types of state changes are mapped against the forms of obsolescence in Figure 3.

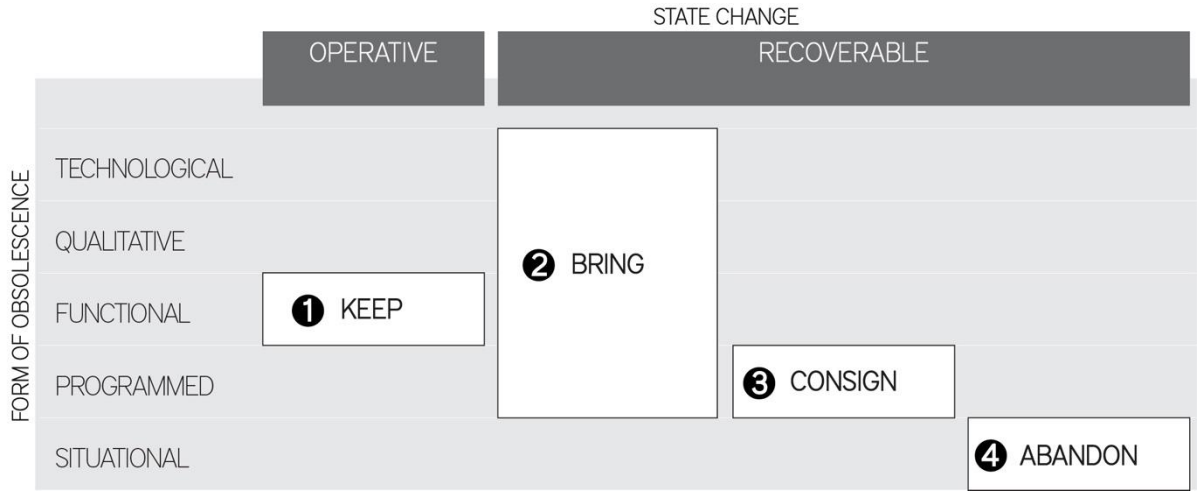

Figure 3. Archetypical roles mapped against state change and form of obsolescence.

A change to the operative state

Services that permit consumers to replenish obsolete facilitating components with new consumable components make obsolete resources operative. Resources can only become operative if consumers invest time to either to go to a refill station or request the delivery of consumables. The change from an obsolete state to an operative state is only modelled for *keep*. Resources become operative during 'preparatory' activities in which packaging is replenished with consumable components. Consumers 'prepare' either in the purchase or the use stage. Consequently, carrying out those activities closes the loop and extends the lifetime of facilitating components. It is worth noting that it is important for the facilitating components to remain intact to reverse from the obsolete to the operative state without the need for complex processing of resources.

A change to the recoverable state

Obsolete resources that await recovery have been defined as presources (Den Hollander, 2018). However, to permit their recovery, obsolete resources must be intercepted in volumes sufficient for economic resource recovery processes. Interception takes place in designated locations where service providers have systems in place for further processing. Resources are positioned in these locations if consumers carry out required activities. Once there, the resources become recoverable as soon as consumers 'detach' from them. In the simplest form this implies that consumers *bring* obsolete resources to designated locations. In the studied PSSs we identified designated locations as common as public post boxes and schools, as well as more exclusive locations such as brand-specific stores.

Resources can also be intercepted in locations where consumers *consign* obsolete resources to retrieve value, such as in photo developing shops. Due to programmed obsolescence, the residue of the consumable component and the facilitating component remain assembled. Only the photo developer can disassemble the obsolete resources and separate the valuable residue from the facilitating components. Hence, the activities carried out by consumers position all components in the designated location, permitting interception of the facilitating components. Service providers can also intercept obsolete resources in locations where consumers *abandon* them. Situational obsolescence can then be used to position obsolete resources in designated locations at set times.

4.3. Prerequisite activities

Resources were found to lose their obsolete state during one of two activities i.e. 'prepare' or 'detach'. Nevertheless, those activities could only be carried out if consumers had performed prior activities. One or multiple activities were found to be essential for revalorisation in each PSS. We defined the first indispensable activity for each PSSs as the prerequisite activity and used it to model the archetypical roles. Only the five activities highlighted in Figure 4 were found to be possible prerequisites.

