Adoption of product-service system and the potential as a sustainable solution: A literature view in the fashion industry

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Abstract

Fashion industry is highly dependent on natural resources, being of high environmental concern since those materials are consumed in high frequency and disposability to produce, distribute and to maintain its products. The adoption of Product-Service Systems (PSS) can provide to industry a mechanism to increase factors such as product quality and longevity, while providing alternative consumption models that reduce environmental impact. In this context, the purpose of this paper is to identify the existing models of PSS in the literature applied on fashion industry, its characteristics, and sustainable potential. Content analysis of 24 articles was performed, which are discussed according to the feasibility of operation and its environmental impact. There were identified 11 types of PSS applied in fashion industry and 7 types of green practices were observed in the models examined.

Keywords
Fashion industry; Product-service system; PSS; environmental impact.

1. Introduction

According to MGFI (2018), the fashion industry encompasses six groups consisting of clothing, footwear, sportswear, handbags and luggage, watches and jewellery, and other accessories. The MGFI (2018) also discusses the unsustainability on the mode of production and using in the segment, the growing of Asian market and interconnectivity worldwide.

In 2018, the sector expects moderate growth (between 3.5-4.5%), mainly driven by emerging markets in Asia, Europe and Latin America and sales from fast fashion segment (growth of 20% in the last 3 years). The demand in this area includes products with short life cycle and intensive use of material to meet the needs of high-volume clients and emphasis on diversified products (Armstrong et al., 2015; MGFI, 2018).

In addition, there is a growing consumer interest in more sustainable products as shown by 65% of emerging market consumers actively sought sustainable fashion in 2016 (MGFI, 2018). This concern demonstrates that environmental

impacts, fashion-life planning and production achieving are not restricted to retailers and manufacturers, but depends within the whole supply chain in a complex range of variables (Janigo, Wu, 2015). Thus, finding more effective ways to meet exclusive purchasing with fewer products is important in the fashion segment because of its environmental impact is significant in all phases of the product life cycle (Armstrong et al., 2015).

A sustainable alternative model is Product-Service System (PSS), which uses the concept of rent, redesign, maintenance, or sharing to reduce dependence on natural resources and increase product longevity (Tukker 2004). The PSS models applied to the fashion industry can provide a mechanism to increase factors such as product quality and longevity, while providing alternative consumption models that reduce redundant consumption (Armstrong et al., 2015).

Therefore, the objective of this study are to identify the models of PSS applied to the fashion industry and its characteristics, as well as to identify the sustainable potential within the PSS models found in the literature. Paper intention is also to contribute to a better understanding of the models applied to the sector and to direct the research for the viability of the analysed business from the perspective of the sustainability.

2. Research methods

The methods applied in this work were adapted from Franco (2008), Bardin (2010), and Garza-Reys (2015). The procedures were delimited based on the criteria of material's location, selection and validation, content's synthesis and analysis, and result's presentation, as illustrated in Figure 1.

2.1 Location, selection, and validation

The ISI Web of Science, Scopus, and Elsevier databases were accessed for the location of the articles, and EndNote® software was used to import the selected publications. For data-bases's searching, the following keywords was used to select the articles: "*product-service system*", "*PSS*" AND "*cloth**", "cloth* industry", "*fashion*", "*fashion retail*", "*fashion industry*", "*apparel industry*", "*textile retail*", "*garment retail*", "*garment industry*". The criteria defined to select the materials from databases were: (i) no restriction of year established; (ii) based on search in titles, abstracts, and keywords; (iii) it were not selected conferences papers, books or book chapters, as well as technical articles, and (iv) only articles written in English were considered. The material was collected in March 2018, comprising publications up to that time.

After completing the search using the 12 keywords in the 3 databases, it were selected 199 publications.After duplications were discarded, a screening procedure was performed in titles, abstracts, and key-words in order to identify association with the research. The procedure was taking into account: (i) PSS must have been applied in the context of apparel, footwear, handbags, sportswear, or accessories (belt, gloves, caps, and hats) and (ii) it was not considered sustainable potential related to the social and economic aspects.

