

# 124 Clothing Circulator - Data to extend the lifetime of garments

Sari Järvinen<sup>1</sup>, Satu-Marja Mäkelä<sup>2</sup>, Juha Häikiö<sup>3</sup>, Essi Karell<sup>4</sup>

<sup>1</sup>VTT Technical Research Centre of Finland, Kaitoväylä 1, 90570 Oulu, Finland, sari.jarvinen@vtt.fi

<sup>2</sup>VTT Technical Research Centre of Finland, Kaitoväylä 1, 90570 Oulu, Finland, satu-marja.makela@vtt.fi

<sup>3</sup>VTT Technical Research Centre of Finland, Kaitoväylä 1, 90570 Oulu, Finland, juha.haikio@vtt.fi

<sup>4</sup>Aalto University, Otaniementie 14, 02150 Espoo, Finland, essi.karell@aalto.fi

## Abstract

Fashion industry is the second largest polluter in the world. To tackle the environmental crisis globally, we must minimize the environmental impact of fashion industry. The extension of garment lifetimes leading into smaller number of garments produced and sold has been identified essential towards sustainable fashion. This requires novel business models substituting volume-based fashion business. The purpose of this study is to investigate, how data can be used to promote the reuse of clothing and sustainable fashion. The first result is a state-of-the-art review focusing on clothing reuse. An integrative literature review method was used to examine the consumer challenges, current services and technologies. Previous research has identified challenges on reuse of different products as well as usage of consumer-to-consumer marketplaces to be on selling and buying experience, trust on the marketplace as well as quality of the product, and difficulties in finding the required size and style. The review provides a logical starting point for the second result, which is a multifaceted description of the Clothing Circulator concept. The concept presents a novel data-driven solution for extending the garment lifetimes and it was created as a multidisciplinary collaboration between fashion, consumer, service and technology researchers during a series of 7 workshops. Holistic, transparent view on the garment lifecycle from design to material recycling is the essence of the concept, which describes stakeholders and their roles, data sources in different phases through the garment's lifecycle, key enabling technologies and consumer aspects that are relevant for the clothing circulator solution. The consumer gets tools to curate wardrobe with a stylish and sustainable selection of garments. It helps in reselling the underused items and estimates the value of the underused garments based on big data from the marketplaces. For the brands the concept provides data on usage of the garments: how often the items are used, how long the items are kept as part of the wardrobe, what kind of combinations are created with the brand items, what type of customers seem to like/dislike the items, what is the resale value of the items and finally, how the items are recycled in the end of the lifecycle. Based on these insights, the brands can

base the design choices on measured data, which optimally leads to diminished waste of unsold items as the design and production would meet better the consumer expectations. This research is a first step towards data-driven approach to support reuse of garments, and hence extending garment lifetimes and more sustainable fashion. In the sustainable fashion research, the data-driven solutions to support reuse or decision-making in the design and production phases have not been extensively studied, even if sustainable consumption is a rising trend among “early adopter” consumers, especially in younger age groups. In the future, the research community should study the topic from a multidisciplinary perspective involving e.g. consumer, technology, data and business research together with the industry, targeting at the development of successful data-intensive solutions to support sustainable fashion.

**Keywords:** Clothing reuse, Data-driven solutions, Sustainable fashion, Garment lifecycle, Future consumer

## Introduction

The environmental impact of fashion industry is remarkable on global scale considering the use of resources (Niinimäki et al, 2020). It is considered to be the second largest polluter in the world (UN News, 2019). To tackle this, we must find ways to minimize the environmental impact of fashion industry. Currently most of the research and development activities in fashion industry are targeted at development of more sustainable materials and improvement of working conditions aiming at ethical manufacturing. Even if both these topics are highly relevant, the extension of garment lifetimes leading into smaller number of garments produced and sold has been identified essential towards sustainable fashion. This requires a transformation from current volume-based fashion business to novel business models offering sustainable options. One of the main challenges is the underutilization of produced pieces of clothing: consumers tend to efficiently use only a portion of their clothing and often many clothes end up in hanging in the wardrobe or being disposed early as waste (Laitala and Klepp, 2015; Maldini et al., 2018). The textile and clothing industry are more and more under radar by the regulators and there is a burning need for improved services supporting consumers in their choice of clothing (no false purchase decisions) and C2C sharing (lending, renting and selling) of extra clothes, which can enhance the use of clothes in their first form. Luckily, today’s consumers are increasingly motivated to make environmentally friendly choices. The purpose of this study is to investigate, how data can be used to promote the reuse of clothing aiming at novel sustainable fashion services.

