Reducing clothing production volumes by design: a critical review of sustainable fashion strategies

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Abstract

Based on a literature review, this article discusses how the challenge of diminishing clothing production volumes has been approached within the field of sustainable fashion. We identify six common strategies in literature and discuss the approach of user involvement in the process of design and/or manufacture of garments in detail. A critical analysis of the state of the art in the field points out that these strategies have been constructed, studied and promoted without empirical validation. The article concludes with a recommendation to move forward from conceptual to empirical studies. Analyses of existing initiatives and their results in terms of consumer buying behavior and obsolete inventory are recommended as first steps towards validation.

On the challenge of diminishing clothing production volumes

"Efforts to lessen the impact of the fashion sector at the level of individual garments have been eclipsed by the vastly increased total number of garments that we now buy", states Kate Fletcher, Professor in Sustainability, Design and Fashion at the University of the Arts London (Fletcher, 2015). In this claim Fletcher acknowledges the value of actions aimed at reducing the environmental impact of garments, while calling for attention to a complementary approach in sustainable fashion: that of enabling a decrease in the enormous amount of garments in circulation; a particularly relevant challenge in a sector where utilization and longevity of products are in decline.

Fletcher's statement is in line with scholars studying the environmental impact of rising consumption in general, such as Jackson (2009) and Mont & Plepys (2008). These authors show evidence that humanity's environmental efforts have focused on improving resource efficiency as a way to integrate increasing economic output and decreasing environmental impact. However, such efforts have not had an overall positive effect, given a more significant increase in production and consumption levels. Their main claim, put in very simple terms, is that along with a resource-lighter industry we should promote a consumption-lighter society, an argument that has evident application in the apparel sector.

According to Euromonitor, the amount of clothing items purchased per capita was growing slowly but steadily in Western and North European countries until around 2005. The popularization of fast fashion retailers, the economic crisis, environmental and economic policies

or environmental awareness may have had particular effects in different countries. Figure 1 shows that after that year national consumption rates have differed. For example, in the UK annual individual purchases escalated up to 36.7 items in 2016, while Denmark reached its peak between 2007 and 2010, with 37.8 items. France and the Netherlands, on the other hand, have been slowly decreasing their volume per capita since 2007. In Germany, developments have been more predictable, with a small increase in purchase rates during the last 15 years.

Analyses of the environmental effects along the different stages of clothes' life cycle also illustrate the importance of tackling the issue of production and consumption volumes. These studies do not always coincide since footprint per phase depends largely on product category. For example a cotton T-shirt requires less energy and water during production than during use (frequent laundry is central here), while for a winter jacket the relation is the opposite (Allwood, et al., 2006; Roos et al., 2015). However, studies that consider clothing as a whole agree in that production is by far the most intensive phase. A report elaborated by the WRAP organization in the UK states that the production phase "contributes over three-quarters of the carbon footprint, over 90% of the water footprint, and around one-third of the waste footprint of the whole lifecycle" (WRAP, 2012). According to the same publication, the great majority of CO_2 emissions in the sector are created during material production. A Swedish Life Cycle Analysis based on five clothing categories shows similar results (Roos et al., 2015).

These studies are useful to discuss the effects of strategies aiming at developing a more sustainable fashion industry

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based on the current state of affairs. For example localizing production does not have such a significant impact since only a very small portion of the footprint is ascribed to distribution. Similarly, recycling textile material, even if using the least harmful mechanical techniques, diminishes only in part the footprint involved in fibre production. This underscores the argument given above; that the amount of clothes being produced is a central issue. However, approaches to diminish production volumes are particularly challenging, since brands, manufacturers, media and consumers are all benefiting from the ever-growing fashion industry.

Enabling decreasing production volumes in the apparel sector by design

Sustainable fashion scholars have proposed a variety of solutions to tackle the issue of growing clothing volumes. Literature on design strategies aiming at diminishing clothing volumes was collected in a systematic review, starting by well-known sustainable fashion books (e.g. Black 2008, Fletcher 2008, Fletcher & Grose 2012, Niinimäki 2013, Gardetti & Torres 2013) and related journals (e.g. Journal of Cleaner Production and Fashion Practice). An analysis of the above-named publications helped to identify suitable keywords to refine and continue the literature search, namely: slow fashion, multifunctional garments/clothing/fashion, modular garments/clothing/fashion, durability, longevity, craft, DIY, customization, co-design, participatory design, product-service systems, collaborative consumption, etc. Subsequently, relevant references were traced leading to other publications; the review included publications issued before July 2016.