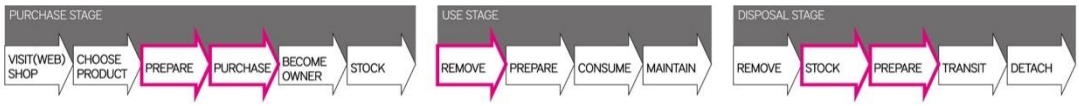

Figure 4. The activities that can be prerequisites for state changes.

'Prepare' (purchase stage)

Consumers may be required to 'prepare' for revalorisation as early as in the purchase stage. In several PSSs, consumers must obtain a collect-and-return product before making a purchase if their role is to *bring* obsolete resources. 'Prepare' is the first indispensable activity for two PSSs: Boldking's consumers must add a stamped envelope to their order of blades; and Nespresso's consumers must request the envelope.

'Purchase' (purchase stage)

The consumers of Grolsch, Milk&More and Repack's 'purchase' not only the FMCGs but also a surplus to use the revalorisation service. These three PSSs interestingly are the only variants of *bring* that aim to reuse the components rather than recycle the materials that embody them. 'Purchasing' can also be the prerequisite for *keep* if consumers must order consumable components that are indispensable to make obsolete resources operative, such as for Splosh. Finally, to permit to *abandon* obsolete resources, consumers must plan far ahead and 'purchase' a Kartent in advance of the event.

'Remove' (use stage)

For HP, consumers stumble on the collect-and-return product when removing the FMCG from its packaging. As the stamped collect-and-return envelope is indispensable, consumers must 'remove' it from the packaging but also retain it until the cartridge becomes obsolete and needs to be returned to HP.

'Stock' (disposal stage)

It is not uncommon for service providers to only accept and sometimes reward a minimum amount of resources that are intercepted as a bundle. For example, Lush and MAC exchange five and six obsolete resources respectively for a free product. It appears that such 'stocking' is the first prerequisite activity for the majority of PSSs in which consumers *bring* obsolete resources to designated locations. Preserve and the four PSSs operated by Terracycle use the public post box system to intercept resources. In those cases, the successive activity requires consumers to 'prepare' by retrieving accessible, free-of-charge and downloadable collect-and-return products to assemble and stamp the bundle. It must be noted that these PSSs also offer alternative journeys such as drop-off points in regular and exclusive venues which have not been mapped. Exclusive venues are also used for MAC and Lush which both receive and reward the eligible quantities of obsolete resources in brand-specific stores.

'Prepare' (disposal stage)

Physical movement of obsolete resources to designated locations is an indispensable activity in many PSSs. However, prior to 'transit' consumers must carry out 'preparatory' activities such as planning and remembering to move obsolete resources. This requires consumers to invest time to organise the movement of obsolete resources into 'transit'. These logistical efforts were not supported by any service provider. 'Preparatory' activities can be the prerequisite for two roles. First, consumers who *keep* obsolete resources may be required to remember to take them to refill points. Second, consumers who *consign* will only retrieve the value they see in the residue of the consumable if they remember to take obsolete resources to the photo developing service provider.

4.4. Facilitators of activities

Carrying out prerequisite activities and other indispensable activities depends on the motivation of consumers. The CJMs were studied to understand what brings about such engagement. We defined the engagement-creating elements as facilitators and categorised them into investments if they were input made by consumers, and incentives if they were output of the system from which consumers benefitted. We found combinations of investments and incentives as presented in Figure 5 and used them to model variants of archetypical roles.

