Strategies to improve design and testing for clothing longevity

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Nottingham Trent University, Nottingham - UK

Authors:

Professor Tim Cooper Dr. Lynn Oxborrow Stella Claxton Dr. Helen Goworek Helen Hill Angharad McLaren

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1 Executive summary

The report summarises the final outcomes of the Defra and WRAP funded project: Strategies to improve design and testing for clothing longevity, for which research was undertaken between March 2014 and December 2015. The project consisted of a comprehensive literature review; primary research including interviews with 31 industry practitioners; three consumer focus groups; and a series of three industry and consumer round tables and an expert workshop.

Building on this preparatory research, four pilot actions were undertaken with UK clothing retailers to evaluate issues associated with:

- 1. An exploration of durability testing to support a clothing lifetime guarantee marketing campaign;
- 2. An investigation into customers' views on the durability and longevity of clothing to understand how a retailer can influence the behaviour of its consumers;
- 3. Development of a testing regime for colour fastness representative of consumer laundering practices;
- 4. Investigation of a quality problem in the supply chain to identify the upstream causes of garment failure.

With respect to processes that support clothing longevity, the combined research confirmed that it is technically possible to produce clothing that lasts for longer, but highlights issues relating to:

- The adoption of advanced textile processes and finishing techniques that could enhance product longevity;
- Time, cost and technical constraints on the type and effectiveness of product testing carried out during the NPD process;
- The impact that retailers could have by influencing both consumer behaviour and enhancing their own approach to user-centred design and clarity in garment care labelling;
- A depletion of technical skills and knowledge within retail NPD teams and throughout the supply chain, and a pressing need to enhance multi-disciplinary collaboration across the supply chain to promote better design practices from fibre to end-use;
- A continuing lack of evidence to encourage retailers/brands to pilot and adopt new business models that support clothing longevity.

A number of areas for potential further research were identified. These include:

- Testing new business models within a commercial context to understand and evaluate the business case for approaches to clothing longevity;
- Understanding the garment and textile technology, collaboration and consumer benefits of adopting a range of new technologies (product, NPD and communications) when designing, producing, distributing and promoting longer lasting clothes, within the rapidly changing technology landscape;
- Evaluating the design and sustainability impacts and commercial opportunity for wider scale adoption of emerging fabric finishes and processes that help to enhance clothing longevity;

• Exploring issues of design, production and distribution of clothing within the global context of clothing supply chains, brands and markets, and associated cultural and behavioural issues.

The policy implications emerging from the research cover four broad areas as illustrated below:

- 1. Support for direct, short-term initiatives that promote the longevity agenda more broadly within business and consumer contexts.
- 2. Resources and infrastructure that support education, training, knowledge sharing and collaboration, within and between organisations in the supply chain, across the sector and with consumers.
- 3. Support for research into (i) commercialisation of the business case, innovations in technologies processes and testing related to design of longer lasting clothes and (ii) emotional durability and user-centred design in order to strengthen the business case and influence consumer behaviour.
- 4. Guidance and legislation to influence the uptake of aspects such as clarity of garment labelling and improved recycling initiatives, and to encourage retailers and brands to take more responsibility for their products within a circular economy.

The final report includes details of dissemination activities undertaken in 2015/16 and a toolkit to facilitate uptake of the findings within industry and education.

2 Introduction

2.1 Background

The report summarises the final outcomes of the Defra and WRAP funded project: Strategies to improve design and testing for clothing longevity. The research commenced in March 2014 and was concluded in December 2015. It presents a literature review, key findings from primary data collection and pilot actions, an assessment of the implications for industry, policy and further research, a preliminary outline of a proposed toolkit, and details of dissemination activities.

This project set out to build on previous research (Cooper *et al.*, 2013; WRAP, 2013; Cooper *et al.*, 2014) by drawing on technical innovations combined with knowledge of consumer perspectives, new product development (NPD) practices and commercial objectives. Researching, piloting, evaluating and communicating the issues arising from this consolidated approach was necessary to understand and overcome the barriers previously identified to implementing sustainable practices and behaviours by introducing NPD for clothing longevity within commercial constraints.

The project set out to understand how existing processes and behaviours of clothing NPD impact on clothing supply chain performance, particularly in terms of cost, time and product longevity. It then went on to explore how technological innovations and appropriate testing processes could be incorporated into the NPD process and wider supply chain to improve clothing longevity, while identifying obstacles to the implementation of such innovations. Ultimately it aimed to establish whether innovations in clothing NPD, testing and other supply chain processes could enhance communications, knowledge and skills relating to clothing longevity within organisations, throughout the supply chain and with consumers, and to understand to what extent this could impact on behaviours relating to clothing longevity.

The report concludes by introducing a toolkit that has been prepared to help share findings with current and potential industry practitioners in an attempt to make real change towards extending the lifetime of clothes and, as a result, reduce the harmful level of clothing sent to landfill.

2.2 Key Findings

The findings are embedded in an industry context in which there is convincing evidence that many retailers have devalued clothing products over recent years. This compromises durability, with premature failure especially attributable to pilling and colour loss. For most retailers, cost - along with aesthetics - continues to dominate design decisions to the detriment of longevity. Furthermore, the research found that issues of commercial governance and agency support this prevailing cost focus and perpetuate the systemic obstacles to introducing longevity as a wide scale solution to garment waste.

With respect to processes that support clothing longevity, the research highlights issues relating to:

- the adoption of advanced textile processes and finishing techniques that could enhance product longevity;
- time, cost and technical constraints on the type and effectiveness of product testing carried out during the NPD process;
- the impact that retailers could have by influencing consumer behaviour and enhancing their own approach to user-centred design and addressing the lack of clarity and consistency in garment care labelling;

- a depletion of technical skills and knowledge within retail NPD teams and throughout the supply chain, and a pressing need to enhance collaboration across the supply chain to promote better design practices from fibre to end-use, noting the benefits of a multidisciplinary approach which accounts for commercial, technical and sustainability objectives;
- a continuing lack of evidence to encourage retailers/brands to pilot and adopt new business models that support clothing longevity.

3 Literature review

A short review of relevant literature highlighted a range of relevant topics drawing on extant knowledge across a number of disciplines. These include consumer and brand perspectives on sustainability and longevity; material and emotional durability; product testing and failure; the new product development process and design for longevity; retail and brand responses to the challenge of extending clothing lifetimes; the clothing supply chain; new technologies and business model innovations.

The review found that there is limited literature on brands' perspectives on sustainability generally (Miller and Merrilees, 2013), or New Product Development (NPD) specifically, despite its pivotal role in affecting clothing sustainability, longevity and failure. Indeed, greater understanding of how consumers maintain and retain garments could impact upon efforts to achieve greater sustainability through clothing longevity (Goworek *et al.*, 2012).

An important distinction between durability and longevity was identified. Durability is a measure of how long a product will continue functioning and withstand 'wear and tear' before it develops a defect that is deemed irreparable. By contrast, longevity describes a product's life-span, which may be determined by factors other than design and manufacture, such as user behaviour and socio-cultural influences (Cooper, 2010).

3.1 Clothing longevity and sustainability

There is a clear link between clothing longevity and sustainability; the 'Valuing our Clothes' report showed that extending the active lifetime of clothing by an average of three months would reduce its carbon, water and waste footprint by 5-10% report (WRAP, 2012). Based on the current average active lifetime for clothing of 3.3 years, a study for WRAP (2013:11) suggested that *"there is scope for behaviour change, with around a third of respondents* [51% *of which were under 35*] *interested in doing more to buy clothes that are made to last and in doing more to care for their clothes so they are kept in regular use for longer"*. An earlier WRAP report (2012) had established that more than half of respondents (56%) considered buying good quality clothes to be a 'sound investment'. Subsequent research found that some retailers were starting to look for ways to promote longevity in key products (Cooper *et al.*, 2014), although this is hard to measure, not widely tested and dependent upon the complexities of consumer usage. Fisher *et al.* (2008) had previously found that consumers were primarily influenced by economic and personal factors rather than sustainability; for example, they were reluctant to wash at low temperature or less frequently even though aware that this is environmentally preferable (*ibid*).