Then excluded articles that has no relation to the subject addressed, it was resulted in 19 articles. Later, other studies were selected from reviewing the references from the selected articles, summing up 24 publications for the next step, described next.
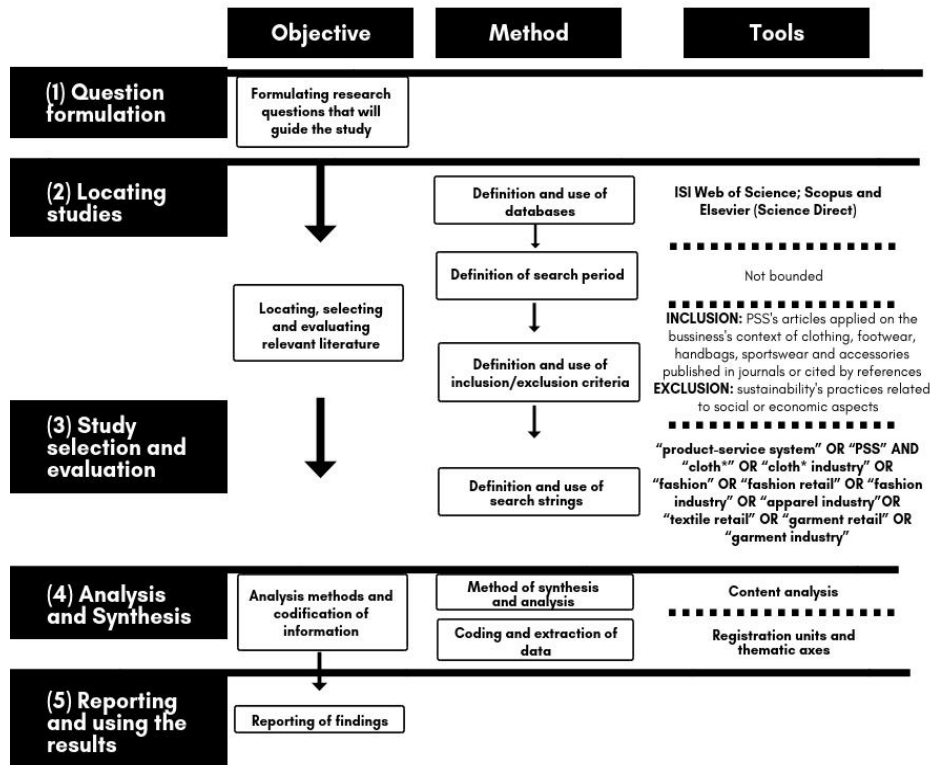
Figure 1. Survey stages diagram (based on Garza-Reys, 2015).

2.2 Synthesis and analysis

Adapted from Bardin (2010), content analysis was chosen for content's coding and extraction from selected articles. The content's coding and extraction were based on: (i) registration units, and (ii) thematic axes. Endnote® and Excel® assisted data collecting and processing. The registry units and thematic axes's terminologies were based on Sarkis (2001), Mont (2004), Tukker (2004), Armstrong et al. (2015), Hvass (2015), Mejía-Gutiérrez et al. (2015), Zhu et al. (2008), and Retamal (2017).

The registration units were: 'product', 'service', 'customer', 'infrastructure', 'network', 'business viability', 'institutionalization', 'PSS types', 'PSS model applied to fashion'; 'environmental management', 'green purchasing', 'customer cooperation' (cc), 'eco design' (eco), 'regulations', 'reduce', 'recycle', 'reuse', 'recover', 'remanufacture' (5R), 'disassembly of equipment' and 'product life cycle analysis (LCA). The thematic axes were divided into the following categories: (1) characteristics (product, service, customer, infrastructure, network, institutionalization); (2) feasibility of the business, (3) PSS type (product oriented - PO, use oriented - UO, result oriented - RO), (4) PSS model applied to fashion; and (5) sustainable aspects.