## Methods

The first phase of this work is a state-of-the-art review focusing on clothing reuse for extending the lifetime and improving the utilization rate of garments. An integrative literature review method was used to examine the consumer challenges, current services and technologies. The review provides a logical starting point for the second phase, which is the definition of the “Clothing Circulator concept”, which presents a novel data-driven solution for extending the garment lifetimes. The concept was created as a multidisciplinary collaboration between fashion, consumer, service and technology researchers during a series of 7 workshops.

## **Fashion reuse market and consumer perspective**

Trade of used goods between people has a long tradition. People have commonly been selling services and goods to other people for example, in flea markets, which have a history of several hundreds of years. This activity is at the core of consumer-to-consumer (C2C) commerce, which has become increasingly popular during the recent years. C2C commerce inherently supports the principles of sustainability and circular economy as it extends the life of the product. The change is global, as indicated by e.g. a Japanese study that presents a clear growth of fashion reuse market in Japan (Yano Research Institute Ltd., 2020). The Covid-19 pandemic also had an impact on the reuse market. For example, in Finland the coronavirus has also increased rapidly C2C sales as between March and May 2020, the amount of C2C parcels delivered by the Finnish postal service rose by almost 70% compared to the same period previous year (Posti Group, 2020). Generally, Covid-19 has also made consumers think more about reuse and environmental impact in the context of fashion and clothing (Statista, 2020a).

As a traditional business-to-consumer (B2C) commerce requires a business to consumer relationship, in C2C commerce a role of business is more facilitating the environment that enables trade between the consumers. Traditional physical (offline) environments, such as self-service flea markets, are still popular among consumers, but consumers are increasingly moving to using different types of online e-commerce platforms. In practice, these platforms provide a digital marketplace for selling and buying used goods. Selling products in these environments is typically based on auction or fixed price sales. Many of these C2C e-commerce platforms are providing a wide array of different product categories (e.g. Craigslist, eBay) and a part of the platforms provides service to both C2C and B2C sectors. In addition, some C2C e-commerce platforms focus on a specific product sector, such as fashion and clothing. At its best, these fashion e-commerce platforms can have tens of millions of unique visitors every month. (Statista, 2020b). There are also platforms that have focused especially on fashion and clothing and enable online trading of used clothing between the consumers (e.g. Zadaa). In practice, these companies base their business on taking care of all activities from collecting the clothes to delivering them for consumers.

Typically, the revenue is based on a commission-based model in which the company charges a pre-agreed share of the products sold.

