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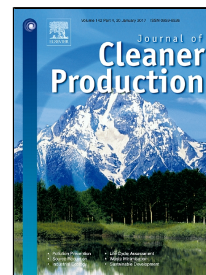
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## Evidencing the waste effect of Product-Service Systems (PSSs)

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### Abstract

This paper adopts a waste-centric analysis of Product-Service Systems (PSSs) to demonstrate that they do not automatically contribute to a dematerialization of the economy, a decoupling of production from material and energy consumption, and thus a transition toward sustainability. A qualitative analysis of various Nordic fashion PSSs that uses a combination of Tukker's (2004) classification of PSSs and the European waste hierarchy model demonstrates that the waste effect of a PSS is independent of its being product-oriented, use-oriented, or result-oriented. Rather, the effect depends on how the business model of the PSS organizes material flows at production, distribution, use, and post-consumption stages in relationship to prevailing waste regimes where the PSS operates. We suggest that if a PSS is to reduce its waste effect and contribute to dematerialization, its business model should design material flows that fit with the prevailing waste regimes within the area it operates and prioritize waste prevention before considering reuse, recycling, energy recovery, and landfilling.

### Keywords

Product-Service System (PSS); Fashion; Waste; Dematerialization; Sustainability; European Waste Hierarchy

### Highlights

- A focus on waste opens critical avenues for Product-Service Systems (PSSs)
- A PSS's waste effect is not set by its being product-, use-, or result-oriented
- A PSS's waste effect depends on how it organizes residual material flows
- PSS managers should turn waste into a material and informational input
- PSS design should develop waste strategies that prioritize waste prevention

## 1. Introduction

As Vandermerwe and Rada (1988) have observed, servitization entails that more and more corporations are offering customer-focused “bundles” of goods, services, support, self-service, and knowledge where services dominate. Contemporary societies have entered what Yarmolinsky (1968) calls a service society. As Lusch and Vargo (Lusch and Vargo, 2014; Vargo and Lusch, 2004) argue in their Service-Dominant Logic-thesis, this is a society where the fundamental units of exchange are services rather than goods, all firms are service firms, and all organizations, markets, and societies are service-based. Product-Service Systems (PSSs) (Beuren et al., 2013; Reim et al., 2015; Tukker, 2004, 2015) exemplify this transition to a service economy (Beuren et al., 2013; Gaiardelli et al., 2014; Reim et al., 2015; Tukker, 2004, 2015). Defined originally as “a marketable set of products and services capable of jointly fulfilling a user’s need” (Goedkoop et al., 1999, 18), the hyphen between Product and Service in “Product-Service” stands for an integration of products with services that dissolves the conventional contradistinction between the two.

Will, however, a servitization of the economy contribute to a dematerialization of the economy and a decoupling of production from material and energy consumption? The question is of significance as it underlies the actual potential of PSSs as tools of a sustainability transition (Avelino et al., 2016; Markard et al., 2012). For some, since PSSs focus on functions (Mont, 2002; Stahel, 1997), they embody “the potential of decoupling economic value generation from material and energy consumption” (Ceschin, 2014, 17). Considered as epitomes of a sound material-cycle society (Tasaki et al., 2006), PSSs are supposed to support dematerialization by reducing material and energy intensity (Beuren et al., 2013; Ericson and Larsson, 2009; Mont, 2002; Mont et al., 2006), thereby contributing to sustainability (Evans et al., 2007). For others, PSSs do not automatically entail less material and energy flow (Baines et al., 2007; Bartolomeo et al., 2003; Beuren et al., 2013). They can be pure financial instruments (Mont et al., 2006), may entail increases in consumption (Vezzoli et al., 2015), and may even create rebound effects that offset their immediate environmental benefits (Vezzoli et al., 2014). The impact on the environment of a PSS is an unsettled matter. Thus it is unclear if PSSs can live up to the expectations that some have put on them to open the way toward an economy that demands less material and is thus more sustainable. There is a need for addressing the issue of how scholars, but also producers and consumers can approach the actual impacts of PSSs in general, and of specific PSSs in particular (Beuren et al., 2013).

We address this issue by focusing on waste in the cases of Nordic fashion PSSs that promote rental, reuse, repair, and recycling of clothes. Fashion is a case in point of a service industry where companies show an interest for PSS solutions to reduce their environmental impact (Buttle et al., 2013; Ekström

and Salomonson, 2014; Elander and Palm, 2015). Our approach combines two models: First, it makes use of Tukker's (2004) model of classifying a PSS as being product-oriented, use-oriented, or result-oriented. Product-oriented PSSs stand for a low level of servitization where value creation rests on selling products with additional services, for example, insurance, maintenance, or take-back options. Use-oriented PSSs stand for an intermediate level where the traditional product still plays a central role, but ownership remains with the provider, for example, leasing or sharing. Finally, result-oriented PSSs stand for a high level of servitization where the client and provider agree on a result, and there is no predetermined product involved, for example, catering or transportation services (Tukker, 2004, 2015; Tukker and Tischner, 2006). Second, our analysis makes use of the European waste hierarchy model (The European Parliament and the Council of the European Union, 2008/98/EC) that ranks waste management options from waste prevention at the top, followed by reuse, recycling, energy recovery, and landfilling as a last resort. Combining these two models, we focus on the waste effects these various PSSs produce. We find that the waste effect of a PSS does not depend on its being a product-oriented, use-oriented, or result-oriented one. Rather the effect depends on how material flows induced by its business model relate to a prevailing waste regime, the contribution of PSSs to dematerialization being conditional upon their waste effect.

Ours is a qualitative approach that complements quantitative economic (Buttle et al., 2013) and life-cycle analyses of the textile chain (Blackburn, 2009; Domina and Koch, 1997; Nieminen et al., 2007; Steinberger et al., 2009). To the studies that measure the cradle to grave environmental effects of materials, our approach connects waste to the business model underlying PSSs and explains why some PSSs are more wasteful than others. Making use of the visibility of waste as residual material, the notion of waste effect provides practical guidance to producers and consumers for how to develop and adopt waste effect reducing solutions. Analyzing the residual effect of PSSs proves to be a heuristic of interest for both scholars and practitioners.