The models of PSS applied on fashion industry were organized in: (a) a table with the characteristics, PSS type and PSS model applied on fashion industry; (b) discussion of the feasibility of the business from literature perspective. The issues related to sustainable potential was organized and discussed according to the green practices addressed by Zhu et al. (2008) and Sarkis (2001).

3. Literature Review

3.1 PSS models applied in fashion industry

The fashion industry is characterized by extraction and intensive use of resources to produce, distribute and maintain fashionable items that are used for a short period of time but take years to fully utilize (Armstrong et al., 2015; Petersen, Riisberg, 2017). In addition, consumption of fashion products are also related to its emotional nature, driven especially by desire for novelties, resulting in an increase of disposability of textiles (Lang et al., 2016).

These requirements are facilitated by a fast fashion system, which enables consumers to purchase apparel products at a higher frequency rate thus putting pressure on industry to accomplish more in less time (Lang et al., 2016; Ræbild, Bang, 2017). Besides that, finding more effective ways to meeting these exclusivity needs with fewer fashion products consumed and discarded could solve environmental issues associated with overproduction, consumption and disposal (Lang et al., 2016).

A product-service system (PSS) can provide the fashion industry a mechanism to increase factors such as product quality and longevity, while providing alternative consumption models that reduce redundant consumption and the environmental impact of production (Armstrong et al., 2015). There are 3 types of PSS that incorporate dematerialization from low to a very significant level: (1) product-oriented (PO), (2) use-oriented (UO), (3) results-oriented (RO). The PO-PSS reflects the less radical model and it is more easily implemented for consumer products with embedded services that add value to sales, while RO-PSS models represent the higher possibility of dematerialization and reduce the negative environmental impacts (Tukker, 2004).

Despite services have long supported the use and maintenance of clothing products, these activities have not necessarily been used as a way to achieve durability, sustainability, and dematerialization in the apparel market (Armstrong et al., 2015). For example, the use of take-back service has been recurring in major fashion retailers such as H&M and C&A, although they are often used in exchange for discounts and not necessarily taking into account about the types of disposal, recycling or reuse of those collected items (Armstrong et al., 2015; Pal, 2016; Corvellec, Stål, 2017).

PO-PSS or UO-PSS models can provide a conceptual guide for the industry to combine these service concepts with apparel products to develop innovative and revenue-generating offerings that extend life, avoid waste, and increase product marketing (Armstrong et al., 2015). In the fashion industry, there are already implemented models of PO-PSS such as take-back (with retailers Zara, H&M), repair and redesign (implemented by clothing company Patagonia) (Armstrong et al., 2015; Pal, 2016). The redesign of used clothing has been a common strategy used to stimulate interest in used products while increasing the longevity of the material. With the use of recyclable fabrics, for example, it is possible to reduce dependence on natural resources and extend the product life time (WRAP, 2017).

The PSS-UO models are characterized by not transferring product's ownership to consumer. Recently, practical experiences on PSS-UO have appeared in the fashion industry, such as the Nopsa Fashion Library, which offers consumers clothing and shoes based on monthly subscriptions and Beibambo, which offers a leasing's service for children's clothing made of bamboo material. This is advantageous for growing children who can only wear their clothing for a short period of time (Armstrong et al., 2015). Some others related themes related to PSS-UO schemes are the swap meeting. This activity is emerging as a way to trade items among participants and thus provide a less intensive way of wearing clothes while increasing the durability of items (Pedersen, Netter, 2015).

Although considered traditional practices in the apparel industry, laundry services and second-hand retailing have had shape a new way for companies suit their operations to more sustainable prospects. Companies such as Brastemp and Ariel (line of laundry's detergents), have sought to offer the benefit of keeping clothes in the best condition for as long as possible in partnership with laundries (Mont, 2004; Hvass, 2015; WRAP, 2017).