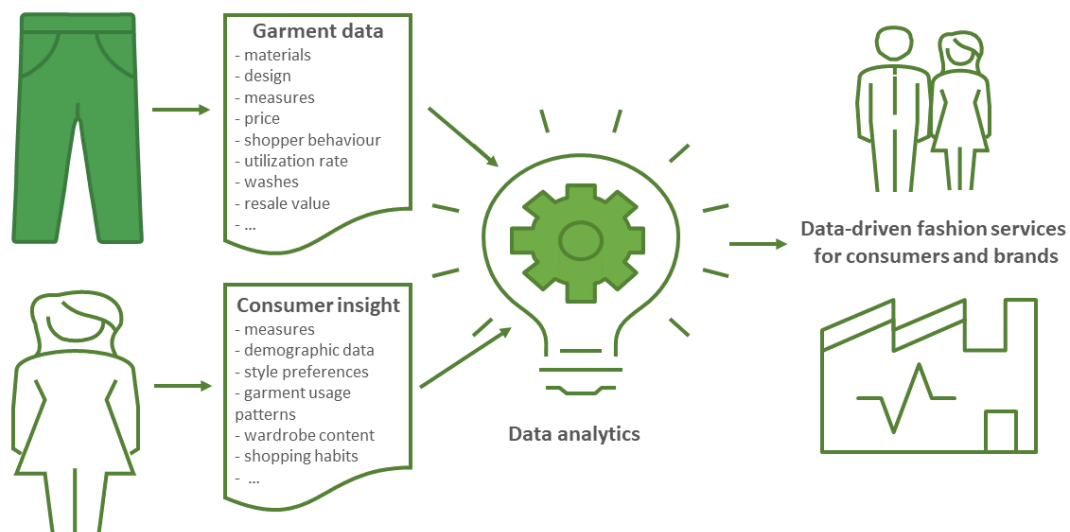
Previous research has identified manifold challenges on reuse of different products as well as on usage of C2C marketplaces. Many times the product does not meet the consumer expectations (Armstrong et al., 2016; Lang et al., 2019). The consumers have also doubts on hygiene of the clothing (Armstrong et al., 2016; Becker-Leifhold and Iran, 2018). Not all the consumers feel comfortable to use clothing that has been previously used by others (Lang et al., 2019). Regarding the C2C marketplaces the challenges are related to buying and selling experience (e.g. sales process, logistics) and trust regarding the platform as well as payment processes (Armstrong and Park, 2020; Becker-Leifhold and Iran, 2018; Leung et al., 2019).

However, there are also various issues supporting the usage of C2C marketplaces and reuse of garments. According to a UK consumer survey, consumers do not use 20% of the garments in their wardrobe (WRAP, 2013). Similar findings on unused garments are reported in other studies as well (Jorgensen and Jensen, 2012; Rathinamoorthy, 2019). On the other hand, the consumers have a need to renew the content of their wardrobe regularly and to avoid being seen rewearing the same clothes (social norms) (Harris et al., 2015; Jorgensen and Jensen, 2012; Klepp, 2001). The impulse buying behaviour often in relation to sales in fast fashion can lead to mistake purchases and to need for resale of garments (Klepp, 2001; Park et al., 2006). In worst cases, the mistake purchases and little-used garments end up as waste (Jorgensen and Jensen, 2012). Thus, there is potentially at least 20% of all the garments in our wardrobes, which could be resold to improve the utilization rate and increase the lifetime of garments.

Often the reuse of garments could be enhanced with repair, customization and refashion services. However, in many cases there is lack of repair skills and the costs are considered to be high (Diddi and Yan, 2019; Gwift, 2014; Laitala et al., 2018). The services can also be difficult to find and in the end the repair, customization or refashioning service is not economically feasible due to the poor quality of the garment (Goworek et al., 2012; McLaren and McLauchlan, 2015).

## **Clothing Circulator concept**

The Clothing Circulator concept (Figure 1) defines a novel data-driven solution for extending the garment lifetimes and it was created as a multidisciplinary collaboration between fashion, consumer, service and technology researchers. The concept aims at providing a holistic, transparent view on the garment lifecycle from design to material recycling and ideas for data-driven services to support efficient usage of garments.



**Figure 1 The Clothing Circulator concept**

For the consumer it provides tools to curate their wardrobes with a stylish and sustainable selection of garments. The Clothing Circulator services help in resale of the underused items and estimate the value of the underused garments based on big data from the marketplaces. For the brands, the concept provides information on actual usage of the garments, which can be used to optimize the design and production processes.

As the Clothing Circulator is based on exact data on a specific garment along its lifetime, from the design and usage to recycling phase, new technologies for identification, tracking and data collection are needed. This study is based on the assumption that the current research and development activities targeted at item specific garment tracking technologies will provide a solution able to store and share the data along the lifecycle of the garment. The Clothing Circulator concept is focused on defining the potential of garment data and data-driven services.