The literature search resulted in 27 relevant publications including books, book chapters, journal articles, articles presented in academic conferences, and PhD theses. Their relevance for this review was determined on the bases of two aspects, namely (a) that they were written from a design perspective, and (b) that they discussed ways to reduce clothing production volumes, explicitly or implicitly. In some of these publications the focus lays on slowing down clothing consumption, extending life spans of garments or enabling intensive use rather than reducing production volumes. However, the implicit expected effect on the environment is that of avoiding overproduction and therefore reducing resource use. Therefore, such sources were included in the selection.

Within the selected publications, design strategies to diminish clothing production volumes are either presented side-by-side with strategies to reduce environmental impacts per garment (see e.g. Fletcher & Grose 2012) or they are discussed individually in detail, within a sustainable fashion framework and focusing on implementation (see e.g. Hur & Thomas 2011).

Table 1 presents an overview of the strategies found in literature, namely production on demand (S1), service-based fashion systems (S2), multifunctional, transformable and modular garments (S3) design for slowness and longevity (S4), design for repairing (S5) and user involvement in design and/or manufacture (S6). These strategies are included in the table on the bases of their expected effect in decreasing production volumes. They may have other benefits in terms of sustainability -such as increasing user awareness of material qualities or enabling take-back systems for recycling- but these are not considered here as the focus is on the challenge of quantity. In Table 1, the strategies are organized in six different categories; however, their implementation or implications sometimes overlap. For example, both S4 and S5 aim at extending the life span of garments, but the implementation of the former is based on aesthetic and material qualities of products (emotional and material durability) while the later proposes to enable consumer care by design; therefore, in Table 1 these are considered as separate categories.

The brief descriptions in the second row of Table 1 clarify the main characteristics of each strategy and how they
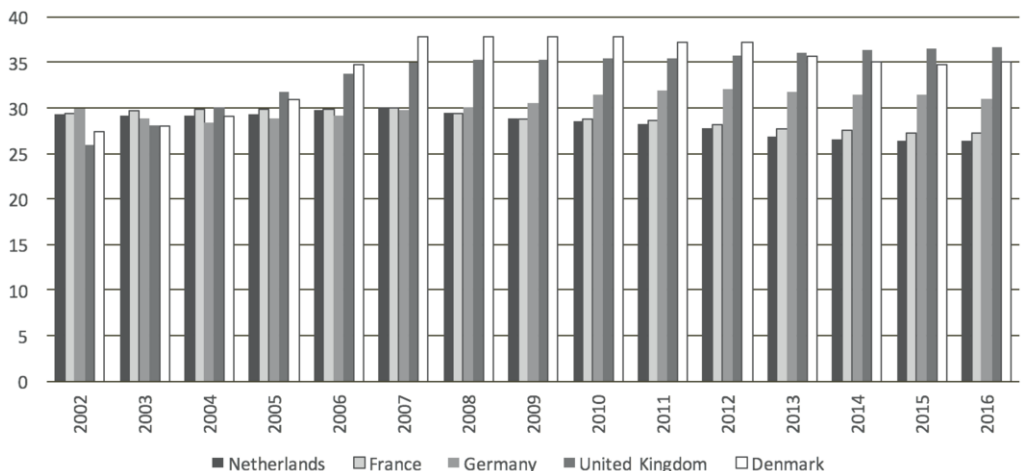

Figure 1. Retail volume per capita (items) in some European countries. Source: Euromonitor.