However, it is important to note that the PSS study in the fashion industry is still incipient and it presents models that relatively few companies have put into practice (Adam et al., 2017). It is also noticed that PSS-PO is the main model currently used on the fashion industry, since it does not imply higher risks for companies (Adam et al., 2017). Moreover, the same garment can pass through PSSs several times, in several loops, for example, being firstly repaired and then reused or recycled, or rented and then sold as a charitable item (Corvellec, Stål, 2017).

3.2 Sustainability and PSS

Even though studies have been taking into account that PSS is as a way of preventing waste generation, it is hard to say that these models can meet expectations for an economy that requires less material and, therefore, be more sustainable (Mont, 2004; Tukker, 2004; Hvass, 2015). These PSS models need to relate to the details of the consumer's prevailing behaviours and waste infrastructures for collection and processing, so that the environmental effect is not dealt with in a superficial way (Corvellec, Stål, 2017).

In order to include the reduction of its environmental impacts, PSS seeks to increase product longevity from concepts such as: product rent, redesign, maintenance or sharing of items (Pal, 2016). In an operational context, it means activities that aimed at reducing the negative ecological impact of products and services as well as improving the environmental efficiency of their operations. Those types of activities are also known as green practices (Zhu et al., 2008; Garza-Reys, 2015).

There are several examples of activities related to a more sustainable way of production, applied in PSS models from the fashion industry, such as: (a) reuse of fabrics; (b) the increase in second-hand retail; (c), the designers new strategies (long life guarantee and product satisfaction); (d) the partnerships between laundry services, appliance industry and cleaners brands; (d) and extended producer responsibility (EPR) to the major fashion brands (Hvass, 2015; Pedersen, Netter, 2015; Yang et al. 2017). Therefore, there is a need to identify the PSS that adds value to the product and service offered, taking into account the characteristics of the business (infrastructure, network, institutionalization), as well as its viability of implementation. Ensuring these requirements, PSS models can provide benefits to the customer, reduce superfluous consumption and provide an environmental improvement for all (Mont, 2004, Armstrong et al., 2015).

4. Results and Discussion

4.1 PSS models applied in the fashion industry

From 24 articles that investigated PSS applied to the fashion industry, 13 were case studies. They focused on specific areas such as consumer research (Rexfelt, Ornas, 2009, Bianchi, Birtwistle, 2010), B2B business (Tomasin et al., 2013, Mejía-Gutiérrez et al., 2015) and general operations (Retamal, 2017, Mylan, 2015, Stål, Corvellec, 2018). In addition, all articles in the portfolio cited issues related to sustainability.

It were identified 11 types of PSS applied in the fashion industry and their characteristics and type are described in Table 1. Analysis of the results reveals that the PO-PSS and UO-PSS were the most cited, both types had 5 conceptual models mentioned. It is also important to note that from 11 PSS models founded on literature, 10 had practice examples implemented and only one (fashion result model) did not have application, i.e., service applied in practice.

Table 1. Characteristics of fashion PSS

PSS areas	Business profile – brief description	PSS type
Manufacturing monitoring	Digital platform for collaborative work between teams of designers and manufacturers of SMBs/SMEs in the links of product design, product detailing, prototype construction and product manufacturing	UO
Laundry	Washing, drying and ironing of garments by cycle wash or in a monthly package, in the categories: shared laundry or laundry service (including transport)	UO
Take-back	Shopkeepers offer the option of returning used clothing and users receive in return a discount for new clothes or a cash coupon	PO

Repair and redesign	Repair: provide repair service for clothing purchased for a fee and / or provide warranty service; redesign: maintenance service for a fee that includes repair and / or alterations to improve fit for a period	PO
Clothing rental	Fashion library it is an online service that customer signs a package to withdraw a certain number of pieces of clothing for a short period of time	UO/RO
Second-hand retail	Collection, sorting, donating or reselling of donated or purchased apparel from third parties	PO
Participatory customization	Boutique offers two custom design services: building a garment, selecting existing components and formats or working with an in-house designer to create a unique piece of clothing (creation, prototype, and execution)	PO
Consulting	Client can purchase an hourly session in person or by videoconference and receive style advice on the use of items that the customer already owns	UO
Clothing swamp	Shopkeepers organize a fashion event where customers buy tickets to attend a party night and Exchange their clothing items in good condition	UO
Make it yourself (MIY)	Modular fashion kit order containing necessary fabric, trim, thread and tools for the preparation of the clothes in the desired way	PO
Fashion result	Customized consulting service where the client provides their sizes, style preferences, their destination within 24 hours before the event then the team creates the desired look, including clothes and aesthetic procedures (hair, makeup, pedicure and manicure)	RO