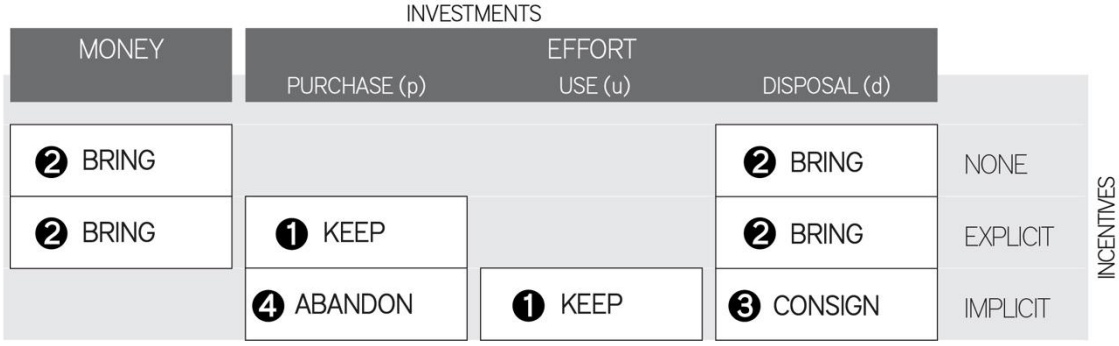

Figure 5. Archetypical roles mapped against investments and incentives.

4.4.1. Investments

Investment of money
In some PSSs for *bring* consumers were required to pay-into revalorisation services when 'purchasing'. Money was either paid as a deposit or for the collect-and-return product. Such facilitators seem a way of creating an early-commitment to the PSSs.

Investment of effort
If there was no monetary investment, we identified investment of effort in one single or multiple activities. Efforts include, for example, time required for planning and transportation; or space required to 'stock' products. Efforts were invested in activities during which the state changes, in the prerequisite or in the successive indispensable activities. If the key investment was effort, we distinguished whether the purchase, use or disposal stage required most effort.

An early investment of effort is made for *abandon*. Kartent's consumers are 'purchasing' the FMCG exceptionally far in advance to its consumption, which is an investment of effort as it requires planning. This is important for the PSS as it allows the provider to organise logistics for resources from the designated location. An early investment of effort is made for *keep* when 'preparing' in the purchase stage to replenish obsoletes with consumable components at designated locations such as at refill stations in retailers, e.g. Ecover. The same activity for this role can occur in the use stage, e.g. Splosh. However, the efforts to order Splosh' refills online at the consumer's convenience are probably less costly compared to time-intensive 'preparing' activities such as planning and remembering to take obsolete facilitating on a visit to a specific store.

Effort could also be invested in the disposal stage, as is common for *bring*, for example when 'stocking' is the first prerequisite activity. If the collect-and-return product required to use a revalorisation service is provided for free, this eliminates the need for early consumer investment. Instead, the efforts are all made in 'stocking', 'preparing' and 'transiting' obsolete resources. This is a similar effort to that invested in the disposal stage for *consign*, for which consumers are required to 'prepare' to organise 'transit' of the obsolete resource. The effort that consumers must invest in each of the activities for the different PSSs depends on factors such as travel distance to the location, how often they have to visit the location or how many resources they have to stock.

4.4.2. Incentives

None
Although two variants of *bring* required an investment of money or effort in the disposal stage, they had no identifiable incentive. We assume that the providers of these services depend on the intrinsic motivation of consumers (Steg and Vlek, 2008) for their engagement.

Explicit incentives
Explicit rewards including money, vouchers, deposits, Terracycle collection points and free or discounted products are categorised as explicit incentives. These are used both for *keep*

and *bring* to motivate consumers. For *bring*, explicit incentives were either the pay-back of the monetary investment or a stand-alone reward possibly introduced to compensate for the invested efforts. For *keep*, explicit incentives included free consumables such as the water from public refill points or discounted consumables such as detergents from refill stations. As the explicit rewards have low monetary value, the materialistic value that consumers can attribute to them seems low and suggests that they are probably only complementary to consumers who may be also incentivised by external factors such as intrinsic motivation.

Implicit incentive

Other incentives were identified, although they were not as explicit. An implicit incentive is, for example, increased convenience experienced as a result of the use of the service. For example, to *abandon* a Kartent is more convenient than carrying a durable tent back and forth. For *keep,* receiving your refills at home is more convenient than going to a store to purchase them. Another type of implicit incentive was identified for *consign* as the value that consumers see in the obsolete resource is what motivates them to carry out the activities. In that case specifically, the incentive, to 'prepare' and 'transit' an obsolete camera to a photo developing service where the facilitating components are intercepted for reuse is simply to retrieve one's photos.