### **Data describing the garment and its lifecycle**

Currently the garments contain relatively simple information such as materials used (typically main fibres used in the fabric), country of production and sizing. The information is most often attached to the garment in production phase using a fabric tag and the information is not updated in anyway during the garment lifetime. However, there is a lot more information, which would be essential in data-driven fashion services. For example, in the design phase, the brands have more detailed information on measures of the garment, style, usage and characteristics of the target user. The marketing operations create product descriptions and multimedia presentations to support the sales of the product. The retailers use the product and marketing

information provided by the brands, and could collect data on sales process: the actual price of the product, time required for selling, demographic information or the customer segment of the buyer of the garment, online/offline shopper behaviour related to the garment etc. From the usage phase, it would be possible to acquire data on number of times the garment is worn, combinations of garments worn together, number of washes required and other information describing garment usage, maintenance and user. The C2C marketplaces supporting the resale of garments can collect detailed information on condition of the garment after the usage phase, the usage time before resale phase, the resale potential and pricing as well as time required to complete the C2C sales process. The recycling operator can record the end of the lifecycle collecting data on the actual lifespan of the garment and the condition the garments are discarded as waste.

The lifecycle described above is simplistic and the actual lifecycle of a garment contains a larger number of stakeholders such as brands, designers, material producers, garment producers, logistics services, packaging providers, online and brick-and-mortar retailers, consumers, C2C and second hand marketplaces, repair and refashion services and recycling operators. All these stakeholders could be both creators as well as users of garment data, which - due to the collaboration of the operators along the garment value chain - gets updated and more detailed during the lifetime of the garment.

### **Data-driven wardrobe curation services for the fashionable consumer**

The fashion consumers are starting to look for not only stylish and comfortable garments, but also truly sustainable choices. As the previous research has shown, consumers often have a large quantity of unused items in their wardrobes. Often the consumers are not willing or able to invest time required for efficient usage of C2C or second hand services to redistribute their unused items or buy used garments instead of purchasing new products. The Clothing Circulator concept in practice for the consumer is a digital style assistant, which tracks the usage of different items in the wardrobe, learns in time the consumer's preferences and analyses the background information related to the preferences. It also identifies the unused garments and can suggest new purchases (from C2C marketplaces, second hand stores or retailers) to complement the wardrobe content to create new varying outfits. The digital style assistant can provide information on maintenance of the garments and suggest refashion options. It knows the updated resale value of the garments and can suggest ways to sell the unused items. It could even identify a potential new user for an unused garment based on the usage and preference data collected from other users. In total, the digital style assistant will make the garments in the wardrobe move either to be worn more or sold to new users supporting the targets of the Clothing Circulator concept to increase the utilization rate and extend the garment lifetimes.

From the technology perspective, the Clothing Circulator concept at home requires solutions to automatically track the usage as the services should be very easy and enjoyable for the end user to use. For example, RFID tags integrated to the garments to identify a specific item and readers to collect information on usage and washes. The data collected is delivered to a background system, which is able to analyse it and interact with the consumer to guide on the garment usage and wardrobe curation.

### **Data to enhance the sustainability of fashion industry**

Adoption of garment tracing and data collection technologies along the lifecycle of a garment in large scale would enable usage of novel data analytics and artificial intelligence methods to guide the decision-making for example in design, production and distribution of garments. Utilizing the big data on garments and their lifecycle it would be possible to predict more accurately the demand or to define the necessary marketing activities to increase the product awareness in the identified target user group.

For the brands, the garment data would provide objective insight, which is not currently available from any source, on actual usage, reuse and end-of-life of the garments:

- how often the brand products are used,
- how long the garments are kept as part of the wardrobe,
- what kind of combinations are created with the brand garment,
- what type of customers seem to like or dislike the garments,
- what is the resale value of the brand products and finally,
- how the items are recycled in the end of the lifecycle.

Based on these insights, the brands can make their design choices using measured data, which optimally can lead to production of garments meeting better the consumer expectations. This way the brands will both save notably on costs and resources as the amount of unsold items discarded as waste will diminish. In addition, the customer experience on brand products will improve.