Strategies in random order	S1) Production on demand	S2) Service-based fashion systems	S3) Multifunctional, transformable and modular garments	S4) Design for slowness and longevity	S5) Design for repairing	S6) User involvement in design and/or manufacture
Description	Garment production based on individual demand, avoiding whole-garment waste (obsolete inventory)	Collaborative consumption, leasing and exchange systems for increased use intensity, detaching material production from company revenue	Versatile garments designed to diminish the material resources needed to keep variety. One garment performs as many garments.	Clothing longevity through attachment based on meaningful aesthetic experiences, material and confection quality and season-free styles	Enable better consumer care by design, for clothing longevity	Design for customization and DIY leading to production on demand and/or longevity through attachment. User involvement in production enables further repairing.
Sources	Niinimäki & Hassi, 2011 Niinimäki, 2013, p. 26	Fletcher, 2008, pp. 154–159 Niinimäki & Hassi, 2011 Fletcher & Grose, 2012, pp. 102–103 Niinimäki, 2013, p. 132 Armstrong, 2013 Armstrong, et al., 2015	Fletcher, 2008, p. 132 Hur & Thomas, 2011 Niinimäki, 2012 Fletcher & Grose, 2012, pp. 77, 80–84 Koo, 2012 Karell, 2013 Cao et al., 2014 Karell, 2014	Fletcher, 2008, pp. 164–169 Fletcher, 2010 Laitala & Boks, 2012 Niinimäki & Hassi, 2011 Niinimäki, 2012 Fletcher & Grose, 2012, pp. 85–87 Cooper, et al., 2013 Aakko, 2013a Aakko, 2013b Laitala, et al., 2015	Fletcher, 2008, pp. 100–103 Laitala & Boks, 2012 Fletcher & Grose 2012, pp. 60–62, 101 Mclaren & Mclauchlan, 2015	Black, 2008, pp. 83–84 Fletcher, 2008, p. 194 Busch, 2008 Niinimäki, 2009 Black et al., 2009 Niinimäki & Hassi, 2011 Laitala & Boks, 2012 Niinimäki, 2012 Busch, 2013, pp. 226–229 Fletcher & Grose, 2012, pp. 105, 143–150 Hirscher, 2013 Hirscher & Fuad-Luke, 2013 Ballie, 2013 Armstrong et al., 2015

Table 1. Strategies aimed at diminishing production volumes of clothing from a design perspective in sustainable fashion literature.

are expected to perform. S1 has the objective of avoiding obsolete inventory (whole-garment waste), S2 is intended to increase clothing use intensity, reducing the amount of garments in circulation, S3-S5 aim at delaying new purchases by extending or expanding the use of garments, and S6 is mainly expected to add emotional and functional value, resulting in intensive and/or extended use.

The literature review pointed out that the above-discussed strategies, in spite of their promises for reducing production volumes, currently remain at a conceptual level. The actual results of these strategies are barely discussed, and only a few authors have acknowledged potential limitations with minor attention. Among those acknowledging that the effect of these strategies is still unknown are Niinimäki & Hassi (2011). The authors discuss "strategies that offer opportunities to better meet an individual customer's needs, create deep product satisfaction and thereby offer the opportunity to decrease consumption" such as customization services. However, they point out that consumer behaviour is not easy to predict; "it is not yet verified whether this happens in reality. Consumers may still increase total consumption". Similarly, Hirscher & Fuad-Luke have mentioned after a participatory sewing workshop with halfway products (to be finished by the user) that "it cannot be assured whether [the participants'] overall consumption of garments has reduced or if the made garments maintain a stronger value than bought fashion or clothing. This needs to be evaluated over a longer period of time" (Hirscher & Fuad-Luke, 2013, p. 186). Finally, Fletcher & Grose (2012, p. 77) have discussed the difference between conceptual and real applications of these strategies by questioning the effects of transfunctional garments; intended to augment use intensity and to reduce the amount of clothes manufactured based on, for example, the use of waterproof yet breathable materials. "If the end user's

behaviour remains unstudied," they stress, "there is no guarantee that the sustainability savings made on a single transfunctional product will not be lost on an additional purchase".

In the same line, we argue that as these strategies are based on conceptual explorations that are not validated in practice, they may not have the anticipated effect in terms of sustainability. Therefore, for the time being, they should be considered as hypotheses for the challenge of reducing production volumes rather than demonstrated solutions. For instance, S2 is based on the idea that detaching material production from company revenue may reduce overall production volumes. Examples of such initiatives are rental systems of clothing, where ownership of the product remains at the company and consumers benefit only from their use; a concept that can be implemented by brands or independently, through clothing "libraries". However, it is still unknown if consumers use such services as a substitute of personal wardrobes or as a way to increase variety while keeping purchasing and discarding their clothes at the same pace. As long as the effects of such initiatives in terms of production volumes remain unstudied we will stay uncertain of how they may affect our future.

The approach of user involvement in design and/or manufacture

As shown in the table, S6 (user involvement in design and/or manufacture) is the method that appears most frequently in literature. A central argument behind this strategy is the possibility of reducing consumer demand by extending the life span of garments through attachment. The sources cited by the authors in S6 indicate that this strategy is inherited from conceptual explorations in the field of industrial design as enabler of emotional attachment and durability (e.g. Chapman 2005; Mugge

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2008). The hypothesis is that the participation of users in the process of creation adds emotional and functional value to objects and encourages attachment, leading users to keep and take care of them for longer periods and preventing early replacements. As a result of longer lasting object-user relationships, replacement frequency decreases and production volumes will decrease. Kohtala (2015) has pointed out that this series of linked concepts are often promoted as a "formula" for sustainability, which is illustrated in figure 2.