3.2 Consumer perspectives on longevity

Clothing durability, care and disposal are important influences on sustainability through clothing longevity. In a UK survey, many consumers regarded cheap clothes as disposable, with frequent

reference to "throwaway clothes" (*ibid*). The main purchase criterion is value for money and at the same time one third of UK consumers prefer to buy clothes that are made to last (WRAP, 2012). More than half (58%) of UK consumers regard quality clothes as an investment, but few know how to measure quality. Similarly, in Scandinavia, over 60% of consumers suggested they would wear clothes for longer if the quality was better (Laitala and Klepp, 2011). Furthermore, some 80% of UK consumers would accept alternative, low-impact fibres that look, feel and cost the same as normal fibres, and there is interest in fibres that dry more quickly (WRAP, 2012).

However, some one third of clothing in the average UK wardrobe is not worn because it no longer fits, with 57% of consumers owning clothes that do not fit and one quarter suggesting they would wear items longer if they could be altered for fit or style. By comparison to the 36% of consumers own unworn items because they no longer like the style and 10% who have items they no longer wear because of damage during laundry (*ibid*). In contrast, the Scandinavian research found that clothing is most commonly discarded due to garment failure (e.g. fading) followed by size and fit, taste, loss of fashion and function (Laitala and Boks, 2012). Consumers' response to different garment types also varies. In Scandinavia, trousers/jeans, underwear, socks and hosiery/leggings were most likely to be rejected due to wear and failure, whereas tops, jackets, nightwear and accessories were most likely to be replaced because of new or preferred alternatives or because they became too small (Laitala and Klepp, 2011).

Of the Scandinavian survey respondents, 80% agreed that they were ready for repairable garments that cost more but had a longer life. However, the same consumers were most ready to accept familiar practices of repair and recycling, rather than more radical interventions. Design strategies from niche markets (such as long-life guarantees; product attachment through unique design; customisation and modularisation; co-creation and open source design; design services and leasing) could all be scaled up (Niinimäki and Hassi, 2011). However, the extent to which these findings apply to consumers in the UK or elsewhere in Europe is unclear, and there is a lack of evidence of the extent to which such services have a positive impact on longevity, sustainable production and consumption.

Attitudes and behaviours towards clothing differ across consumer segments, as well as across cultures. In the UK, 58% of 16-24 year-old consumers said they own items that are unworn because they no longer like the style (WRAP, 2012). In Finland, where consumer focus groups suggest that the adoption of new clothing product-service systems have led to longer garment life and/ or reduced clothing waste sent to landfill, it appears that young consumers engaged readily in services such as swapping, rental and fashion updates, while more mature consumers were more likely to favour redesign, repair and customisation (Armstrong *et al.*, 2015). However, from a range of UK consumer segments associated with differing sustainability behaviour, consumers buying clothes that last longer may not be those most willing and able to act sustainably in other ways; they could potentially include segments such as 'waste watchers' who are driven by economic drivers as much as environmental concern (Defra, 2008).

3.3 Brand perspectives on longevity

The approach of retailers and brands was found to be somewhat at odds to that of their consumers. Retailers have reduced product quality over time to meet retail price-points and items are often accepted for sale in the short term on commercial grounds, even if they have failed quality tests (WRAP, 2014). However, retailers perceived that garment failure was attributable to the way that consumers wash and store items, rather the quality of the products that they design, make and sell. The Danish Fashion Institute has suggested that improved communication to consumers by retailers could help promote more sustainable behaviour (DAFI/BSR, 2012), while design can influence

longevity by reducing garment failure and prolonging garment use, as well as reducing the laundry impact of extended clothing maintenance (Laitala and Boks, 2012).

3.4 Material durability

Durability, or manufacturing for longevity rather than disposability, involves retailers' and suppliers' designers, garment and fabric technologists - all being central to sustainable decision-making through their selection of processes and choice of materials (Cooper, 2010). New technical guidelines are available in relation to textile durability (Annis *et al.*, 2012) and retailers and brands were found to be adopting new innovations in key product areas (WRAP, 2014) such as:

- Marks and Spencer's Stay NewTM product ranges, launched in 2012, use a variety of yarn and fabric production technologies and finishes that are intended to prolong garment lifetimes. These include an enzyme treatment that removes any protruding fibre ends, keeping the surface smooth to reduce fading and pilling, and an anti-pill finish used on micro-fleece (Marks and Spencer 2014a). The technology is used in schoolwear and a growing variety of core men's wear and ladies' lingerie styles.
- Schoolwear by Marks and Spencer (2014b) and George features adjustable hems and waistbands to accommodate growth, a special thread that bonds with fabric to prevent hems unravelling, non-iron shirts to reduce the effects of heat, and heat-sealed buttons that prevent the need for mending. Marks and Spencer applies finishes such as *Stormwear+^{TM,} StainawayTM* to promote durability, while George incorporates *TeflonTM* Stain Release and advertise *Stay White* and *Lasting Colour* technologies to retain newness for 20 washes.
- Boden is trialling a memory fibre treatment which is intended to ensure that viscose fibres return to their original shape after washing (WRAP, 2014).
- Levi Strauss (2014) incorporates 4% *Dyneema® The World's Strongest Fiber™* into its strong denim jeans range. Designed for military and industrial uses, the company claims that a small amount of Dyneema® is enough to improve durability while retaining a 'cotton touch'.
- Lycra Xtra LifeTM, an elastane fibre designed to be incorporated in denim, swimwear and hosiery that keeps its shape for longer, is resistant to chlorine, sunscreen and heat, and stops tights from developing ladders.

While these fibres and treatments may extend fabric and garment life, the advantages of reducing the material complexity of short-lifecycle clothing in order to facilitate recycling has been acknowledged (Laitala and Klepp, 2011).

3.5 Product testing and failure

Product testing is seen as essential to confirming performance against durability expectations and our previous report for WRAP (2014) proposed that better yarns, fabrics and construction methods should be combined with extended wearer trials and wash tests to enhance garment longevity. However, extended tests were perceived to take too long and be too costly in a cost-centred industry. In practice, trials found that extended wash tests represented better value than wearer trials, but needed to simulate from 10 to 40 washes (for knitwear and cotton shirts respectively), to evidence signs of failure. Wearer trials capable of identifying comparable wear and tear would need to last for 500 hours or more. Extreme tests of durability for some performance items are available that could fit better with the supply chain's speed and cost imperatives and consumer behaviour (Shellenbarger, 2001; Annis *et al.*, 2012; Cooper *et al.*, 2014). However, with the trend towards fast fashion, the emphasis on materials testing has tended to be reduced to shorten the critical path

(Marion, 2013). In higher value markets the importance attached to design and brand integrity has led to slow decision making and added product testing (Brun and Castelli, 2008; Pisano and Adams, 2009), and this in turn fosters a resistance to innovative design practices and could even inhibit creativity (Abecassis-Moedas, 2006; Oxborrow, 2015). In spite of these divergent tendencies in NPD, but consistent with earlier findings, a report for WRAP (2014) concluded that better relationships between designers and technologists, better education of consumers and clearer care instructions are necessary to accurately predict and avoid premature garment failure.