5. Implications and discussion

This work aimed at understanding and defining the role of consumers in closing FMCGs' resource loops. We have modelled four archetypical roles using dimensions that emerged from the dissection and systematic comparative analysis of eighteen PSSs. The archetypical roles are *keep, bring, consign,* and *abandon* obsolete resources. As opposed to research on business models (Bocken et al., 2016; Tukker, 2004) and consumer behaviour (Maletz, 2017; Wastling et al., 2018) in the circular economy, this work aimed first at identifying the flow of resources and then deriving the contributions that have to be made by consumers to establish those flows. This work confirms that consumers' roles are critical in closing resource loops (Breen, 2006; Charnley et al., 2015) and provides new understanding of how such roles are integrated in PSSs. This work has implications for three aspects of PSSs that aim to produce closed-loop resource flows. We now highlight these implications and discuss them against the literature.

5.1. Revalorisation takes place in designated locations

FMCGs are tangible resources and therefore they have to be accessed for revalorisation. In the studied PSSs, obsolete resources were positioned in locations equipped for revalorisation, such as the infrastructure to make resources continue the journey towards the reuse or refurbishment of components, or recycling of materials (Ellen MacArthur Foundation, 2015). This implies that *PSSs always require a stakeholder to position obsolete resources in designated locations*. Based on the results, we articulate two tactics that were used to achieve this:

- Consumers *(1) move obsolete resources to locations* where providers of revalorisation services intercept or replenish the resources;
- Consumers do not move obsolete resources, but *(2) resources become obsolete in locations* where revalorisation takes place.

As resources are to be accounted for at all times in the circular economy, it is worth understanding which stakeholders access them in the various types of PSSs (Manzini and Vezzoli, 2003; Mont, 2002; Tukker, 2004). Although in this work it was the consumer who fulfilled the role that positioned obsolete resources in locations designated for revalorisation, the tactics seem applicable to consumers in all types of PSSs. For example, consumers in 'use-oriented' PSSs are stakeholders who do not have permanent ownership of resources but, instead, they are charged for the time they use a resource (Tukker, 2004). The service provider and consumer agree on the duration of use and on the location that the resource must be returned to. Therefore, the role of the consumer involves moving obsolete resources to designated locations, a tactic used in many of the archetypical roles. In this case, however, the responsibilities are formally agreed, and this can be seen as an additional explicit incentive, reducing the risk of unfulfilled roles.

The tactics also appear applicable to other types of stakeholders in PSSs. For example, manufacturers of resources are expected to fulfil new roles as they are encouraged to become or partner with service providers. Consequently, manufacturers are incentivised to prolong the life of their resources, which slows and narrows the resource loops (Bartels et al., 2012; Bocken et al., 2016; Stahel, 1994). However, to manage waste, they have to carefully consider material flows (Corvellec and Stål, 2017) and product lifetimes (Bakker et al., 2014b). Similar to consumers, manufacturers will then face various forms of obsolescence and have to decide when they can no longer use their resources. To flow these obsolete resources in closed-loops, they must also reach a designated location. This implies that manufacturers who are service providers now must fulfil a role that positions obsolete resources in these locations.

5.2. The roles of consumers come at a cost

Whether it is an investment of money or effort, the archetypical roles imply a cost for consumers. The cost of effort is based on parameters such as the time that consumers need to invest in planning and carrying out activities, and the volume of the resources that needs to be moved. Therefore, the quantification of the value of this cost is complex. Nevertheless, the position and accessibility of designated locations in relation to consumers gives an indication of the size of the investment (Zeeuw van der Laan and Aurisicchio, 2019). Interestingly, a great number of the identified locations seemed inconvenient and out of one's way. For example, a common location to *bring* obsolete resources was the place of purchase. Although this seems logic, combining a journey made to purchase FMCGs with the intent to dispose in this location does not happen without planning in advance. Therefore, both 'preparing' and 'transiting' become costly activities in terms of effort. Some locations appeared highly convenient and therefore these two activities were made inexpensive, mitigating the risk of consumers not fulfilling their role. This implies that *PSSs can be designed to reduce or cut the costs of consumers' roles*. Based on the results, we articulate three tactics that were used to achieve this:

- Rather than picking-up consumable components, *(1) the consumable components are moved towards the obsolete resources*, such as when consumers *keep* them.
- Instead of exclusive locations, such as a brand-specific store*, (2) more convenient locations are used*, such as one's doorstep in *bring*.
- Instead of moving obsolete resources, *(3) resources become obsolete in designated locations*, such as when allowing consumers to simply *abandon* them.