Notes: PO – product-oriented PSS; RO – result-oriented PSS; UO - use-oriented PSS.

The most discussed PSS in the literature was the rent of clothes (9 articles), followed by repair and redesign (8), take-back (6), laundry and second-hand retail (5), personalized and participatory design, consulting, clothing swamp and MIY (2 articles each), and manufacturing monitoring as well as fashion result (1 article each). All articles were categorized in one category at least, while some of them were placed within two or more categories.

In general, the studies concentrate their analysis on issues related to the viability of the business in the segment (difficulties and opportunities). The rent of clothes, for example, is already applied in Scandinavian fashion digital libraries studied by Pedersen and Netter (2015) and clothing brands such as the Swedish fashion brand *Filippa K* (Petersen, Riisberg, 2017). However, there is little awareness about consumer acceptance with this practice (Armstrong et al., 2016; Pedersen, Netter, 2015) as well as the ability of this model being designed to survive and thrive in harsh environments (Corvellec, Stål, 2017).

Some studies (e.g., Corvellec, Stål, 2017; Lang et al., 2016) have also shown the benefit to associate brand awareness with quality requirements of their product from consumer perspective. For example, it can be explored practices around repair and redesign services that can increase the longevity and quality of the products offered while maintaining consumer relationships (Armstrong et al., 2015).

Although grouped as a same category, the repair and redesign PSS models differ in results (Armstrong et al., 2015), while the repair makes minor adjustments to the item, redesign modifies from small details to change the whole structure. The most widespread type of PSS in the fashion industry is repair (Adam et al., 2017). Their ultimate concern is not to lose the aspect of exclusivity, a fact also addressed in relation to take-back practices (Lang et al., 2016).

From take-back's perspective, the product return can refers perceived quality to consumer. According with Corvellec and Stål (2017), Boomerang's uses take-back system as a way of promoting clearly the longevity of the material used on their products. In some other articles, the concern it is in the operationalization of the model

(Ekstrom, Salomson, 2014), the reverse logistics (Yang et al., 2017), collection and sorting (Adam et al., 2017), and destination (Pal, 2016).

In short, there are a range of possibilities from the take-back PSS model (Goworek et al., 2012, Corvellec, Ståll, 2017). Besides that, this work identified that in the models of rent, repair, redesign, and second-hand retail, the take-back system was the service responsible for providing the raw material of these activities. Although indirectly, the take-back can be considered one of the most widespread models of PSS in the fashion industry (Armstrong et al., 2015).

The second-hand retailing is an example of what can be done after take-back system's collecting and sorting the choosing items. There are several possibilities such as: selling, exchanging or donating items, although there is a higher risk of deterioration due to improper handling, bad adjustments, and difficulty for its operationalization (Bianchi, Birtwistle, 2010). In addition, it should be noted that many other PSS (swamp, rent, and redesign) are also second-hand retail types (Pal, 2016).

Looking forward, indirectly linked with clothing industry, there are laundry services and their difficult on delivery logistics that can make the service unfeasible for both laundry services: (i) laundries that delivery and (ii) models that customers need to carry out clothing's transportation (Chiu et al., 2017). Other factors such as infrastructure and current legislation may vary according to consumer's needs (Retamal, 2017; Mont, 2004).