The evolving database of garment specific information described above could be used to create services enhancing the sustainability of fashion industry not only for consumers and brands, but also for other stakeholders in the garment value chain. For example, using more detailed information on the garment measures, material and style in combination with data-based insight on consumer preferences and measures, the Clothing Circulator services could diminish the number of mistake purchases tackling the problem of product returns in e-commerce.

## **Results and Discussion**

This study is merely the first step towards a data-driven approach to support reuse of garments extending garment lifetimes and aiming at more sustainable fashion industry. In the sustainable fashion research, the data-driven solutions to support for example

reuse of garments or decision-making in the design and production phases have not been extensively studied yet, even if sustainable consumption is a rising trend among “early adopter” consumers, especially in younger age groups. In the future, the research community should study the topic from a multidisciplinary perspective involving e.g. consumer, technology, data and business research together with the industry, targeting at the development of successful data-intensive solutions to support sustainable fashion.

The adoption of data-driven solutions in fashion industry in practice requires collaboration of different actors in the industry to enable collection and sharing of relevant data along the lifetime of the garment. A standard format for garment data should be defined and agreed globally. The basic technology building blocks are already available for garment tracking and creation of data-driven services. The economic feasibility of a Clothing Circulator service implementation is however depending on the overall data-driven garment lifecycle management as the tags should be integrated into the garment in the production phase and the brands as well as other stakeholders should provide the detailed garment data to support the functionality of Clothing Circulator services.

The transformation towards sustainable fashion services necessitates also changes in current volume-based business models and operational models in fashion industry. For example, the quality of the garments should be high enough for enabling higher utilization rates and longer lifetimes of garments. High quality clothing also would make repair and refashion services economically feasible and raise the potential resale prices of used garments accelerating the development of C2C marketplaces and second hand fashion markets. Adoption of sustainable business models and development of data-driven fashion services opens up new possibilities for technology savvy operators as well as for third party companies entering the fashion business with novel service offering targeted at consumers, brands or other fashion industry stakeholders.

## **Conclusions**

The purpose of this study was to research and innovate on the potential related to extensive data collected and shared along a garment lifecycle from design and production to material recycling aiming to enhance the sustainability of fashion industry. The first phase of the work produced a review of consumer challenges related to extending the lifetime of garments and usage of C2C marketplaces. In the second phase, the Clothing Circulator concept was defined to describe a novel data-driven solution for extending the garment lifetimes and decreasing the usage of resources. The Clothing Circulator concept provides a holistic view on the data along the lifecycle of the garment and ideas for innovative data-driven services for consumers, brands and other stakeholders of fashion industry. Finally, the implications for both data-driven



solutions in fashion industry as well as novel business models moving away from volume-based business are discussed from research and industry perspective.

## References

Armstrong, C. M., Niinimäki, K., Lang, C., & Kujala, S. (2016). A use-oriented clothing economy? Preliminary affirmation for sustainable clothing consumption alternatives. *Sustainable Development*, 24(1), 18-31.

Becker-Leifhold, C., Iran, S. (2018). Collaborative fashion consumption—drivers, barriers and future pathways. *Journal of Fashion Marketing and Management: An International Journal*.

Diddi, S., Yan, R. N. (2019). Consumer perceptions related to clothing repair and community mending events: A circular economy perspective. *Sustainability*, 11(19), 5306.

Goworek, H., Fisher, T., Cooper, T., Woodward, S., Hiller, A. (2012). The sustainable clothing market: An evaluation of potential strategies for UK retailers. *International Journal of Retail & Distribution Management*, 40(12), 935–955.

Gwilt, A. (2014). What prevents people repairing clothes?: An investigation into community-based approaches to sustainable product service systems for clothing repair. *Making Futures Journal*, 3.

Harris, F., Roby, H., Dibb, S. (2016). Sustainable clothing: challenges, barriers and interventions for encouraging more sustainable consumer behaviour. *International Journal of Consumer Studies*, 40(3), 309-318.

Jørgensen, M. S., Jensen, C. L. (2012). The shaping of environmental impacts from Danish production and consumption of clothing. *Ecological Economics*, 83, 164-173.