The structure of the paper is as follows. Section 2 shows that PSS literature tends to pay perfunctory attention to waste, whereas section 3 shows that legal studies and social sciences research provide an enlarged understanding of it. We present our method in section 4 and describe in section 5 the sample of PSSs used in the study. Section 6 maps the differences in waste effects of Nordic fashion PSSs that promote rental, reuse, repair, and recycling of clothes, and presents the finding that the waste effect of a PSS does not depend on its being a product-oriented, use-oriented, or result-oriented one, but on how its business model relates to a prevailing waste regime. Our conclusions in section 7 stress the importance for PSS managers to turn waste into a material and informational input. We suggest also that to participate optimally in a sustainability transition, PSS design should develop waste strategies (Bartl, 2014a) that prioritize waste prevention before reuse, recycling, recovery (incineration), and landfill. More generally, if servitization is to entail dematerialization, decoupling, and sustainability

transition, there is a need to develop an awareness of the waste effect of services. The principle that the best possible way of dealing with waste is to prevent it could inform such an awareness.

## 2. Waste in PSS literature

Even if from their inception PSSs have been credited with an ability to reduce environmental impacts (Goedkoop et al., 1999), PSS authors have shown a perfunctory interest in waste. For example, Sakao (2013) discusses the sustainability of engineering PSSs but without mentioning waste. Others acknowledge the importance of waste for PSSs (e.g., Ceschin, 2014; Mont, 2002), but in rather general terms that do not problematize what waste is. For example:

The PSS absorbs materials from the environment and transforms them into products. In the end, all materials are transformed into a type of waste and sent back to the environment. The quantity and quality of the used materials or waste are one of the main reasons for environmental problems. (Beuren et al., 2013, 226)

Or:

At its best PSS thinking can offer dematerialization possibilities for clothing consumption and opportunities to close material loops, to decrease reliance on resources, and to reduce waste. (Armstrong et al., 2015)

When manifest, the interest of PSS literature in waste derives from practical concerns: reducing costs for industries (Baines et al., 2007; Manzini and Vezzoli, 2002); re-designing products to reduce spills (Mont et al., 2006; Vezzoli et al., 2014; Vezzoli and Manzini, 2008) developing technology (Tasaki et al., 2006); innovating (Ceschin, 2014; Mylan, 2015; Tukker, 2015); and mitigating the negative environmental effects of industrialization (Ceschin, 2014). This interest also derives from environmental management for life-cycle thinking (Manzini and Vezzoli, 2002), such as natural capitalism or cradle to cradle (Ceschin, 2014). It is even an answer to the environmental problems created by increasing waste volumes (Armstrong et al., 2015) and the corresponding need to develop more sustainable consumption (Hirschl et al., 2003). It is an interest that accompanies an evolution of waste management (Mont and Plepys, 2008) and the European legislation on waste (Mont and Lindhqvist, 2003; Plepys et al., 2015) from an end-of pipe-approach towards recycling, reuse, and waste prevention (The European Parliament and the Council of the European Union, 2008/98/EC). However, none of these expressed interests fully realize the potential of a waste-centric analysis of PSSs.

In line with the principles of functional economy (Stahel, 1997), the literature puts forward that PSSs make it possible to shift from providing goods to providing service (e.g., Cherubini et al., 2015) or offering added value (e.g., Barquet et al., 2013). Such a shift could entail PSS-providers internalizing

the costs related to collection and disposal of end-of-life products and services (Baines et al., 2007; Goedkoop et al., 1999; Mont, 2002; Vezzoli et al., 2015). It could also require a transformation and re-direction of consumer demand (Mylan, 2015) toward alternative modes of production, distribution, and consumption (Goedkoop et al., 1999; Tasaki et al., 2006). It might even require that producers offer integrated solutions (Manzini and Vezzoli, 2002) that help users manage the end-of-life of what they purchased (e.g., Vezzoli et al., 2015; Vezzoli et al., 2014). Standard examples of this shift to function are a replacement of selling by renting or leasing (Mont et al., 2006; Tasaki et al., 2006; Tukker, 2015), or the development of a sharing economy where consumers share possessions such as houses, cars, tools, and clothes with each other (Ceschin, 2014; Goedkoop et al., 1999; Halme et al., 2006; Manzini and Vezzoli, 2002; Piscicelli et al., 2015; Zhang et al., 2015).

Some authors discuss specific aspects of waste governance, in particular extended producer responsibility (EPR) systems (Bartolomeo et al., 2003; Ceschin, 2014; Cook et al., 2006; Plepys et al., 2015; Vezzoli et al., 2015). Others address specific aspects of waste management, such as waste collection (Bartolomeo et al., 2003), recycling (Mont et al., 2006), revalorization (Bartolomeo et al., 2003), preparation for reuse (Mont et al., 2006), reuse (Gelbmann and Hammerl, 2015), and waste prevention (Halme et al., 2006; Halme et al., 2004; Manzini and Vezzoli, 2002). Some even address how to postpone the moment when a product becomes waste (Gaiardelli et al., 2014) or the need to integrate formal and informal waste systems (Srinivasan, 2014).

Developing a resource efficient economy by substituting a service element for material, reducing end-of-life problems, and reducing energy use are featured as potential advantages of PSSs (Evans et al., 2007), but these advantages are asserted in hypothetical normative ways, often as part of conceptual arguments rather than in systematic analyses (Beuren et al., 2013; Reim et al., 2015). There exist case studies that pay specific attention to waste, for example, of new food production systems (Evans et al., 2007), industrial PSSs (Sundin, 2009), and renting or leasing systems (Besch, 2005; Intlekofer et al., 2010; Mont et al., 2006; Tasaki et al., 2006). Likewise, Mont et al. (2006) or Gelbmann and Hammerl (2015) do mention the European waste hierarchy model (see below). As a whole, however, and as recent reviews (Beuren et al., 2013; Reim et al., 2015; Tukker, 2015) show, waste has been considered a non-central dimension of PSSs and has had a low level of attention. For instance, there is no discussion of the nature of the substances referred to as waste or how differently various waste management options affect the environment. A more efficient management of waste has not been high on the PSS research agenda except as an ideal environmental benefit, a potential for cost reduction, and a way to comply with EU regulations such as the recast of the Restriction of Hazardous Substances Directive (RoHS 2; The European Parliament and the Council of the European Union, 2011/65/EU) or the Waste Electrical and Electronic Equipment (WEEE) Directive (The European Parliament and the Council of the European Union, 2012/19/EU).

Expanding on the research agenda laid down in these recent literature reviews (Beuren et al., 2013; Reim et al., 2015; Tukker, 2015), we adopt a waste-centric perspective to show that focusing on waste has a strong theoretical and practical potential to help understand the environmental impacts of PSSs and develop tactics to improve the design and implementation of sustainable PSSs. More specifically, the notion of waste effect serves here a methodological, theoretical, and practical means to evidence the material dimension of PSSs, and to open innovative demands and perspectives on PSS developments towards sustainability. Not the least, the waste effect extends the understanding of PSSs to a full acknowledgement of what happens to products and services at the post-consumption stages of their life cycles. As we describe in the next section, it also builds on the understanding, derived from legal studies and social scientific research, of waste as equivocal, contextual, and transient.