It is also important to notice that the ability of companies make consumers purchasing services instead of purchasing a product differs depending on the nature of this product (Retamal, 2017). For instance, consumers do not buy household appliances as often as they consume garments, because usually consumers tend to fix old domestic appliances and tent to disposal old clothes and buy new ones, then business models that are more linked to the use and result models, such as custom and participatory design, custom design and MIY are still initial models with a few or no practical application.

Furthermore, higher time spent in activities related to custom design and MIY may also leads to difficulties to obtain acceptance in relation to more traditional consumers (Niinimäki, Hassi, 2011; Armstrong et al., 2015). Moreover, PSS's models such as custom design, consulting and fashion result are often used for specific occasions making it difficult to propose these services in usual situations. According to Lang et al. (2016), these types of PSS are interesting from the point of their help to increasing product longevity although consumers still have the habit of consumption and disposal of clothing items (Lang et al, 2016).

The reduction in consumption is also pointed out by Mejía-Gutiérrez et al. (2015). From an operational perspective, the reduction in consumption of raw material is focused on manufacturing monitoring, allowing a lower incidence of unscheduled pauses such as repairs and order changes, leading to an improvement in product quality (Mejía-Gutiérrez et al., 2015). In addition, the services that are less familiar from consumer's perspective, such as rent, consulting and swamp, calls for more awareness and education for their effective adherence in the fashion industry.

Moreover, services that seek greater dematerialization are few accepted in consumer surveys (Armstrong et al., 2016, Armstrong et al., 2015, Rexfelt, Ornas, 2009; Tukker, 2004), as the case of swamp, rent, and second-hand retail. Finally, it should be noted that consumers are less likely to invest time in clothing items (Adam et al., 2017) and are demanding perceived quality, design and brand experience (Petersen, Riisberg, 2017). Finally, it can be concluded that the most practical examples of PSS are those that do not imply greater risks to companies such as repair and take-back.

4.2 Sustainable potentials identified in PSS models

Table 2 shows the sustainable potentials of the PSSs addressed from the perspective of green practices, adapted from the studies of Zhu et al. (2008) and Sarkis (2001). In most studies, 5R and LCA were the most discussed practices. The results also suggested that some of the PSS business models have emerged with a view to sustainability (e.g. Corvellec, Stål, 2017; Yang et al., 2017; Pal, 2016). In this way, PSS's models that have sustainable aspects in their business's value could better support product dematerialization, in order to reduce its residual effect, noticed by Tukker (2004).

Table 2. Green practices identified in PSS models applied to fashion industry

PSS areas	Green practices
Manufacturing monitoring	5R (focus on reduction)
Laundry	Cooperation with customers, 5 R (focus on reduction and reuse) and LCA
Take-back	5R, customer cooperation, regulations
Repair and redesign	5R, customer cooperation
Clothing rental	Green purchasing, Life Cycle Analysis (LCA), 5R (focus on reduction and reuse)
Second-hand retail	5R, customer cooperation
Participatory customization	LCA
Consulting	LCA
Clothing swamp	5R (focus on reduction and reuse)
Make it yourself (MIY)	LCA
Fashion result	LCA; 5R (focus on reduction)

Therefore, if the objective of the PSS is to reduce its residual effect and contribute to dematerialization, companies should focus on prioritizing waste prevention and building a business model with adequate material flows from the post-use perspective, prioritizing: (1) collection; (2) sorting and, (3) final destination (Corvellec, Stal, 2017). The collection and sorting systems were widely discussed in the take-back, repair, and redesign models (especially regarding recycling process).

In take-back's model, the recycling services are outsourced by large retailers and the responsibility for collection, sorting and destination of textiles is worked by outsourced company (Adam et al., 2017). On the other hand, in the repairs and redesign's model, designers and SMEs business separate and delivery low-value textiles to outsourced companies recycling these resources in by-products, indicating that raw material to recycling practices are also related to redesign and retail of second-hand clothing (Ekstrom, Salomonson, 2014).