Common tactics to increase the fulfilment of the roles do not typically address endured costs. For example, when consumers are required to *keep* obsolete components, tactics include banning single-use alternatives e.g. the ban of plastic bags (Ritch et al., 2009); and punishing their use in comparison to reusables e.g. a penalty for using a disposable coffee cup (Poortinga and Whitaker, 2018). Other common tactics focus on the design of facilitating components, such as designing components that: are durable in performance and can recover from functional obsolescence in multiple product use cycles (Den Hollander, 2018; Lofthouse et al., 2009); and are emotionally durable to resist relative forms of obsolescence (Chapman, 2009; Den Hollander, 2018). Regardless of these tactics, the costs to fulfil the role to *keep* remain equal or become, arguably, higher.

In practice, consumers who have to *keep* are required to carry out 'preparing' and 'transiting' prerequisite activities, similar to the activities carried out to *bring* obsolete resources. Carrying out such activities is subject to the availability of technical facilities and infrastructure (Steg and Vlek, 2008). PSSs that insufficiently facilitate prerequisite activities could thus put the fulfilment of roles at risk. Without adopting tactics to eliminate or devalue costly activities, consumers may experience large costs for their role, such as the value that they may attribute to the inconvenience of recycling (Domina and Koch, 2002; Rousta et al., 2015; Sidique et al., 2010).

5.3. Obsolete resources can have a specific perceivable value

FMCGs are often altered as a consequence of consumption and undergo physical changes that can devalue the resources (De los Rios and Charnley, 2016; Haffmans et al., 2018) and cause them to become obsolete (Bartels et al., 2012; Burns, 2010; Cooper, 2004; Feldman and Sandborn, 2007; Packard, 1960; Van Nes et al., 1999). In the studied PSSs, the conditions of some obsolete resources involved physical alterations. Resources, however, became obsolete for various reasons and they remained in various physical conditions, some of which seem easily reversible. It appears that the value that consumers perceive of obsolete resources in PSSs differs from the initial value perceived, but it does not necessarily drop. This implies that *PSSs can induce a specific perceivable value of obsolete resources*. Based on the results, we articulate five tactics that were used to achieve this:

- The perceivable value of obsolete resources is increased using *(1) knowledge of the existence of a revalorisation service*. In that case, functional obsolescence as in *keep* fosters the potential value of obsolete resources as facilitating components remain intact.
- The measurable value of obsolete resources is prompted using *(2) explicit incentives*, such as those identified in some variants of *bring* when consumers receive a discount on a next purchase as a reward.
- The *(3) investments made by consumers prior to consumption,* consisting of money or effort as seen in other variants of *bring*, promote a perceivable value that lasts even when the resources become obsolete. For example, when having paid for a collect-and-return product, as early as when purchasing the product.
- The perceivable value of obsolete resources is influenced by the *(4) physical change of the resource*. Rather than decreasing the perceivable value, however, physical change can be used to increase it, as identified in *consign*. In this case, it is thought

that the value that one can perceive of the obsolete resource increases to the extent that retrieving it can become an incentive.

- The perceivable value of obsolete resources is lowered by *(5) intentionally expiring the product use cycle*, such as when using either situational obsolescence in *abandon,* or technological obsolescence to make a resource obsolete by offering a replacement.

Dominant tactics to improve recycling behaviour include increasing awareness and knowledge of environmental issues related to consumption to build intrinsic personal values that incentivise consumers to fulfil their roles (Magnier and Schoormans, 2015; Singhirunnusorn et al., 2012) or positioning this behaviour as normative (Babader et al., 2016; Barr, 2007; Poortinga and Whitaker, 2018). Nevertheless, not everyone seems to be receptive to these incentives nor are they sufficient to always guarantee engagement (Steg and Vlek, 2008) and collection rates are shown to remain low (Ellen MacArthur Foundation, 2017).