### 3. Understanding waste

As described in *Global Waste Management Outlook* (Wilson, 2015), household waste worldwide reaches 2 billion tons per year, and waste from commerce, industry, and construction adds another 5-8 billion tons (waste from mining and carrying excluded). In the developed world, which accounts for about 50% of the total waste, waste volumes have somewhat stabilized, for example, around 500 kg post-consumption waste per person and year in the European Union. However, waste production is increasing rapidly, albeit from a low-level, in developing countries under the combined effects of population growth, economic development, and accelerating urbanization. It brings with it other consequential negative impacts: on public health, by spreading cholera, dengue fever, and other infectious diseases; on the environment, where it contributes to soil and water pollution; and on the climate through methane emissions from landfill sites. With the *Global Waste Management Outlook*, the United Nations Environment Program and the International Solid Waste Association unite to send through Wilson's (2015) statistics, the message that moving from waste management to a global resource management is more than merely desirable: it is absolutely essential.

Beyond this alarming message, a key issue is that waste is an equivocal label. For example, the definition in the European Waste Framework Directive of waste as "any substance or object which the holder discards or intends or is required to discard" (The European Parliament and the Council of the European Union, 2008/98/EC) describes waste having such heterogeneous origins as actual disposal practices, mere intentions, and legal obligations. American legislation defines waste even more diversely. A resource is considered "wasted" under the following circumstances: it is not used according to an optimal cost/benefit; it is not used in the best and immediate interest of society; its use forecloses the option for future generations to meet their needs; its designated use is disrupted, replaced, or altered; and if the maintenance of an ecosystem's integrity is threatened—which means attributing a score of origins to waste (Pappas, 2014).



Legal definitions of waste render that nothing is inherently waste (Strasser, 1999), and there are many waste regimes, as Gille (2010) aptly calls established societal ways of conceiving and managing waste. Waste regimes, Gille (2010) explains, rest on culturally entrenched notions of shame and taboos (Douglas, 2002 (1966)). They are characterized by valuation practices (Hawkins and Muecke, 2003): people value things and decide that some have a zero or negative value and are thus waste. Waste regimes are embedded in the production, distribution, consumption, and disposal practices (Gregson et al., 2013a) that determine the kinds of material and artifacts that pass through the economy as well as the physical and social trails of waste (Royte, 2005). They depend on and determine how waste is collected, processed, and brought back to the market by available waste infrastructures (Corvellec and Bramryd, 2012), for example, collection schemes, recycling facilities, incineration plants, landfills, but also public waste policies, private recycling companies, and civil society actors engaged in waste prevention. These socio-technical infrastructures condition the conversion of waste into resources, what O'Brien (1999) calls the political economy of waste. Waste regimes are expressions of the politics of value (Corvellec and Hultman, 2014) characterized by trade-offs between the economic, environmental, and social values involved. Waste regimes also contribute to establish ethical relationships to disposability, dispossession, and rejects (Hawkins, 2006). For instance, the waste status of a discarded glass bottle depends on the relative values granted to glass and energy; how producers, distributors, and consumers view and organize the consumption of glass bottles; moral views on recycling responsibilities; and whether or not there exists a glass recycling system or a bottle reuse system. Thus the waste effect of activities such as a PSS can only be assessed within the specific context of the waste regime (Gille, 2010) within which the PSS interacts, and two elements of this regime seem to be of particular importance: valuation practices (Hawkins and Muecke, 2003) and waste infrastructures (Corvellec and Bramryd, 2012).

Moreover, the status of waste is transient (Thompson, 1979). On the one hand, waste is only a temporary attribute of a resource (Dijkema et al., 2000), and organizing how to put waste back into the capitalist circuit of commodity (O'Brien, 1999) has become the mission of waste governance. Changing valuation principles or consumption practices can start attributing value to what has so far been considered as valueless (Hawkins and Muecke, 2003). Innovation can bring back into markets things and materials that were formerly externalized as waste (Gregson et al., 2013b). As the European Waste Framework Directive (The European Parliament and the Council of the European Union, 2008/98/EC) underscores, waste that undergoes a recovery, for example, through recycling, ceases, under certain legal and environmental conditions, to be waste. On the other hand, waste can return, for instance, in the shape of CO<sub>2</sub>-emissions, to threaten the systems that once wasted them (Gregson et al., 2007). Furthermore, inspired by bio-semiotics and cross-species scholarship, Reno (2014), suggests to cease viewing waste as an end point, a sign of death, and start instead considering it as the starting point for trans-species encounters and new forms of life.

The equivocal, contextual, and transient nature of waste is acknowledged by the European waste hierarchy (Bartl, 2014b; The European Parliament and the Council of the European Union 2008/98/EC) considers waste both as the object of discarding practices and a potential resource. Expressing a life-cycle way of thinking (Lazarevic et al., 2012), the hierarchy aims to orient waste governance in Member States toward sustainability. It orders five different waste management options according to their environmental impact. At the top of the hierarchy is prevention that corresponds to practices aiming to reduce the quantity and dangerousness of waste. This most preferred option is prevention followed by reuse, recycling, energy recovery, and the least desirable option, landfills.

One can question the European waste hierarchy model on several accounts. It is difficult to see where reuse and waste prevention start (Arcadis Belgium, 2010; Gharfalkar et al., 2015), and it is contradictory to present waste both as something that should be valorized and prevented (Hultman and Corvellec, 2012). The hierarchy promotes an end-of-pipe approach to waste that deviates attention from reducing demand (Price and Joseph, 2000) and from making production more efficient so as to reduce material and energy use (Price and Joseph, 2000; Van Ewijk and Stegemann, In Press). However, the waste hierarchy also has the merit to make waste visible and thereby break with what de Coverly et al. (2008) call a systematic social avoidance of waste, the tendency to hide waste from view, both physically, socially, and politically. It is also compatible with different waste definitions and waste regimes as it caters to the possibility that waste has to end being waste, and makes it clear that waste is not something generic but something that results from deliberate choices and practices. Further, since the waste hierarchy ranks waste handling techniques from best to worst, for example, putting recycling facilities above waste-to-energy plants, it stresses the key role that waste management infrastructures play, for better or worse, in waste governance. Finally, by ordering waste management alternatives from worst to best, it signals that all waste management options are not equally good and thus advantageous. Thereby, it makes it possible to order waste management options, compare how two companies manage their waste, and assess how waste governance evolves. Albeit imperfect, because the European waste hierarchy model is an operational tool that makes it possible to assess how well waste is taken care of in its equivocal, contextual, and transient nature, we use it as an analytical device as described below.