3.6 Emotional durability

Enhancing person-product attachment is considered necessary alongside increased durability, as it leads to customers wanting to wear garments for longer (Niinimäki and Armstrong, 2013). Emotional satisfaction and product quality can both be enhanced by changes to the retail/brand productservice mix, where the service element includes design input as well as aspects of customisation and repair, which can therefore also lead to longer active clothing lifetimes (Niinimäki, 2012). A number of business model innovations such as swapping, rental, redesign, repair, customisation and advice could extend garment life, along with designing-in features associated with longer use, such as flexibility to fit, trends and individual's look (Laitala and Klepp, 2011; Armstrong *et al.*, 2015). However, design challenges such as improving technical quality, designing items to fit better (women's), adapt to body size (children's) and flexibility to style or fashion (men's) also need to be addressed to derive environmental and social benefits (Laitala and Klepp, 2011).

3.7 Design for longevity and a systems thinking approach to NPD

Many environmental impacts of garments are determined at the design stage (Wolf *et al.*, 2011) and effective sustainable design is dependent on multi-disciplinary co-operation between designers, merchandisers, business strategists, production teams, marketing staff, and sustainability managers to achieve customer value and sustainable design (Hong *et al.*, 2009; Curwen *et al.*, 2012). Because of the apparently conflicting approaches to longevity of consumers and retailers/brands described above, a more pro-active, visionary and far-sighted design approach is needed to create product satisfaction, enhance product lifetime and promote sustainable consumption (Niinimäki, 2012). A systems thinking approach that takes purchasing, maintenance and disposal into account should be adopted, to design-in features associated with longer use (Laitala and Klepp, 2011). With a favourable organisational ethos and a systems thinking approach, sustainable clothing design can effectively consider customer value and cost alongside reduced impact from use and care (Waage, 2007; Allwood *et al.*, 2008; Hong *et al.*, 2009; Huang *et al.*, 2009).

One model for sustainable clothing design is the 'C2CAD' process which has four main steps: problem definition and research, sample making, solution development and collaboration, and production (Gam *et al.*, 2008). The sample making stage, which takes into account commercial, technical, production and environmental considerations, and the solutions and collaboration stage, which depends on information sharing with a network of suppliers to address materials, design and consumption, are especially relevant to designing for longevity.

A case study of one company (Eileen Fisher) revealed how a proactive business culture, objectives, structure and processes supported sustainable design, enabling designers to communicate with suppliers and benefit from their capabilities through numerous cross-functional teams. Based on this experience, five principles of design for sustainable clothing were proposed: company mandate; shared values within and between firms; knowledge sharing; re-organisation and cross-functional working; and a simplified and short supply chain (Curwen *et al.*, 2012). In summary, solving sustainability problems depends upon implementing strategies such as early supplier involvement, information sharing and integrative product development (Kogg, 2003; McDonough *et al.*, 2003;

Petersen, Handfield, & Ragatz, 2005), while considering ecology alongside commercial and aesthetic values (Gam *et al.*, 2008).

3.8 The global apparel supply chain

Clusters of firms better acquire fashion and technical knowledge, but traditional apparel supply chain clusters have fragmented because retailers have assumed greater responsibility for design and have increasingly outsourced production globally (Aage and Belussi, 2008; Abecassis-Moedas, 2006) with frequent supplier switching (Tachizawa and Thomsen, 2007). Correspondingly, risk mitigation factors are limited because they are demanding on data, collaboration and time and building social capital, such as brand reputation (Christopher *et al.*, 2011; Rauer and Kaufmann, 2015). In this context, barriers to the adoption of sustainable supply chain practices include lack of transparency, variable data reliability and limited influence over upstream suppliers (Rauer and Kaufmann, 2015). Evidence suggests that many of the pre-requisites of a sustainable supply chain and a systems thinking approach to sustainable design are not routinely practiced within the existing, increasingly global, apparel supply chain (Oxborrow, 2015). Two different approaches to environmental sustainability performance have been observed. Large companies tend to focus more on incremental product and process improvement with limited risk and associated cost benefits, whereas small companies have been able to completely reshape their supply chain to draw upon reputational advantages (Caniato *et al.*, 2012).

3.9 Technological innovations

Technical and process innovations in clothing NPD include Computer Aided Design (CAD), 3D and virtual prototyping; modularisation and pre-tested fabric platforms (standardised base fabrics for multiple end-uses); durable components, materials processes, treatments and finishes; testing technologies and simulation; alternative methods of production; design for recoverability/recycling, care and labelling; monitoring and traceability, including developments in RFID and garment level tracking; and communications tools. Selected examples are discussed below.

Innovations in fibre, fabric and garment testing include enhanced wash tests; extended wearer trials and simulation of wear; a range of fabric/component durability tests used in sportswear, outdoor wear and automotive interiors; objective measurement of test results, such as rub and colour fastness; and clarification of manufacturing standards (Annis *et al.*, 2012). There are also a growing range of fabric finishes and treatments and assembly processes that enable garments to be kept for longer (as discussed in section 3.4). Indeed, one of the obstacles to use is the plethora of options available and lack of comparable data to evaluate their impact. The case of Marks and Spencer's 'Stay New' technology includes a complement of enzyme and other finishes to reduce pilling combined with a specially devised durability test that garments must pass before they can be labelled as 'Stay New'. This implies considerable investment in both the NPD process and the testing regime, as well as an on-cost for applying the finishes, but the strategy reinforces brand value through product quality and durability.

Developments in Computer Aided Design (CAD), include 3D visualisation of products during the design stage to facilitate evaluation of garment fit and aesthetics. Emerging 3D CAD systems can variously transfer 2D sketches into 3D shapes; simulate the drape and style in 3D; and/or convert 3D design into 2D pattern pieces for production. In commercial terms such systems are predicted to improve communications with remote suppliers, reduce the high cost and lead-time delays caused by extensive physical sampling and facilitate the detection of errors (Sayem *et al.*, 2010). In the context of clothing longevity this could help to re-align the critical path to enable more physical product testing; facilitate visual comparisons of the drape of durable and aesthetic materials and

predict early failure points. However, these latter two benefits depend on systems being backed up by adequate datasets relating to fabric properties and garment failure.

Radio Frequency Identification (RFID) consists of a radio enabled tag that can be embedded in clothing, clothes labels, item or consignment packaging. Signals transmitted by the tag are picked up by a remote sensor. Although increasingly used for stock control and anti-counterfeiting, durable RFID transmitters can now be incorporated into sewing thread (Swedberg, 2014), virtually imperceptible in items of clothing, and could therefore have wider uses. For example, RFID technology could, in theory, support longevity by controlling a sensor-enabled washing machine, notifying the user of delicate items or even dictating the wash setting for such items (Yanko Design, 2008). In reality, limited accessibility of sensor technology suggests that more centralised usage would be more achievable, such as use in commercial laundries; notifying a recycling facility of the fabric composition and recycling instructions for tagged garments to reduce labour-intensive sorting; or monitoring use and care during wearer trials.

Mobile applications (apps) are another emerging technology with potential significance to clothing longevity. Touch Closet is an app that enables users to record the items in their wardrobe, track when items were last worn; calculate cost-per-wear; co-ordinate existing outfits and help buy new garments that coordinate when shopping (Blasigh, 2013). Other app concepts are used to convey detailed care instructions or help consumers to develop repair or upcycling skills.

3.10 The business case and business models

Business model innovation is an increasingly popular concept in entrepreneurial circles, although early models failed to address sustainability adequately (Chesbrough and Rosenbloom, 2002; Chesbrough, 2010; Osterwalder and Pigneur, 2010). The applicability to businesses adopting more sustainable practices is clear because of the need to balance multiple interests. Some core features of business models are:

- broadening revenue generation beyond the sale of products by improving service support and performance, or monetising intellectual property;
- encouraging value co-creation from inside and beyond the organisation;
- enabling external suppliers and research organisations to contribute to the R&D process of individual organisations;
- re-configuring value-chains through the use of data and information technologies (Ehret *et al.,* 2013).