Another concern is about the disposability of products that take years for their full use and it has also raised questions about circularity. As exemplified by Stål and Corvellec (2018), Swedish companies works together in the Textile Recycling Network, with the aim of creating joint solutions for the circular economy and drawing the attention of consumers to the environmental footprint of clothes discarded. Consumer's communication and education were also discussed in others PSS's models, mostly in renting, take-back, repair, redesign, swamp, and second-hand retail.

According to Goworek et al. (2012), increasing consumer's awareness about sustainable way of using and disposal of clothing could be facilitated by governments and retailers that offer viable alternatives to collect and separate discarded items (i.e., clothes donation campaign, potentially in collaboration with the mass media). In the case of laundry, marketing activities undertaken by cleaning products or washing machines related to socio-environmental issues on clothing industry produced positive effects on the consumers, such as more informed choice and more engaged action by the laundry users (Mylan, 2015).

In relation to LCA practices, laundry systems also demonstrate to have a greater environmental impact than washing at home, because people tend to dry their clothes when washing in a laundry room (Mont, 2004). The studies of Mylan (2015) and Chiu et al. (2017) point out that low-temperature washing and the frequency of washing cycles could contribute because it would reduce energy and water consumption.

Results have also shown that LCA was more cited in the UO-PSS, which it may be related to the purpose of the business model of total product's usage before its disposal. Those PO-PSS have focused more on the practice of 5Rs and they have been more discussed with practical cases of large retailers such as *H&M* and *Boomerang*, as they may be more affected by regulations (such as the EU Waste program) or could be understood as a marketing activity to promote brand value.

In summary, all these aspects indicates that companies that integrate sustainability as business value tend to be more concerned about the impact of clothing products. The rent business model was the one with the greatest debate about the acquisition of the raw material, production and commercialization of the products (Ræbild, Bang, 2017, Rexfelt, Ornas, 2009). After all, a return system driven by a fast-fashion company like *H&M* is different then a return system drive by a rental system committed to higher product quality, such as *Vigga*, even though both of them offering to recycle the fabrics for apparel use (Corvellec, Stål, 2017).

Nevertheless, although there are already green practices in the PSS models implemented, more managerial models such as internal environmental management, eco design, and equipment dismantling were not mentioned. This can be illustrated due to the characteristics of the current models being recent and less widespread. So, it is possible that with the evolution PSS's models implemented, the green practices will guarantee a greater impact on the evaluated businesses.

5. Conclusions

The studies that deal with PSS in the fashion industry concentrate their analysis on issues related to the viability of the business in the segment (difficulties and opportunities) such as: operationalization, consumer behaviour, and production methods applicable to the fashion industry. In this context, this work identified and characterized the existing business models of PSS in the fashion industry, as well as its sustainable potential, from the green practices perspective.

In this research, 11 PSS practices were found in the fashion industry, such as: manufacturing monitoring, laundry, repair and redesign, take-back, participatory customization, make it yourself, consulting, fashion result, clothing rental, clothing swamp, and second-hand retail.

The most discussed PSS in the literature was the rent of clothes. Although indirectly discussed, the take-back model was also present, being considered the supplier of raw material for other types of PSS such as rent, second-hand retail, and repair and redesign. In addition, the literature indicates a trend towards implementation of PSS that do not imply greater financial risks for companies such as repair and take-back.

Regarding sustainable potential, studies have shown that PSS models have emerged with a view to sustainability and aimed at reducing the residual effect of business impact. The most widespread green practices in the literature were life cycle analysis and 5R (especially material recycling). Besides, internal environmental management, eco-design, and disassembly of equipment were not quote at any of those publications. The product dematerialization, consumer education and the life cycle assessment were arguments used to justify the practical effectiveness of the models in relation to economic and environmental benefits.

Finally, the characteristics of current models still encompass more reactive practices, such as recycling and remanufacturing, than activities that actually promote the reduction in the use and disposal of garments, although there were companies whom already concerned with the circularity of the materials inside of the productive model. For this reason, the possibility of new work confronting the theoretical analysis with a practical case are relevant and using scenario models to verify the viability and evolution of the types of PSS implemented.

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Acknowledgements

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