#### **4. Methodology**

This research stems from our interest in the environmental effect of services in general and PSSs in particular. Using waste as an instance of material inefficiency and environmental threat (Wilson, 2015), we conducted a critical analysis of how PSS literature approaches waste. Through a combination of snowball-type and keywords-based literature searches, starting from three special issues of the *Journal of Cleaner Production* (2003, 2006, 2015), we built a collection of key PSS texts, then systematically searched for “waste” to assemble a source file containing relevant quotes and

summaries.

Parallel with this work, we followed Siggelkow's (2007) recommendation and oriented our work toward specific case studies. Our choice fell on PSS schemes in Nordic fashion for two reasons. The first derives from the growing interest in Nordic Countries for the environmental impact of textiles and ways to address it (Elander and Palm, 2015; Watson et al., 2014). Textiles have a major negative environmental impact from the production of fibers to disposal through the use of dyes, water, and non-renewable energy (Allwood et al., 2008). Increasing levels of textile and clothing consumption produce today 350,000 tons of textile waste out of which only 120,000 tons are collected (Elander and Palm, 2015). Thus, all efforts made at increasing the recycling of textiles (Ekström and Salomonson, 2014; Kant Hvass, 2014), prolonging the life of clothes (Fletcher, 2013; Niinimäki and Hassi, 2011), or developing rental and leasing alternatives to purchases are seen as potential contributions to a needed transition toward sustainable systems of production, distribution, and consumption (Armstrong et al., 2015) of textiles. This leads to the second reason for our focusing on textile PSSs: an increasing interest among Nordic textile firms for PSSs. A systematic desktop pre-study of policy and research reports (e.g., Elander and Palm, 2015), media, and webpages provided a systematic overview that confirmed the interest for PSSs in the Nordic fashion industry. Because the purpose of this overview was to chart the variety of PSSs that exist in this industry, we made special efforts to go beyond the more frequent product-oriented PSS and find use- and results-oriented schemes. For our sample, we used all such examples whereas we did not include all examples of the considerably more common take-back systems that we found.

After having built a representative sample of the variety of PSSs in Nordic fashion, we collected additional data on each case via multiple sources, depending on how and where we could obtain relevant information regarding the case. Primary data came from interviews, mainly with sustainability managers (although representatives from all firms could not be interviewed), and in-store observations. Secondary material came from interviews with industry representatives, firms' sustainability reports, online videos, media (interviews and articles), policy and research reports, and webpages (see Table 1).

Table 1: Presentation of the case companies

<i>Company</i>	<i>Turnover/market focus</i>	<i>Data collection</i>
Boomerang	23 Million Euro (MEur)/single (premium) brand	Interview with market and CSR manager; webpage
H&M	19 644 MEur/integrated fast-fashion retailer with own international store chain	Sustainability report, newspaper interview, videos, in-store observations
Indiska	80 MEur/integrated retailer with own Nordic store chain	Sustainability reports, interview sustainability managers (2 different ones), in-store observations, webpage
Filippa K	56 MEur/single (premium) brand	Sustainability reports, interview sustainability manager (twice) & store coordinator, in-store observations

Nudie	41 MEUR/single premium brand	Web page, sustainability reports
The Clothes Library	Unknown/pop-up store	Interview with manager, webpage
UFD	1 MEur/single premium brand	Webpage, interview with industry representative
Vigga	Unknown/single (online) premium brand	Webpage, video, policy reports

We analyzed the data according to the following procedure. First we classified the different PSSs according to Tukker's (2004, 2015) typology, not only because it is a common way to classify PSSs (Armstrong et al., 2015; Beuren et al., 2013; Reim et al., 2015; Tukker, 2015) but also because it describes how the degree of servitization increases from product-oriented PSSs, via use-oriented ones to result-oriented ones (Tukker, 2004). If the PSS entailed a transfer of ownership to consumers, we categorized it as product-oriented. If the company retained the ownership of the clothes that consumers borrow or lease, we categorized the PSS as use-oriented. If customers chose the service but the service provider chose the clothes, the PSS was understood to be results-oriented, as the garment itself plays a subordinate role. For instance, Vigga's customers subscribe to a service, and the firm chooses what clothes the consumer will lease, whereas customers at Filippa K and Uniforms for the Dedicated (UFD) lease individual clothes and pay per each occasion. In systems such as Vigga, customers choose a result and the provider delivers relevant products. Second, we analyzed the waste effect of each PSS using the Waste Hierarchy Model (see Figure 1). The service was classified reuse if it entailed that products or components were used again for the same purpose for which they were conceived. We considered it recycling if it entailed materials reprocessed into products, materials, or substances whether for the original or other purposes, except energy recovery. It was considered prevention if it entailed measures that reduce the quantity of waste, the adverse impacts of the generated waste on the environment and human health, or the content of harmful substances in materials and products. We paid particular attention to the fact that the same piece of cloth or textile could pass through the system several times.

The purpose of combining Tukker's (2004, 2015) typology with the waste hierarchy model is to show how this effect relates to the degree of servitization that underlies Tukker's typology (see Table 2). The next section describes the sample of PSSs that serve as a basis for the study.

## 5. A sample of Nordic fashion PSSs

PSSs have become common among Nordic fashion companies where they stand for sustainability efforts to tackle the issue of mounting textile waste, an issue that has become a chief concern within the industry alongside overuse of water, poor work conditions, and the uncertain effects of chemicals. This section describes the rationale of the PSSs contained in the sample for this study; classifies them according to Tukker's (2004, 2015) typology of product-, use- and results-oriented PSSs; and describes how they deal with textile waste in the terminology of the waste hierarchy (Table 2).