WRAP's five-year plan sets out how businesses, organisations and consumers can be part of a 'resource revolution' that will re-invent, re-think and re-define how we use materials (WRAP, 2015). Alternative or innovative business models can extend product life, conserve resources and prevent materials from becoming waste. The WRAP map in Figure 3.1 showcases a range of alternative business model propositions. The REBus Project, also delivered by WRAP (2016b), profiles a small number of clothing cases, including:

- Rentez-Vous a UK based peer-to-peer rental market place for special occasion and designer clothes (*ibid*).
- Mud Jeans a Dutch jeans company offering long term lease of recycled and organic denim jeans, ultimately to be returned, swapped or kept by the consumer. Returned jeans are re-

used, upcycled with worn-look finishes or recycled into new denim items (Ellen MacArthur Foundation, 2015).

 Dutch aWEARness – a small firm that creates work clothes from 100% recyclable polyester (Returnity[®]) that can be continuously recycled. The business model has a number of integral characteristics: customers pay for the use and performance of the clothing products over a period of time; the product is designed to be recoverable; close collaboration with suppliers and a track and trace system deliver an effective closed loop system (Earley, 2014).



Figure 3.1 Innovative business model map for resource efficiency

While service systems, hire and leasing are also key features of Scandinavian research into clothing longevity (as discussed in section 3.2), it is not clear to what extent these examples have been commercially tested, are scalable and transferable into other markets such as the UK, where market representation is modest. Earlier WRAP research (2013b) evaluates the financial viability of different product-service clothing business models and concludes that those that are financially viable in 5 years have little resource impact, as summarised in Table 3.1. After 10 years, only the retailer buyback and resale of pre-owned fashion clothing model performs well on both counts, based on a conservative scenario plan.

Table 3.1 Summary of business model financial appraisal and resource impact (conservative
scenario)

	After 5 years		After 10 years	
	Financial	Resource	Financial	Resource
	viability	impact	viability	impact
Repair services and workshops	No	Acceptable	No	Good
Lease of baby clothes	No	Good	Maybe	Good
Formal clothing hire	Yes	Not	Yes	Acceptable
		acceptable		

Source: WRAP, 2016a

Buy-back and resale fashion clothing	Yes	Acceptable	Yes	Good
Peer-to-peer rental	No	Not acceptable	No	Not acceptable

Adapted from WRAP (2013b)

The same analysis also evaluates the effect of scaling up to a tipping point at which alternative business models become commercially attractive (taking into account input prices, technological change and changes in consumer behaviour). Based on this, and illustrated in Table 3.2, the leasing of baby clothes and peer-to-peer exchange models become more financially attractive. However, while the resource impact of peer-to-peer exchange improved, Only the short-term resource impact of baby clothes leasing and long-term impact of clothing hire were negatively affected by scaling-up. Only the buy-back and resale of fashion clothing model performed consistently well in financial viability and resource impact in both scenarios.

Table 3.2 Summary of business model financial appraisal and resource impact (tipping-point scenario)

	After 5 years		After 10 years	
	Financial	Resource	Financial	Resource
	viability	impact	viability	impact
Repair services and workshops	No	Acceptable	No	Good
Lease of baby clothes	Maybe	Acceptable	Yes	Good
Formal clothing hire	Yes	Not	Yes	Not
		acceptable		acceptable
Buy-back and resale fashion	Yes	Acceptable	Yes	Good
clothing				
Peer-to-peer rental	No	Acceptable	Maybe	Good

Adapted from WRAP (2013b)

From the definition above, business model innovation can also encompass changes to the design and value-adding process (Ehret et al., 2013), such as enabling suppliers to contribute to addedvalue through their technical knowledge and product research. However, an emerging body of research in sustainability management suggests that the governance structures of firms adjusting their product-service mix need to evolve in order to permit internal NPD teams, suppliers and other external organisations to contribute more fully to adding value to products and services or incorporation of end-of-life processes, as seen in the case of Dutch aWEARness (above) (Boström et al., 2014; Hoejmose et al., 2012; Lockett et al., 2011; Lozano et al., 2014). Research also suggests that this requires changes to the relationship between the product and the consumer and a more detailed knowledge of the use phase of products (Taylor, 2013). There is a lack of evidence based research into the commercial case for such approaches to longevity; most published research focuses on fast fashion case-studies such as H&M and Zara. A recent report by Kurt Salmon Associates (2014) suggests that retailer innovation priorities include adopting multi-channel; geographical differentiation; mass-customisation; speed of product innovation and information integration; and changes to the sourcing landscape. These will require additional management of cost, quality and speed to market, and involve sourcing and environmental risk.

4 Methodology

The project was based on a multi-method action research approach (Lodgaard *et al.*, 2013), using three stages and building upon previous WRAP projects by exploring existing processes and behaviours in relation to NPD and the supply chain.

The research involved an evaluation of potential interventions (including new technologies, processes and approaches) and a piloting phase to test and evaluate effects, scalability and replicability. Primary research took the form of semi-structured interviews with industry professionals, consumer focus groups and ethnographic research, expert round tables with industry and academic specialists, a multi-disciplinary academic workshop, and four pilot exercises with clothing companies that drew upon the findings of the theoretical work. The methodology behind each of the stages is described below.

4.1 Industry Interviews

Face to face and telephone semi-structured interviews were undertaken to understand current views and practices relating to design for clothing longevity and discuss opportunities and limitations to embracing change. The interviewees comprised industry professionals in various roles covering different businesses, representing the clothing supply chain and related services, including product testing. They were chosen using purposive sampling to ensure a diversity of views (Bryman and Bell, 2015) from contacts known to NTU associates, specific targeted companies and a list of contacts provided by a national industry association. In total, including initial interviews at the project scoping phase, 31 individuals representing 21 different businesses were interviewed.

An interview schedule was developed based on previous research and informed by the literature review, with sections aimed at senior managers, technical specialists and design/sales/buying representatives. Interviews were undertaken between July 2014 and July 2015. Most lasted from 60-90 minutes and were at the company premises or by telephone. Some also included a tour of production facilities to provide a visual record of the processes followed. Interviews were recorded and transcribed, with summary notes prepared by the interviewers for accuracy (Bryman and Bell, 2015).

Key themes covered during the interviews included: business context; sustainability generally, longevity and durability specifically and challenges to achieving this; product testing; design for longevity/durability; the case for durability; clothing care; skills and knowledge and the supply chain. The findings are discussed in section 5.1.

4.2 Consumer research

4.2.1 Focus groups

To better understand consumer perspectives on clothing longevity and the consumers' role in achieving longer clothing lifecycles, four focus groups were undertaken in November and December 2014 with a total of 29 participants. Participants were chosen using purposive sampling to ensure demographic and behavioural segmentation. The aim was to uncover rich, descriptive data in an area in which relatively little is known rather than data generalizable to the population as a whole

(Hennink, 2014; Bryman and Bell, 2015). The groups were segmented according to age, social grade¹ and personal/ family circumstances as follows:

- F1: Young participants aged 18-30 years old associated with fast fashion consumption: 6 students from mixed disciplines and social grade C1 (NTU; November 2014).
- F2: Young participants aged 18-30 years old associated with fast fashion consumption in and social grade B-D: 5 full-time employed administrative staff targeted through university support services and external businesses (NTU; December 2014).
- P: Parents of school aged children in and social grade A-D: 8 participants targeted at a local sports club (Arnold, Nottinghamshire; December, 2014).
- S: Employees in and social grade B-C2, aged 30-60 years associated with classic styles and garment durability. 8 participants including academic and administrative staff from the University of Leicester, a manager from a national charity and retired former manager (University of Leicester; December 2014).