It might, instead, be more effective to use the value that consumers can perceive of obsolete resources, as this value can be used to elicit behaviour (Haffmans et al., 2018; Scheepens et al., 2016). For example, people were more likely to litter obsolete packaging if it had features that they associated with something as valueless as waste (Baxter et al., 2016). As such, tactics that imply an association with a specific value could be used to elicit specific behaviour. Although money seems to imply a self-evident association with value, offers of monetary incentives are found to not always be successful in nudging environmental behaviour as those who engage in programmes such as recycling are driven altruistically (Steg and Vlek, 2008). Rather, tactics can be used to induce perceptions of non-monetary value. For example, the uptake of recycling was found to be strongly influenced by whether consumers were aware of programmes (Jenkins et al., 2003), suggesting a successful use of the tactic to generate awareness of revalorisation services.

In PSSs tactics could then be used to strategically exert control over the value that can be perceived of resources and timely elicit the required behaviour. For example, expiring the product use cycle can be used to instantly drop the perceivable value, such as by using a one-for-one take-back service in which consumers receive a new resource only when they have returned the obsolete one (Östlin et al., 2008). Physical change of resources during consumption was used by Fuji to gradually increase the perceivable value of obsolete resources. The latter is a type of value-creation that can be related to the co-creation which develops psychological ownership over resources and leads to personal attachment (Baxter et al., 2015). This could explain why the use of this tactic is successful in the fulfilment of the role of *consigning* obsolete resources. Which tactic is appropriate to use in a PSS and whether to induce a low or high perceivable value depends on the role that consumers are required to fulfil and influences whether consumers will fulfil it.

6. Limitations and further work

The authors note that a limited number of PSSs fit our scope at the time of the research. New PSSs are emerging, which could make cases of interest for future work. The authors acknowledge that the archetypical roles are representative of a specific product category and services, as the research has focused on FMCGs. Additional roles could be identified by

systematically studying other stakeholders such as manufacturers; PSSs that are use-oriented or result-oriented; and PSSs based on products in other categories.

This work presents a comprehensive understanding of the roles of consumers in the specific context of closed-loop FMCGs. Although two roles are based on one data point only, the authors believe that they are conceptually distinct from the other roles and expect that they provide the FMCG sector with opportunities to explore new value propositions to consumers and develop and implement circular business models. Further research on the roles of stakeholders in closing resource loops can strengthen the current archetypical roles and develop a comprehensive set that can be used to design PSSs with closed resource loops.

This study is based on information that is available to consumers who use revalorisation services provided by parties offering those services. Our interpretation of this secondary data thus represents how the activities are theoretically carried out. The dataset was suitable to systematically compare the activities amongst various PSSs and develop conceptual archetypical roles but does not give us insights in the agenda of companies that offer these services; how and whether consumers in the real-world carry out the activities as suggested; or how successful each archetypical role is. When collecting the data on the PSSs we have come across FAQ pages and blogs that have given us an opportunity to further understand the PSSs as well as how well consumers engage with the systems. Further consumer research is needed to understand the actual behaviour and measure the extent to which consumers fulfil the archetypical roles, and how each dimension influences this. This work discusses the presence of the cost of a role and the possibly perceivable value of obsolete resources in PSSs. To qualify and quantify the value that is attributed to these, perception studies in PSSs need to be undertaken.

7. Conclusions

Consumers have a critical role in the revalorisation of obsolete resources in the circular economy. Using customer journey mapping we have dissected PSSs that consist of FMCGs and revalorisation services. Four dimensions, emerged from the systematic comparative analysis of PSSs, were used to model consumers' archetypical roles in closing resource loops, namely: the form of obsolescence; the prerequisite activities; the type of state change; and the facilitators of the activities. Consumers were found to fulfil one of four archetypical roles to position resources in designated locations: *keep*, *bring*, *consign* or *abandon* obsolete resources.