<Insert table 2 about here>

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**Table 2: A selection of Nordic fashion-PSSs**

<i>Company</i>	<i>Activity</i>	<i>Type of PSS</i>	<i>Type of waste treatment</i>
Boomerang	In store take back system Sold as vintage in-house Sold as home textile Given to charity - Sold as clothes - Recycled	Product-oriented PSS	Collection Reuse Reuse textiles / Recycling clothes  Reuse Recycling (progressive down-cycling)
H&M	In store take back system Collaboration with I:CO - Sold as clothes - Use to produce other products (e.g., cleaning clothes) - Recycled fibers <i>Even: Use recycled fibers</i>	Product-oriented PSS  <i>(Not PSS)</i>	Collection  Reuse Recycling  <i>Recycle (external purchase of recycled materials for the production of new clothes)*</i>
Indiska	In store take back system Given to charity - Sold as vintage in-house - Sold as clothes - Recycled	Product-oriented PSS	Collection  Reuse Reuse Recycling (progressive down-cycling)
Nudie	In store take back system Repair Resale as vintage (in house) Occasional recycling (one-off collections)	Product-oriented PSS	Collection Prevent Reuse Recycle
Filippa K	In store take back system Curate wardrobe Short-term lease  Develop and offer fabric care advice and products Sold as vintage Given to charity - Sold as clothes - Recycled	Aspire to result-oriented PSS Use-oriented PPS  Product-oriented PSS	Collection Prevent (frugal consumption) Reuse Prevent Prevent Reuse  Reuse Recycled (progressive down-cycling)
The Clothes Library	Rent	Use-oriented PSS	Reuse Prevent
Uniforms for the Dedicated (UFD)	Rag bag (surface mail) Short-term lease  <i>Even: Use recycled fibers</i>	Use-oriented PSS  <i>(No PSS)</i>	Collection Reuse Prevent  <i>Recycle (external purchase of recycled materials for the production of new clothes)</i>
Vigga	Arrange and rent clothing packages Recycle worn textiles	Result-oriented PSS	Reuse Prevent

			Recycle
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### 5.1. Product-oriented PSS

Product-oriented PSSs, particularly take-back systems, are the most frequent type of PSS in our sample (Table 2). For instance, the Swedish premium clothing and interior design company Boomerang has offered since 2008 a service of in-store take-back in its Swedish stores that aims at reuse and recycling. Named the Boomerang-effect, the initiative came from one of the designers who found it problematic that a new winter jacket for kids would cost as much as an adult jacket even though it would be quickly outgrown. She argued that Boomerang should offer consumers the possibility of returning the jacket to the store. Today, the company presents the service as a way to communicate long-lasting quality and strengthen the Boomerang brand. Upon handing a piece of Boomerang clothing back, a consumer receives a 10 % discount for the next purchase, which can have a substantial impact on the profitability of single sales if the purchased product is significantly cheaper than the returned one. The returned clothes are transported from stores to a central location where they are sorted into three piles: some are given the Swedish Society for Nature Conservation's Good Environmental Choice label and sold as vintage in Boomerang stores; others are cut up to make pieces for interior design products also sold in their own stores; yet others are given away to charities that will sell the clothes or recycle the textiles. While the take-back service does not appear that impressive in terms of added-value for consumers, the company states that many consumers appreciate having the possibility to return rather than throw away cherished clothes.

Other companies offer similar take-back services. For example, Indiska, a medium life-style brand, also offers a take-back service oriented toward reuse and recycling. The company collects used textiles on behalf of Myrorna, a second-hand retailer owned by the Salvation Army; Indiska has even started selling in its own shops a limited amount of selected jeans with a Myrorna tag. Likewise, the premium Swedish brand Filippa K offers a combination of reuse, collecting used garments of its own brand to sell some of them in a second-hand Filippa K store, and gives the rest to charity for recycling. Likewise again, second largest global clothing retailer H&M has set up a take-back system, mostly oriented toward recycling. H&M lets I:CO, part of the used textile and recycling SOEX group, run a collection system in its stores and accepts any textiles regardless of origin, providing consumers with a fixed discount for their next purchase according to I:CO's slogan: Rethink, Recycle, Reward.

UFD has designed an original collection system geared toward reuse. UFD is a premium brand that mostly uses up-cycled materials and aspires to design and produce the most environmentally friendly fashion garments on the market and lead a movement for a changing industry. The company has introduced a shopping bag that, if turned inside out, becomes a "rag-bag" that can be stuffed with an old item and mailed directly to a charity free-of-charge. Denim-retailer Nudie is another premium brand emphasizing sustainability, and its services combine collection, prevention, reuse, and recycling. Nudie profiles itself by their elaborative narratives regarding how to wear jeans to adapt their looks



and extend their life. While Nudie runs a take-back system, sells vintage jeans, and experiments with recycling old jeans, its boldest move has been to introduce free repairs to all Nudie jeans owners. This service has become central to Nudie as fully-owned stores have been renamed into “repair shops.” Moreover, it has important organizational consequences as extra personnel and storage space is needed to provide the service.

## 5.2. Use-oriented PSS

Other firms experiment with use-oriented PSSs where they retain ownership and the consumer pays for access. The very idea of clothes libraries, often operating at the margins of the retail industry, is to let people rent or share clothes. Even UFD offers short-term lease of selected parts of their collections, an offering with a potential of waste prevention if customers use this service as a substitute for purchasing. For example, one can lease a jacket for 15% of the price for 3 days or 20% for 7 days. Another company experimenting with leasing is Filippa K, with the same potential for waste prevention. In the beginning of 2015, Filippa K started offering a particular collection of dinner jackets and dresses for rent in some of their Swedish stores. However, after six months the company decided to extend the offer to all items for sale as they expanded the concept to stores in their foreign markets. Filippa K’s proclaimed purpose of introducing leasing is to try to teach consumers a new way of consuming clothes, moving from ownership to use. Hence, the effort appears inspired by ideas of trying to re-direct consumer demand toward alternative modes of consumption (Goedkoop et al., 1999), although Filippa K argues that it is part of a more strategic and long-term change of its value creation strategy, away from physical retailing as a means of distribution and sales. However, the most salient result of this action has perhaps been the positive publicity, putting forward Filippa K as a sustainability role model.

## 5.3. Results-oriented PSS

Finally, a few fashion PSSs tend toward being result-oriented. While overviews suggest that such systems are fewer in number (e.g., Watson et al., 2014), and much in line with the predictions of Tukker (2004, 2015) that these are more difficult to implement, Danish Vigga can be considered a result-oriented PSS that offers customers the possibility to focus on the result of having their babies dressed in chemical-free and organic clothes (GOTS-certified organic cotton) rather than on any specific pieces of clothing. To achieve this result, Vigga puts together packages of clothes for its consumers based on baby’s size; replaces these packages with new packages as the child grows; then washes and prepares used clothes for reuse by other consumers; and, eventually, recycles worn out pieces. Likewise, Filippa K has started providing customers with advice and products to deliver a “curated wardrobe” that could be considered an embryo of a result-oriented PSS as it focuses on outcomes rather than on means.