Questions were designed to prompt discussions on four main stages in garment lifetimes: purchase, usage, re-use and disposal. Personal expectations and experiences of different garment lifetimes were described to explore individual and common behaviours at each of the stages and determine what limits garment lifetimes.

Interactive tasks explored participants' relationships with clothing by asking them to tell the story of a 'favourite garment' and seeking their perspectives on a range of potential sustainability strategies and influences. Each group was presented with images representing products, services and marketing initiatives that could support clothing longevity (ranging from the '10 Year Hoody' to different recycling schemes and mobile apps). Some were illustrated with recent industry examples and others presented as hypothetical scenarios developed by researchers where real examples were limited or absent (following Armstrong *et al.*, 2015).

4.2.2 Clothing diaries:

To further explore and observe some of the behaviours uncovered during the focus groups an experimental process of recording clothing diaries was subsequently undertaken with 6 consumer participants, reflecting (but not duplicating) participants from three of the four consumer focus groups and equally split between genders. The ethnographic approach, appropriate for an in-depth investigation of an aspect of culture (Quinlan, 2011; Bryman and Bell, 2015), was taken to explore the details of consumers' routine clothing maintenance. Clothing diaries (Figure 4.1) were designed as an empirical tool for qualitative data collection in the participants' homes.

Each consumer participated by:

• Maintaining a clothing diary recording wash, wear and care patterns of an individual, everyday garment selected by the participant and covering an eight-week period.

¹ Social Grade classifications and current percentage of each in the UK (2015): A - Higher managerial, administrative and professional, 4%; B - Intermediate managerial, administrative and professional, 23%; C1 - Supervisory, clerical and junior managerial, administrative and professional, 27%; C2 - Skilled manual workers, 21%; D - Semi-skilled and unskilled manual workers, 16%; E - State pensioners, casual and lowest grade workers, unemployed with state benefits only, 9%. Source: National Readership Survey (2015).

• Taking part in a post-diary interview in order to describe their attitudes towards clothing longevity and social factors behind their behaviours, as well as their experience of the methodology.



(image: Angharad McLaren, NTU)

The process required an extended commitment, which limited the sample size and resulted in a high drop-out rate – hence the exclusion of one focus group category (the parents). The combined findings of the consumer research are discussed in section 5.2.

4.3 Expert round tables and workshop

The research interviews, focus groups and clothing diaries highlighted a number of unresolved issues and contradictions concerning the practical implementation of strategies to enhance clothing lifetimes. In order to explore potential solutions, a series of expert round tables were undertaken to explore particularly sensitive issues, test the parameters of existing practice and discuss potential future developments or mitigating actions. The topics covered included product testing, pilling and understanding and informing consumer behaviour. Each round table involved from four to eight invited experts from across a range of disciplines and professional specialisms. Several of those invited to the round tables volunteered to provide data by email instead of attending. In addition, an expert workshop was held to brainstorm wider issues of design and product development, consumer perspectives and the business case. This was led by five academic experts and attended by 17 researchers and practitioners.

The round tables followed a common format, which included identifying a 'key question' to share with participants, a brief presentation of findings from the research so far, along with examples of good practice. Participants were then presented with a series of specific sub-questions for discussion (Hennink, 2014). The subsequent discussion was videoed and transcribed, and key points written up and circulated. Additional views were sought remotely, by email, after sharing these notes.

The expert workshop was similarly based on the presentation of findings to date, with experts asked to comment on a specific question relevant to their field. This was followed by 'table discussions' on four key topics which were recorded by note takers and an audio device on each table. Findings were shared at the end of the session, with the lead experts offering final discussant comments on each topic.

A summary of the process for each session is provided below and the findings summarised in section 5.3.

4.3.1 Testing round table

Participants included three technical and testing experts from two major retailers, a specialist from a testing house, an independent specialist consultant, a technical adviser to WRAP, an advanced textiles academic expert and a NTU research student.

Key question: How can textile testing be improved to facilitate extended use of garments by consumers?

4.3.2 Pilling round table

Pilling was identified as a particularly intractable problem in the focus groups and testing round table, so a follow-up round table was set up to explore this issue. Participants included an independent specialist in textiles testing, a technical specialist from a knitwear brand, a representative from a textile finishing supplier, a research expert from a major detergent supplier, an international fibre expert (via questionnaire), and a garment technology academic.

Key Question: How can pilling be reduced and managed in both the short-term and future?

4.3.3 Consumer round table

Participants included a consultant in sustainable consumption and behaviour, a research expert from a major detergent supplier, academic experts in sustainable fashion, popular culture and consumer behaviour (via questionnaire) and (also via questionnaire) practitioners including a PR and market research consultant, a retail brand marketing representative, a consumer ethics journal editor and a sustainable design consultant.

Key question: how can industry and government influence positive consumer behaviour change towards longer clothing lifetimes?

4.3.4 Expert workshop: Integrating design for clothing longevity

A multi-disciplinary panel was invited to lead a workshop at the 'Product Lifetimes and the Environment' (PLATE) conference in order the draw upon the expertise of delegates (Cooper *et al.*, 2015). The panel was comprised of academic experts in clothing technology, innovation and sustainability, the circular economy, ethical fashion, sustainable behaviour in fashion, and design and visual culture. It was joined by 17 conference delegates with knowledge and interest in sustainable business and design, many of them with specific expertise in the clothing industry.

Key question: How can design strategies for clothing longevity be placed at the heart of the clothing industry?

4.4 Pilot studies

Four pilot exercises with retailers and brands were carried out as part of this project with the objective of changing working practices, using new technologies and testing materials, garments and components in order to improve the sustainability and longevity of the final product within the constraints of the NPD process. The pilots were identified as a result of the engagement with retailers and brands through interviews and expert round table discussions that explored the barriers to designing, testing and manufacturing products with longer lifetimes. Each focused on a specific problem or opportunity related to clothing lifetimes that the retailer or brand was keen to

explore. The intention was to establish what works in practice, what does not, and why, and produce findings that could feed into a final tool-kit and provide evidence and recommendations for improved practice, test validation and future research.

The pilots covered the following themes:

- **Brand A (a supermarket childrenswear brand):** An exploration of durability testing to support a potential '200 day guarantee' marketing campaign.
- Brand B (a mass market clothing brand): An investigation into customers' views on the durability and longevity of clothing in order to establish opportunities to influence behaviour change and inform potential business initiatives aimed at lengthening clothing lifetimes.
- **Brand B (a mass market clothing brand):** Development of a testing regime to evaluate colour fastness using a range of domestic detergents and softeners that represent consumer practice in laundering.
- **Brand C (a niche luxury knitwear brand with own manufacturing):** Investigation of a quality problem in manufacturing to identify the cause of severe pilling in cashmere knitwear.

An overview of the four pilot studies is provided in section 6, which outlines the objectives, methodology and key findings.

5 Research findings

5.1 Interviews

Key findings from interviews with industry representatives are summarised below in a series of key themes. The respondents were coded according to their role (designer, director, technical, etc.) and the type of organisation they represent: retail, brand (responsible for end-products sold through their own or other retail outlets), supplier (of garments, fabrics, yarns) and services (testing, dyeing and finishing, etc.). This enabled comparison within and between different groups, while maintaining individual anonymity.