Klepp, I. G. (2001). *Hvorfor går klær ut av bruk? Avhending sett i forhold til kvinners klesvaner*. Oslo: SIFO. The National Institute for Consumer Research.

Laitala, K., Klepp, I.G., 2015. Age and active life of clothing. In: Cooper, T., Braithwaite, N., Moreno, M., Salvia, G. (Eds.), *Product Lifetimes and the Environment 2015*. Nottingham Trent University, CADBE, Nottingham, pp. 182-186.

Laitala, K., Klepp, I. G. (2018). Care and production of clothing in Norwegian homes: Environmental implications of mending and making practices. *Sustainability*, 10(8), 2899.

Lang, C., Seo, S., Liu, C. (2019). Motivations and obstacles for fashion renting: A cross-cultural comparison. *Journal of Fashion Marketing and Management: An International Journal*.

Leung, W. K., Shi, S., Chow, W. S. (2019). Impacts of user interactions on trust development in C2C social commerce. *Internet Research*.

Maldini, I., Duncker, L., Bregman, L., Piltz, G., Duscha, L., Gunningham, G., Vooges, M., Grevinga, T., Tap, R., & van Balgooi, F. (2017). Measuring the Dutch clothing mountain: Data for sustainability-oriented studies and actions in the apparel sector.

McLaren, A.; McLauchlan, S. (2015) Crafting Sustainable Repairs: Practice-Based Approaches to Extending the Life of Clothes. In Proceedings of the PLATE Conference, Delft, The Netherlands, 17–19 June 2015.

Niinimäki, K., Peters, G., Dahlbo, H., Perry, P., Rissanen, T., Gwilt, A. (2020). The environmental price of fast fashion. *Nature Reviews Earth & Environment*, 1, 189–200.

Park, E. J., Kim, E. Y., Forney, J. C. (2006). A structural model of fashion-oriented impulse buying behavior. *Journal of Fashion Marketing and Management: An International Journal*.

Posti Group. (2020, June 9). The coronavirus got Finns to go through their closets – C2C e-commerce is growing at a rapid rate. Finnish postal service newsletter. [https://www.posti.com/en/media/media-news/2020/korona-sai-suomalaiset-siivoamaan-komeroitaan--vertaisverkkokauppa-kasvaa-nyt-hurjaa-vauhtia/#\\_ga=2.26789563.740486411.1591861010-1356823157.1590475153](https://www.posti.com/en/media/media-news/2020/korona-sai-suomalaiset-siivoamaan-komeroitaan--vertaisverkkokauppa-kasvaa-nyt-hurjaa-vauhtia/#_ga=2.26789563.740486411.1591861010-1356823157.1590475153) (accessed 28.07.2021).

Rathinamoorthy, R. (2019). Consumer's Awareness on Sustainable Fashion. In *Sustainable Fashion: Consumer Awareness and Education* (pp. 1-36). Springer, Singapore.

Statista. (2020a). Impact of coronavirus on consumer attitudes towards the fashion industry in the United Kingdom in 2020. <https://www.statista.com/statistics/1136613/coronavirus-impact-on-consumer-opinions-fashion-industry-in-the-uk/> (accessed 28.07.2021).

Statista. (2020b). Number of unique visitors to selected C2C fashion e-commerce platforms in May 2020. <https://www.statista.com/statistics/712248/c2c-fashion-unique-visitors/> (accessed 28.07.2021).

UN News (2019). UN launches drive to highlight environmental cost of staying fashionable'. <https://news.un.org/en/story/2019/03/1035161> (accessed 28.07.2021).

WRAP. (2013). Valuing our clothes: The true cost of how we design, use and dispose of clothing in the UK. WRAP.

Yano Research Institute Ltd. (2020, April 13). Fashion Reuse Market in Japan: Key Research Findings 2020. Yano Research Institute press release. [https://www.yanoresearch.com/en/press-release/show/press\\_id/2395](https://www.yanoresearch.com/en/press-release/show/press_id/2395) (accessed 28.07.2021).