## 6. Textile PSSs and their Waste effects

### 6.1. Ambiguous, Multifaceted, and Uncertain Waste Effects

The equivocal, contextual, and transient nature of waste produces PSSs with ambiguous, multifaceted, and uncertain waste effects. To start with, Nordic fashion PSSs display equivocal relationships to waste, even within themselves. For example, take-back and repair systems are in a way one another's opposite. Whereas repair systems offer to prolong the active life of garments and thus delay the moment when customers discard their clothes, take-back systems invite customers to turn part of their wardrobe into waste in exchange for a voucher. Moreover, rent or lease systems offer customers to pay for avoiding the waste responsibility that follows ownership. Hence, combining the reuse and resale of used garments with the reuse of textiles and the recycling of textile fibers, fashion PSSs stand for a contradictory, multi-dimensional commitment to discarded clothes, technically speaking, waste. This commitment appeals to different stakeholders, combines different time scales, and ultimately develops a different politics of value (Corvellec and Hultman, 2014) for used clothes and fibers. Developed in tandem with increasing levels of consumption, shorter trend and production cycles (Armstrong et al., 2015), the fashion PSSs at Boomerang, Filippa K, H&M, Indiska, Nudie, UFD, or Vigga let fibers, textiles, and clothes move equivocally along and across the line of demarcation that exists between products and waste (Gregson et al., 2013a; Kennedy, 2007; Scanlan, 2005). Correspondingly, we suggest that what matters is how the business model of the PSS organizes material flows at production, distribution, use, and post-consumption stages in relationship to prevailing waste regimes where the PSS operates. The notion of business model refers here to the activity system involved as value is created, delivered, and captured (Zott and Amit, 2010; Zott et al., 2011). Thinking in terms of business models is a holistic approach that takes into account the upstream environmental effects of producing textiles and clothes, and stresses that it is not possible to tell the waste effect of fashion PSSs without tracking the post first-consumption lives of the fibers that companies bring onto the market.

The different business models of fashion PSSs combine valuation practices in ways that connect the fashion industry to the world of waste. In a mix of new and old and of high and low, fashion PSS associates conventional marketing practices, from pricing to trendspotting (Cachon and Swinney, 2011) through positioning brands (Fletcher, 2013), with a variety of valuation practices that characterize second hand cultures: from giving away plastic bags of clothes to thrift shops to selling selected items to vintage boutiques (Gregson and Crewe, 2003; Hetherington, 2004). Take-back systems blend the old with the new. They coalesce the planned obsolescence of fast-fashion (Niinimäki and Hassi, 2011) with the lasting quality label of vintage clothing. For premium brands, these systems symbolize the quality of clothes, indicating that they will last long enough to be sold multiple times. Rental systems, in turn, make it possible for a customer to "borrow" the symbolic power of the brand without paying the full price for it. These systems thereby potentially challenge the

idea that the capacity of clothes to act as social identity markers (Ekström and Salomonson, 2014) resides in the ownership (Tukker, 2015) of clothes. And systems that promote the reuse of clothing defy cultural norms on dirt (Douglas, 2002 (1966)) and newness (Campbell, 2015). Illustrating the difficulties of changing consumer preferences concerning hygiene and ownership (Armstrong et al., 2015), Filippa K has put much customer trust and loyalty on the line when starting a rental system that created a risk to be felt “cheap” and unhygienic. This risk is a reminder that the possibility to repair, rent, or lease are only value propositions (Corvellec and Hultman, 2014; Grönroos and Ravald, 2011). Consumers may not accept these propositions, or they may accept them, but in ways that obliterate the environmental ambitions behind the PSS’s business model. For instance, consumers may rent clothes to enlarge their range of choice rather than to replace their conventional purchases, with no decrease in waste effect as a result. Waste effects get realized through actual consumption practices, entailing besides purchase such elements as use and appreciation (Mylan, 2015).

Moreover, the waste effect of PSSs that entail take-back services, reparation, and rentals should be evaluated in the context of actual waste infrastructures. In Scandinavia, except for the items entrusted to established non-profit circuits of collection, sorting, and resale of used clothes and textiles (Ekström and Salomonson, 2014), used clothes and textiles are routinely disposed of as unsorted household waste and transformed into electricity and heat for district heating systems (Elander and Palm, 2015). It is against the backdrop of a waste regime where most textiles end up being transformed into energy that fashion PSSs have been developed and operate, often in collaboration with actors already involved in prolonging the life of fibers, textiles, and clothes. Boomerang and Indiska team up with the main Swedish chain of thrift shops; H&M contracts its take-back activity to a major private textile recycler; and Vigga puts forward its collaboration using an established standard of textile fibers. Patterns of collaboration are idiosyncratic, though, and whereas H&M or Indiska accept broken textiles from any producer, Boomerang, Filippa K, and Nudie only take back their own products. Through these collaborations, which are not without elements of competition (Ekström and Salomonson, 2014), fashion PSSs open the collection of used textiles to new places and new behavior rationales.

It is important to keep in mind that the post-consumption social life of clothes and textiles is not determined alone by how the business models of PSSs design material flows. As our respondents stressed, the costs and complexities involved in large-scale collection and recycling demand that firms insert themselves into an existing waste regime upon which they depend, even if they contribute to developing it. The waste effect of a PSS is a matter of complex and changing interactions between the material flows that characterize this system and the solutions available to handle used textiles and clothes. To ascertain this effect, an integrated model such as the European waste hierarchy may be useful.