5.1.1 Sustainability, product longevity and durability

Sustainability is important to most clothing organisations, but this is not generally represented in terms of durability or longevity, except in some niche brands and specific product areas of larger brands. Some organisations are concerned with recycling, others with reducing energy more generally, and some with ethical impacts. Improvements in these areas increasingly involve organisations throughout the supply chain.

On the other hand, price is considered to be an inhibitor of clothing durability. While in some markets either brand quality and reputation or product guarantees raise consumer expectations regarding how long garments will last, this is offset by the proportion of goods designed and made for short-life and fast style turnover. Supplier respondents offer products with a range of lifetime expectations from a few weeks, to 2-3 years and at the extreme 30 years or more of irregular use. Two participants sell products with a guarantee that they will last for 100 washes or 200 days, noticeably towards the lower end of the range. Some suppliers are concerned that poor durability leads to high return to manufacture (RTM) rates which are costly to them and damage their

reputation with retail buyers. Meanwhile suppliers of fast fashion and some retailers are concerned that longer clothing lifetimes could undermine future sales.

Opinions differ with regard to the case for durability, with Supplier A negative about the commercial case for durability, Retailer A, Brand D and Supplier F all claiming that durability enhances brand value. There is no clear correlation between those supporting durability and market level of brand, as Retail A are considered low value, while D and F have relatively high price points. With the exception of those engaged in fast fashion, most agree that there is a compelling case for producing and selling higher value products, but that this is commercially unproven and would be difficult to present to decision makers.

5.1.2 Challenges to longevity and durability of clothing

Challenges to longevity and durability are attributed to a number of factors that can be characterised as: poor customer care; use of inappropriate fibres, yarns, materials, print finishes and knit structures, usually associated with cost and aesthetics being prioritised over longevity; fast style turnover and critical path pressures. Most suppliers claim that their brand/retail customers often overlook advice regarding appropriateness of materials and finishes because longevity and durability are not prioritised. Some suppliers and retailers mentioned poor customer care, with one referring to *"abuse in washing"*. Only one retailer directly referred to the business case by illustrating the imperative to command a higher price for an item that was more easily repairable. However, the trade-off issues raised by several others regarding cost and aesthetic are also contributing factors. The same retailer highlighted the trade-off between longevity and other sustainability attributes, such as using recycled materials or improving factory working conditions.

5.1.3 Design for longevity and durability

Design for durability is associated with choice of materials and their various functional qualities. Most agree that it is desirable to ensure that yarns and fabrics are durable, but disagree in the way to achieve this. Of those in favour of durable materials there is a clear divide between those retailers, brands and suppliers who seek to use the most durable yarns with long fibres for stability and those who favour application of a growing range of special finishes and processes that help to make yarns/fibres of average quality last for longer. These include silicon treatments and finishes such as singeing and cropping, which can be very effective at reducing pilling and loose fibres but can make yarn too 'silky' for the UK market (Supplier C) or too rigid (Retail A) or in other ways alter the feel and aesthetics such that they are not always a desirable solution. However, in some cases speed and cost pressures, or aesthetics, overshadow any consideration of longevity, while in other circumstances fabrics are pre-chosen or pre-ordered by retailers to secure bulk economies, in which case multiple priorities are taken into account over which the supplier has little say. Only one knitwear supplier and one fabric mill referred to adapting final product design to enhance longevity. For a few brands and their suppliers, change has been imposed to meet the stringent testing needs for goods exported to the Chinese market. Future change will include more use of those finishes that help to preserve yarn stability, but which at present cause undesirable feel or aesthetic.

5.1.4 Product testing and care labelling

Testing practices vary considerably depending on the end-use of the garment, the rate at which new materials are introduced and the degree of confidence and trust placed in garment and yarn suppliers. While lack of trust can result in repetition of costly tests on yarns and fabrics at one extreme, fast fashion suppliers report an expectation that their products will fail tests for pilling specifically, as well as other characteristics, while commercial pressure means that problems are not addressed. This is especially a fast fashion problem because of the rapid adoption of new fabrics and

the time/cost pressure to introduce new styles. In other markets, intense and extended tests are reserved for new materials and products which can be used over a period of time. Tests are carried out in-house and by external suppliers, but Supplier A indicated that they anticipate more testing will be carried out at global supply locations in the future and the company is equipping labs in the Far East to do this.

With a mixed approach to test results, findings reveal a further anomaly, with several retailers and brands introducing a standard "wash at 30°" wash care instruction to protect vulnerable items and reduce environmental impact. Others claim that customers don't follow care instructions, which is damaging to clothing longevity. Brand A also revealed that specialist international service providers supply generic care label standards for a range of products.

5.1.5 Skills and knowledge

Most supplier firms claim that they retain a significant range of skills and knowledge, often acquired over many years. In contrast, they claim that retail and brand buying teams are deficient in the skills and knowledge needed to positively affect design decisions and this was confirmed by one niche brand (Brand C) who admitted that *"we are generalists and lack the specific product knowledge of our suppliers"*, a situation echoed by some retailers. In spite of this, several suppliers suggested that their recommendations of fit-for-purpose fabrics, yarns or finishes were sometimes over-ruled in favour of less durable options.

A further recurring theme is the overall loss of skills in the UK as a result of the off-shoring of manufacture and global nature of most supply chains, with a lack of confidence that appropriate technical skills and knowledge are available among off-shore suppliers, an assertion consistently supported by anecdotal evidence from a range of the participants. Design for longevity depends on knowledge of technical and durability criteria, so this shortfall has a direct impact on clothing longevity.

5.1.6 The supply chain as a facilitator or obstacle?

There appears to be distrust between retailers and their suppliers, for example with regard to sharing knowledge and adherence to test standards. Some buying organisations enable suppliers to self-certify their test reports, which is most common for suppliers in long-held relationships and for core products that are repeated season after season. For new products or materials, and for less established suppliers, testing is managed downstream in the supply chain by preferred suppliers, retail sourcing offices, or retail buying departments. Upstream in the supply of raw materials there is further evidence of distrust and lack of transparency, which affects quality and consistency, in this case of luxury yarns, which could compromise durability. Some suppliers expressed concern that, downstream in the supply chain, some decisions taken by retailers and brands are based on limited technical knowledge, aesthetics or to meet cost and speed targets, and could also potentially undermine durability. Other potentially negative impacts arise from common supply chain limitations. Communication of expectations and improved practices to upstream suppliers tends to be sporadic, fragmented and dependent on either generic supplier manuals or individual item specifications and, in the case of one retailer, a supplier conference that takes place as infrequently as every few years. The efficacy of such methods of communication within a global supply chain needs to be considered. Furthermore, some of the more innovative niche brands and retailers admit that they lack the power and influence within the supply chain to have any lasting impact on the practices of their suppliers, resulting in durability standards either not being implemented consistently, or being of limited, short-term benefit.

5.1.7 Other key findings

Comments and suggestions reinforce some of the points made above. Four key areas of focus emerged:

- 1. The damaging impact of cost and speed on any progression towards durability was implicit in many discussions. Cost and speed are emphasised as key drivers for the prevailing business model.
- 2. The emerging importance of standards imposed by China on imported materials and components is a driver for change among exporting brands. Historically this has led to upstream supply moving to China, but, in the recent economic climate, suppliers of innovative materials and clothing are improving their products generally in order to meet the required Chinese import standards, to the benefit of other products and markets.
- 3. The need to balance product development with more service oriented solutions that extend the life of clothing and provide alternative revenue streams includes services such as repair and alterations, as well as rethinking design to encompass modular or more adaptable clothing. In the UK this remains the preserve of niche brands.
- 4. Solutions for enhancing the lifetime of clothing need to be multi-disciplinary and span functional boundaries, while also requiring a degree of technical knowledge and expertise that is currently lacking in many global supply chains. This issue is raised as a limitation in several of the discussions and re-enforces the gap between theory and practice.