To our knowledge, this work is the first to characterise in detail the roles of consumers in closing FMCGs' resource loops. We have taken a novel approach by first identifying the flow of resources and then deriving the contributions that have to be made by consumers to establish the flows. This work presents novel understanding of the roles of consumers in closing loops, provides designers of PSSs with dimensions to model these roles and offers them insights to model them to ensure their fulfilment. We have identified that obsolescence is a state of resources. The obsolete state can reverse to the operative state or change to a recoverable state. We have proposed forms of obsolescence with causes that had not yet been articulated in the literature.

The archetypical roles of consumers modelled in this research shed new light on circular behaviour and studies of PSSs, and how to use the insights of such research to control resource flows and close resource loops. First, revalorisation takes place in designated locations where stakeholders must position obsolete resources. Second, fulfilling archetypical roles comes at a cost, but tactics can be used to design PSSs that cut or eliminate this cost. Third, obsolete resources in PSSs can have perceivable value, which can be induced by the design of the PSS and used to increase role fulfilment by eliciting specific behaviour.

The archetypical roles and the dimensions to model them are suggested to be used in the design of PSSs for the circular economy. This study has focused only on products in the FMCGs sector and the consumer as a stakeholder. Additional roles are likely to exist and might be modelled using the proposed dimensions. An evolved set of archetypal roles has the potential to be applicable to an even wider range of stakeholders in circular PSSs. The dataset was created from secondary data and thus to understand the success of each archetypical role and the influence of the dimensions, further research on consumers and PSSs is needed.

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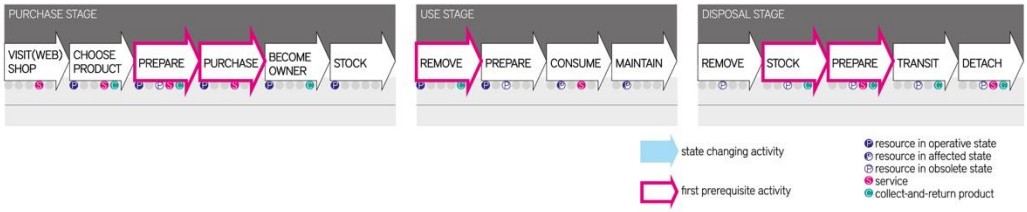
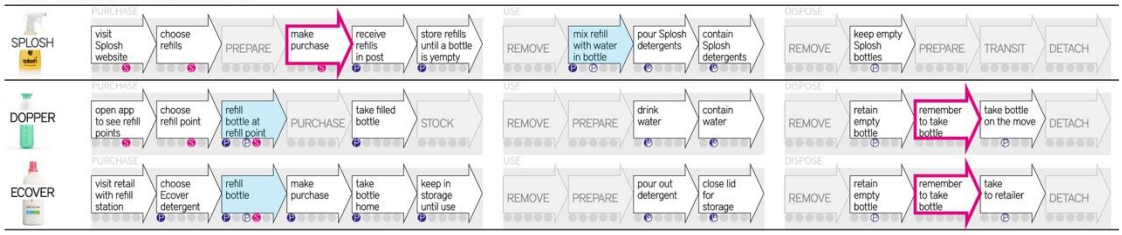
Appendix. Customer Journey Maps of the eighteen product-service systems.

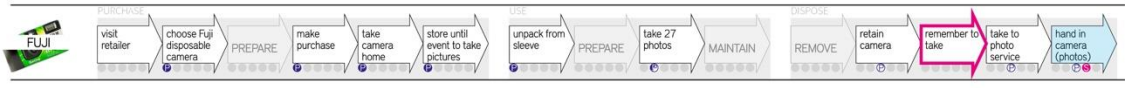


1. KEEP OBSOLETE RESOURCES

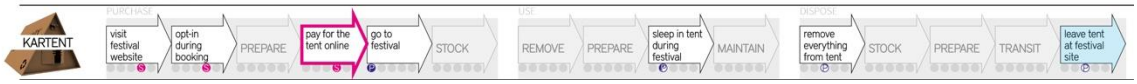


2. BRING OBSOLETE RESOURCES

3. CONSIGN OBSOLETE RESOURCES



4. ABANDON OBSOLETE RESOURCES



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