## 6.2. Ordering PSSs with the waste hierarchy

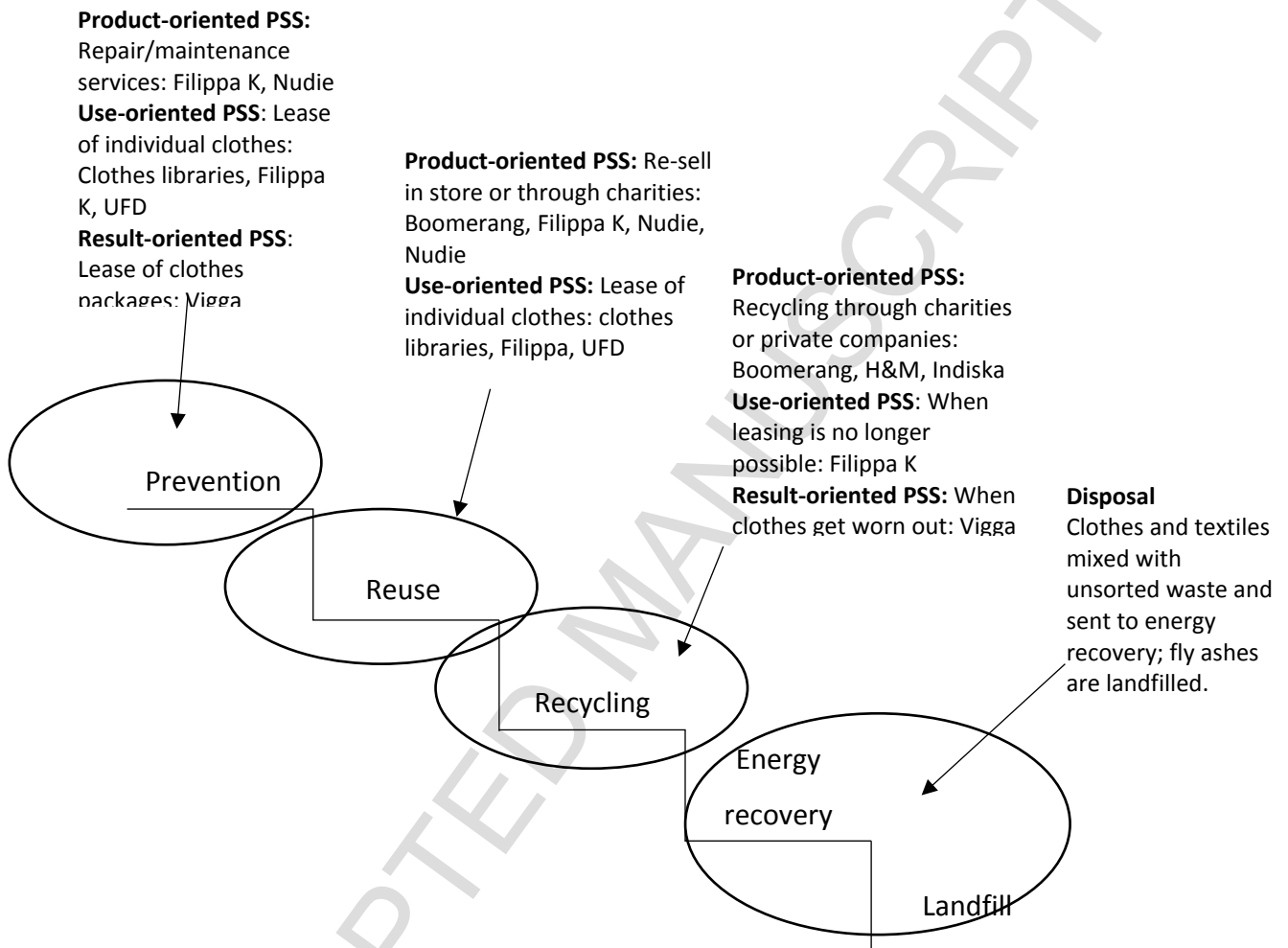
The European waste hierarchy model (The European Parliament and the Council of the European Union, 2008/98/EC) makes it possible to approach the waste effects of PSSs in a systematic and ordered way.

As a recent policy brief to the Nordic Council of Ministers points out: “In the current paradigm most textiles are used only for part of their functional lifetime and then sent to incineration and landfill with a waste of high grade resources.” (Palm et al., 2015, 7). Yet, the European waste hierarchy makes clear that comparatively, landfill and energy recovery are a relatively poor way of managing waste (Bartl, 2014b). Thus, one of the attractive traits of fashion PSSs is to offer innovative possibilities for recycling textiles, reusing clothes, and preventing textile waste that make it easier for customers to climb the waste hierarchy above the stages of landfill and energy recovery.

PSSs rest on a variety of waste treatments (Table 2), and if one positions these treatments within the waste hierarchy (Figure 1), it appears that PSSs offer a variety of ways for customers to climb the waste hierarchy. Take-back systems that collect textiles for recycling potentially recover the material that clothes and textiles are made of (e.g., H&M’s collaboration with I:CO), thus inviting customers to climb above the energy recovery level of the waste hierarchy. The level above recycling is opened by reuse systems where clothes and materials serve the same function as they did originally. It can be take-back systems where clothes are sold again as vintage items in their own shops (e.g., Boomerang, Filippa K), as charity items in their own stores (e.g., Indiska), or as charity items sold in other stores (e.g., Boomerang or Indiska). Also in this category are rental and leasing systems (e.g., The Clothes Library), including the result-oriented PSSs (e.g., Vigga, and to some extent Filippa K) that make reuse of a textile possible after some minor treatment such as cleaning (see Figure 1). Finally, systems aimed at preventing waste (e.g., Nudie providing free repair) open the highest level of the waste hierarchy with an offer to intervene before customers decide to dispose of clothes, thus prolonging their use and delaying replacement. Vigga’s focus on baby clothes, typically outgrown quickly, can probably prevent consumption if there are no rebound or compensation effects. It is noteworthy that most companies offer services that stretch over several steps of the waste hierarchy.

A first finding is that, by design, PSSs have differentiated waste effects. There are no generic waste effects of PSSs. Instead, one needs to look into how a PSS’s specific business model affects material flows and behavior. In terms of the waste hierarchy, some are simply superior to others. Our qualitative approach cannot tell how much better, and we leave it to life-cycle analysts to quantify and confirm the differences. It is, however, an approach that gives visibility to the residual materiality of PSSs, and thus makes that residual manageable. On this account, it is a contribution to managerial

practice. In the specific case of textile PSSs, one could imagine that increasing the visibility of textile waste for producers and customers of PSSs could have up-stream effects on design and generate incentive for companies to collect their own products and try to resell or recycle them, thereby learning from these activities.



**Figure 1: PSS types in relation to waste hierarchy**

We suggest therefore that the waste hierarchy, at least if used with some precautions, offers a way to compare the waste effects of PSSs and order them from worst to best according to these effects. A first precaution concerning this use relates to the variety of routes that clothes and fibers can take through PSSs. The same piece of clothing can pass through PSSs several times, in multiple loops, for example, being first repaired and after that reused or recycled, or being first leased and after that sold as a charity item. It also makes a difference if a small or a large percentage of taken-back items are sold again as clothes, as reusable textiles, or as recycled fibers. It even makes a difference how many times

clothes are rented or leased, and how they are later disposed of. Fashion PSSs do not let used clothes and textiles follow simple routes from products to garbage; they take clothes, textiles, and fibers through intricate sequences of reuse, repair, and recycling that are not one-way and linear. Optimally, to assess the waste effect of a PSS, one would need to track the whole post-first-consumption life of items through the collection, repair, reuse, and recycle schemes that characterize fashion PSSs. This is not something that we can do here as it would require PSS- and even item-specific estimates. A second precaution pertains to how corporate strategy and customer behavior condition the nature and quantity of waste. A take-back system driven by a fast-fashion company such as H&M is different from the rental system driven by a company committed to lasting quality such as Vigga, even if both eventually offer to recycle the textiles. These two systems rest upon radically different approaches to fibers, sense of ownership, disposal pace, and eventual waste effects. Actually, in fast-fashion, distributing vouchers in exchange for used clothes can simply increase the total volume of consumption, ultimately adding to the volume of clothes brought to disposal. Likewise, nothing says that customers who borrow, rent, or lease clothes do this instead of purchasing clothes, which is why the prevention effect of such services is conditional. A third precaution comes from the fact that a piece of clothing can be rented, reused, repaired, or recycled, but this does not say much about the upstream waste effects of the sales of clothes: an assessment of the waste effect of fashion PSSs remains limited to a narrow end-of-pipe understanding of waste.