5.2 Consumer research

The research carried out with consumers, through focus groups and experimental clothing diaries, was designed to both test the methodology employed and to explore the findings revealed by previous consumer research in more detail. The focus groups were a key influence in helping to understand consumer attitudes, particularly to longevity and clothing care, and the findings are summarised below.

The focus groups confirm that consumer segments have differing needs and priorities. For example, the consumer panels very strongly indicated that parents and working consumers need clothes that will wash well together in mixed loads, wear well (e.g. not retain visible creases or pill), and require minimal extra care. For some, visible indicators of longevity considerations may be valued (such as an indication of projected life-time, or potential to pill or fade) so that informed purchase and care decisions can be made. Branding can be a powerful influence on consumer expectations, as consumers admit to making presumptions about clothes from certain brands.

While physical durability is an important factor in ensuring that garments have the potential for a long active life, product lifetime expectations are influenced by factors beyond garment failure. The Focus groups illustrate how unsatisfying user experiences lead to garments having a shorter active life (being worn regularly for a shorter period). Participants agreed that garments that leach colour (either through dye transfer or shedding hairy fibres), pill heavily, or scratch the skin were less likely to be put to prolonged use. Pilling was identified as a particular problem, and one which considerably curtails active clothing life from new, as well as inhibiting re-use.

Consumers suggested that their feelings towards items of clothing are influenced by the quality of the original material, and the way it changes through wash and wear over time. For example, denim and leather are considered as not only more durable, but also as having more lasting appeal as they soften and wear well over time. One group observed that these are items which often have a

lifetime extended in second-hand markets. However, consumers reported a number of reservations to buying and wearing pre-owned clothes, such as hygiene, being uncomfortable wearing strangers' clothes, questions of quality, disliking the shopping experience and being dubious of high prices. Perhaps surprisingly, the younger (F1) group discussed how they thought older clothes were better quality, made with more craftsmanship and care to last longer. The F1 group suggested that they feel trapped by the current cheap, fast system of short-life garments, which 'obliges' them to frequently buy new. Participants concluded that trend-led should not have to mean poor quality – despite having a short expected lifetime and that good construction and material helps to ensure that garments have the potential for a full, active life beyond short-lived trends.

Some of the liveliest discussions were about the otherwise mundane and everyday issue of laundering clothes. One aspect common to all groups was the need to address social norms and habits if seeking to reduce wash frequency e.g. washing after only one wear due to fear of social disapproval, or better storage of clothing between wears to avoid crumpling. For example, some consumers identified their potential to reduce washing by hanging /airing clothes between washes. Increased knowledge about the effects of washing on garments could help encourage reduced wash frequency. The focus groups revealed that consumers' knowledge of the laundry process was limited or based on habits, traditions or other priorities, such as energy, water or time saving. Few of the participants were fully conversant with appropriate detergent choices for different fibres, varying wash and spin cycles to preserve clothing, or the importance of measuring detergents. Participants did suggest that more care is taken with new items, in which case care labels are checked and items washed separately, washing machine users found that programme choices were restricted by limited or unclear machine settings, which varied according to the age of the machine.

Once consumers have decided that clothing items have reached the end of their useful life, there is evidently a sense of guilt about throwing things out. Participants acknowledge that it is not good to act in a throwaway manner but feel restricted by lifestyle factors such as time restraints and limited or unclear recycling or re-use infrastructure, such as uncertainty about what to do with well-worn garments, socks and underwear that appear not to meet the profile required by charity collections. Repair services, better recycling systems and information could help.

Both focus groups and clothing diaries suggest that education and information could have a positive impact on clothing care, and encouraging consumers to better value all clothes would help increase their level of care, maintenance and repair. Focus Group participants were asked to evaluate some of the tools and innovations that could help them to make more informed decisions. The most favourably received were: a 'Traffic Light' durability labelling system; textile recycling collections; and TV programmes/media promoting vintage clothes and sewing/DIY clothing techniques. Longer lasting guarantees; online platforms such as the 'Love Your Clothes' website; mending, alteration and repair classes; and 'swishing events' were least favourably received. Apps and professional repair services received mixed responses.

In summary, the findings confirm that brand image is linked to perceptions of quality and durability, illustrating the opportunity for product developers to make sure they match consumers' expectations and needs in terms of quality, durability and ease of garment care, as well as aesthetics. However, user experience also influences emotional attachment and motivates consumers to want to wear items more and for longer, so to facilitate a long active life clothes benefit from being both functionally and materially durable, providing a satisfying experience through comfort, style, ease of care, graceful ageing of clothing items and other factors. Wearing items for longer is important, since the consumer groups lacked enthusiasm for wearing second-hand clothes. Improving perspectives of pre-worn clothes and the shopping experience could lead to prolonged clothing lifetimes through re-use. Higher quality garments could have a greater environmental impact in production and disposal if emotional durability and recycling systems are

not addressed. Brands could do more to make care labelling clearer and matched to consumers' relatively standardised laundry practices. Improved information on clothing care would be helpful. Clothing recycling is a further area where better information could change behaviour, especially knowledge of how to dispose of highly worn items not deemed fit for re-use.

5.3 Technical research

Key findings from the expert round tables and workshop are reported below. The combined feedback from the four discussions is summarised according to the prevailing themes explored throughout the research process:

- physical and emotional durability, encompassing issues of design and product features and performance;
- testing and trials;
- consumer behaviour encompassing aspects of purchase and care and communicating with consumers through labelling;
- strategies for promoting clothing longevity, including new product development, supply chain management, new business models and the skills and knowledge required to implement these.

5.3.1 Physical and emotional durability

The consumer behaviour panel agreed that there is an opportunity to promote longevity by focusing design towards addressing existing consumer use and behaviour, such as washing in light and dark batches. Functional design can encompass aspects of customisation and modularity; enable garments to be adjusted, disassembled or repaired; or could make items easier to care for or even indestructible, using fused hems and buttons. Testing of products in use, such as through extended wearer trials would help generate data to evaluate impact, while better data could be generated from design related returns and recurring faults to inform future fast-fashion and shorter NPD cycles and avoid repeating poor design choices.

However, designers face a number of technical challenges when designing for longevity:

- designing appropriately for both long and short lifecycles;
- designing for longer use, not just longer life products which otherwise may be stored rather than used;
- incorporating Life Cycle Analysis (LCA) data into the design process to match environmental considerations against aesthetics and functionality;
- balancing longevity against other sustainability impacts;
- establishing feedback loops, to enable user-experience to inform future design decisions and improve design for enhanced longevity were all challenges identified by experts.

An example addressed by the experts is pilling, a common problem which can be prevented if quality yarns are used, although this would impact upon cost. Some pilling may be associated with specific fashion trends, such as sublimation printing. Garments pill differently on people according to how they are worn and there are different types of pill depending on fibre and cause, so the provision of specific guidance or a guarantee is difficult.

To avoid pilling, it would be beneficial to address fibre manufacture, specification and testing. For yarn and fabric, the whole process (yarn length, twist, lubrication and finish, fabric weight and density, etc.) affects propensity to pill. More precise specification of fibres, yarns and fabric structure, informed by a databank of past industry experience is, therefore, desirable. However, lack of transparency across the supply chain is an inhibiting factor. Experts agreed this could be partially overcome if technicians were involved early in the NPD process and enabled to apply their skills and knowledge. New technology could be used to capture historical data and aid transparency.