Some of the elements in figure 2 and their correlation have been subject of academic research. A few studies have tested the correlation between user involvement and product value and attachment empirically -based on experiments with other product categories- with positive results. For example, Franke & Piller (2004) have confirmed the positive effect of personalization on perceived value in an experiment based on watches; Mugge et al. (2008) have pointed out that this relationship enables a particular emotional bonding with products in a study of personalized bicycles; Norton et al. (2012) have confirmed a positive relation between user participation in manufacture and perceived value in an experiment with cardboard boxes and Atakan et al. (2014) have investigated the effect of user participation in design and manufacture on product evaluation, affective commitment, and identification of participants with the product. This last study is based on a series of separate experiments for participation in the design and manufacture phases; involving CDs, cardboard photo frames, and coffee mugs.

The relationship between attachment and durability, however, has only been marginally assessed. Moreover, the results of these studies are less supportive of this "formula". Mugge et al. (2006) conducted an investigation based on scenarios, where subjects where asked to predict the degree of product attachment and durability of two different watch models ("extroverted" and "introverted") for two parallel user personalities. The findings indicated that although personality congruity leads to product attachment, a long product life span was expected only for the "introverted" watch. In another study, Maldini (2016) analysed the attitude of users towards self-designed, digitally-fabricated objects. The author found that users were strongly attached to their projects, however this did not lead to long-lasting objects given that the technology used enabled the manufacture of copies relatively easy. As a result, users regarded the material outcomes of their projects as disposable.

Finally, the effect of durability on decreasing production volumes has not been studied at all, not only within the apparel sector but also for other consumer products. As a consequence, it is unknown to what extent keeping a product for a prolonged period prevents new consumer purchases.

Further research is required to investigate whether this strategy can contribute to diminishing production volumes in the apparel sector. Two aspects deserve special attention: the effect of user involvement in design/manufacture on the use intensity and longevity of clothing, and the extent to which the relationship between durability and less consumption applies to clothing, given that garments can be easily stored in a forgotten corner of the wardrobe and they are often not bought with the purpose of replacing an existing item. These points emerge when we analyse the validity of this approach critically, keeping the variables involved in actual practices in mind.

Moving towards empirical validation

In the previous section we discussed one of the strategies aimed at diminishing clothing production volumes in more detail, but the lack of validation applies for the other strategies as well since none of the sources in the table refers to studies assessing their effects. This does not mean that sustainable fashion scholars are not informed about actual practice. On the contrary, many of these strategies have been developed on the basis of empirical studies. For example Laitala et al. (2015) propose a series of design guidelines for clothing longevity based on a previous thorough analysis of discarded clothing (Laitala & Klepp, 2011) and Niinimäki (2012) builds on a consumer survey of product characteristics leading to satisfaction and longevity. What is missing is a complementary assessment after these strategies are put in practice.

Experiments such as the ones employed in the studies mentioned earlier (Atakan et al., 2014; Franke & Piller, 2004; Mugge et al., 2008; Norton et al., 2012) are not suitable for such an investigation because they do not take into account variables such as consumer motivation and product category. These variables are rather neutralized for the purpose of the experiment and participants are included regardless of their desire or need of a new personal CD, watch or box.

Production of garments on demand, service-based fashion systems, multifunctional, transformable and modular garments, design for slowness and longevity, design for repairing, and user involvement in design and/or manufacture are already available. A first step to establish the validity of the strategies in Table 1 is to study existing initiatives with emphasis on (a) obsolete inventory (S1) and (b) long-term buying behaviour of consumers engaging with them (S2-S6). By systematically observing the influence of these strategies in practice, we

| Personalization and user involvement | > | increased product value and attachment | > | longevity and durability | > | decreasing production volumes |

Figure 2. A common strategy aimed at decreasing production volumes lacking empirical validation.

may not only understand to what extent they are valid and effective, but also under which conditions. On the bases of these inquiries we may contribute to the emergence of a consumption-lighter society by design, one that along with a resource-lighter industry enables us to flourish within the constrains of our ecological limits.

Acknowledgments

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