With these precautions in mind, a second finding emerges from using the waste hierarchy to order Nordic fashion PSSs: there is no automatic correspondence between the degree of service orientation of a PSS and its waste effect. Focusing on residual materiality, we do not find that the potential for dematerialization increases from product-oriented, to function-oriented and results-oriented PSSs (e.g., Armstrong et al., 2015; Halme et al., 2006; Lindahl et al., 2014). As shown above in Fig. 1, product-oriented PSSs can be found at any level of the waste hierarchy and can have either better or worse waste effects than result-oriented ones. Moreover, a product-oriented PSS that offers customers repairs and maintenance, like Nudie, to prevent their clothes from becoming waste, can have more benevolent waste effects than use-oriented services that mainly offer increased reuse. Arguably, being product-oriented, function-oriented, or results-oriented does not determine the waste effect of a PSS. Instead, the waste effect is determined by how the material flows that derive from the services and activities offered by the PSS interact with consumers' valuation practices (e.g., reactions to the offer to reuse, repair, or recycle) and available waste infrastructures (e.g., which technical or commercial possibilities exist to collect and process clothes, textiles, and fibers). To put it simply, a degree of servitization is not a measure of waste effect and dematerializations.

As shown, some firms offer a range of services that draw on different types of PSSs to accommodate different needs, types of products, and stages in a product's life. For example, a pair of Nudie jeans or a Filippa K jacket may be worn and repaired, and then handed in through take-back, then sold as

vintage to another owner, then perhaps repaired again, and eventually handed back one last time to end up in the pile of clothes going to recycling. Ultimately, what matters are the paths that textiles and clothes can, and do, take through this system of services. Therefore, the business models of PSSs may offer consumers the possibility to link elements of purchase, use, and appreciation together in ways (Mylan, 2015) that reduce waste effects. Offering a production-oriented service that enables waste prevention when consumers want to hang on to an item, a reuse system when a product is functional but no longer wanted, and a recycling system when things are worn and broken, with firms learning from these services may be just as effective as implementing radically different PSS types.

## 7. Concluding discussion

A waste-centric analysis of PSSs provides critical insights into their potential to contribute to dematerialization, decoupling, and sustainability. As this qualitative study of PSSs in the Nordic fashion industry illustrates, PSSs have differentiated waste effects, if, by waste effect one means the waste that these systems produce. A waste-centric analysis stresses the material dimension of services and a corollary of the present study is that PSS research should get rid of, once and for all, the assumption that because services are intangible, the production of services uses less material than the production of products (e.g., Goedkoop et al., 1999; Mont, 2002). These assumptions are grounded in the popular definition of services as *intangible*, *heterogeneous*, *inseparable*, and *perishable* (the so-called IHIP definition of services, see, e.g., Moeller, 2010). But the IHIP definition of services is a theoretical construction that misses that a real-life service economy is anything but immaterial. As the case of fashion PSSs shows, the actual provision and consumption of services require a consumption of natural resources that makes waste inevitable. It would be a mistake to equal servitization with dematerialization. Real-life services are endowed with a materiality (Edgley, 2014), and considering them as immaterial leads to underestimating and, at worst, missing the environmental impacts of their use of resources (Campbell et al., 2013). Correspondingly, there is an encompassing need to study the material dimensions of services to make this dimension more visible, both qualitatively and quantitatively.

A key finding of this study is that the waste effect of a PSS does not follow from its being product-oriented, use-oriented, or result-oriented. It follows from how the details of the material flows induced by its business model relate to the details of prevailing consumer behaviors and waste infrastructures for collection and processing. This finding could provide renewed enthusiasm for PSSs, as product-oriented ones are sometimes considered easier to develop and implement (Tukker, 2015), and can lead to a reduced waste effect. The environmental potential of PSSs is thus not limited to the rarer result- and use-oriented PSSs (Armstrong et al., 2015) that restrain the potential of PSSs for a sustainability transition. Moreover, what appears as central is the extent to which PSS providers can utilize used-

products on their way to becoming waste as material and informational input. Waste collection and treatment is an industry in its own right, and it is far from obvious for a company to build closed material loops with their own products. It is even far from obvious how to exploit the information potential of used products to learn how to improve the reuse and recycling of the products that firms put on the market. There are many differences among firms that have set up PSSs when it comes to engaging with repair or resale, monitoring the waste that they produce, and following the processing of waste after having helped to collect it. Different PSSs expose decision makers to different waste knowledge and create more or less favorable positions for them to monitor the residual material effect of these PSSs.

Another finding is that the European waste hierarchy model (The European Parliament and the Council of the European Union, 2008/98/EC), or an equivalent model outside the European context, creates a clarity among waste treatment alternatives that may serve as strategies for reducing waste effects. Such strategies would also gain in precision if PSS managers adopted a broad understanding of waste, one that runs along the whole value chain and internalizes its total environmental costs (Watson et al., 2014), including less visible costs such as the negative environmental impacts of recycling activities in poor countries or the lasting emissions of methane in landfills. Such strategies would even benefit from institutional incentives such as raw material taxes, extended producer responsibility (EPR) systems, and other ways to replace current valuation practices and bring along waste regimes where it makes good economic and environmental sense to learn from and account for waste. On this account, PSS designers may gain from collaborating more tightly with waste specialists early in the PSS development process to imagine ways of reducing the residual material impacts of their creations.

More generally, we advocate a systematic awareness of the materiality of PSSs, out of which their waste effect is only one part. To promote dematerialization, decoupling, and transition, a global reduction of material and energy throughputs (Daly and Farley, 2004) in the service economy requires that the materiality of services, among them PSSs, is acknowledged, questioned, and addressed in systematic manners. Developing waste prevention strategies for PSSs is a case in point, but it is only a starting point.

In terms of more specific future research, we think that to grasp waste effects, it is important to explore more fully how the business model arrangements of material flows are linked to consumption in terms of how consumers buy, use, and value different products and services (e.g., Mylan, 2015). Such links may of course differ greatly when analyzed in contexts other than that of fashion. Moreover, in addition to our qualitative comparison, analysis that quantifies amounts of waste may provide additional clarity to the significance of waste, in both fashion and elsewhere. However, such analysis needs to take onboard the equivocal, contextual, and transient nature of waste that we have argued for here.



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