Some experts and certain industry practitioners identified protective finishes that could be applied in production or during wash to prevent pilling, but more evidence is needed to know how well these work in different product contexts and understand their effect on garment design, feel, care, cost and the environment. Generally, technical experts consider that designing garments that do not pill in normal use and care is a solution with greater potential than trying to influence consumer behaviour to avoid pilling, and a best practice label or disclaimer could state when a garment has specifically been designed or made not to pill.

In spite of the compelling sustainability benefits, some of the industry participants were very sceptical about terms such as emotional durability, preferring to refer to aspects such as comfort and fit as drivers of attachment to specific items. Any evaluation and communication of emotional attachment within design departments and across functional teams was very limited. For consumers, aspects such as evaluating cost per wear for higher value items and celebrity endorsement (e.g. celebrities pictured in their oldest item) could be helpful incentives to actively use items for longer. However, some experts suggested that, in order to ensure that consumer and commercial interests are met, initiatives that promote longevity need to include aspects of 'newness' to alleviate consumer boredom with their clothes and generate new business or add-on sales and services for retailers and brands. Suggestions include incorporating features that change as the garment ages, adjustable fit, renewal services (repair, freshening, deep cleaning etc.) or providing consumer credit for high value items (as in other product areas).

5.3.2 Testing and wearer trials

Current tests are used to measure durability and raise awareness of any problems with performance in colourfastness, stability and shrinkage and indicate whether an item is fit for sale and short-term use, prior to going on sale in store. Many garments are discarded because of poor fit, or emotional durability, before physical failure. Items are therefore tested to an anticipated lifetime, rather than to destruction (to establish how long they may actually last). However, British Standards Institution (BSI) test methods do not specify a pass rate and the standard set may vary between retailers or brands, so a given product may be rejected by one team, while accepted by another. A standard of comparable tests and claims would be beneficial.

Furthermore, fabric and garment tests and wash tests are considered outdated by some industry experts, inadequate to reflect modern construction, care or laundry practices, and with limited application to bulk production. For example, the chemical formula used for wash tests was developed in the 1970s and is unlike modern detergents, and washing single items with weights barely represents todays' large load washing machines. However, tests are based on international standards and UK laundry care differs from that in other countries, with greater focus on warm washing and biological detergents, so efforts to standardise are complex.

There are a number of tests available to assess propensity to pill, a key cause of failure. Experts in testing and fabric technology felt that a review of the relative effectiveness of these test methods, in order to identify and adopt a consistent test method and pass standard would be beneficial, though it would be necessary to ensure these standards are adhered to in order to reduce problematic

pilling. However, pilling tests need to be updated with better guidance on implementation and equipment maintenance and less dependence on subjective visual evaluation, aided by technological developments that would enable objective measurement.

Some experts were in favour of wider use of wearer trials, especially to inform future style development where incremental changes are the norm. Trials that typically include 50 hours of wear and 5 washes within a two-week period occupy a small window of opportunity between retailers and brands receiving bulk orders at their distribution centres and goods being distributed to branches for sale. The trials provide feedback on performance, shrinkage, colour and appearance change, and general perceptions, but are generally considered rather unscientific. One expert explained that, in sports and outdoor wear, experienced users are engaged in trials but they report mainly on fit and comfort rather than durability. To be objective, wearer trials require skilled and experienced testers and a systematic process. This is most applicable for standardised items for which trials can be more rigorous. Fabric and garment tests which simulate wear and tear exist, but these are used in specific areas such as car seats and upholstery rather than in clothing, although they could potentially be adapted.

All key stakeholders need to be engaged in updating tests to better reflect current use, laundry care and technology. However, some experts advise that it takes time and resources to develop new test standards and for innovations to be adopted. Obstacles to developing and adopting new tests include an apparent lack of cooperation between functional roles and throughout the supply chain. The testing panel admitted to a lack of knowledge of any UK and international support organisations that could be instrumental in sharing knowledge and influencing the development of updated tests. Furthermore, the business case for updating test protocols is unclear and one expert reported that demand from retailers is in its infancy, so test houses are reluctant to embark on a lengthy process.

5.3.3 Understanding consumers

While previous studies (Birtwistle and Moore, 2007; Fisher *et al.*, 2008; Laitala and Klepp, 2011; WRAP, 2012) provide information about consumer behaviours, some industry participants admit that businesses could do more to improve their understanding of how their specific consumer segments use and care for their clothes. Furthermore, panel experts agree that, since the pace of change within the industry is slow, there needs to be greater urgency in the way that businesses respond to consumer behaviours as they are currently understood, and more importance placed on understanding how consumer behaviour and expectations may change in the future. This applies in the UK and globally as brands become increasingly international. The research shows that there are conflicting messages from brands and consumers of how consumers are perceived to and actually do care for their clothing. Meanwhile businesses lack knowledge about how their garments perform during the use phase when subjected to care regimes representative of actual consumer behaviour. Generic product designers are far more likely than fashion designers are to evaluate products during and after use, and panel experts suggest that the NPD process in clothing should be informed by the practice adopted in product design.

Another concern expressed by experts is how retailers and brands should communicate good practice in use, care and repair to the consumer. In particular, one behavioural expert raised the issue of how new services that prolong clothing lifetimes can stimulate enough excitement to replace the sense of 'self-renewal' that buying new clothes provides. Many individuals need self-renewal to maintain their identity and multiple feel-good influences, such as self-confidence and peer-to-peer compliments, could be lost if clothing lasts for longer - unless there is an alternative. Dry campaigns will not motivate consumers, so new technologies and social media should be used to spread reliable data and encourage behaviour change.

Overcoming consumer perceptions of appropriate care is a further challenge. One laundry expert explained that UK consumers are considered to wash more often than in other cultures (some of which also rely on cold wash systems, as in Spain). To change laundry behaviour, finishes can be applied to keep clothes fresh without laundering, and R&D is underway to develop better spot stain removal treatments that could reduce laundry and provide an up-selling opportunity for clothing retailers. The textile-finishing expert agreed that applying textile finishes could extend clothing lifetimes by reducing the frequency or agitation of washing. Other panel members suggested that perceptions of cleanliness also affect consumer acceptance of second-hand items, and therefore inhibit re-use. The current focus of detergent marketing is on stain removal and scent, perpetuating consumer attitudes, and the impact on the garments being laundered is often disregarded. Better data and customer education could help to change this.

Care labelling and guidance for consumers is considered by technicians to be a persistent problem. Panel experts agree that care communications need to be standardised across garment types and different components of the care process, such as washing machines, garment labels and detergents. Supermarkets that sell all of these items are well-placed to influence change. A better system to encourage consumers to utilise care information by providing clearer, consumer friendly, non-technical guidance, supported by readily available technology, such as 'mobile-friendly' online guidance backed up by RFID or QR codes, would help consumers to make informed decisions and could extend clothing lifetimes. For example, guidance to prevent pilling and colour loss, such as washing in bags and appropriate detergent and softener could help consumers keep garments in active use for longer. For young consumers such information also needs to be culturally relevant and 'cool'. However, it is not clear which care guidance consumers pay most attention to: garment labels, swing tags, online, etc.

5.3.4 Strategies

Technical experts admit that currently available longevity tests do not fit within the critical path employed by most retailers and brands and any updated test methods need to reflect this. The NPD process could benefit from more detailed technical specifications established earlier in the critical path process and based on data from preceding products or libraries of previous tried and tested specifications. This would require an adequate training programme, as designers and technicians need to be appropriately skilled.

The panel experts agree that pressure on margins is one of the main constraints. Retail prices of clothing have been static over many years, so retailers and brands increase profits by reducing costs, which in turn contributes to garment failure. Cases where inferior materials and processes are used, such as shorter fibre yarns more likely to pill or lower cost dyes which leach more readily, represent a commercial trade-off between product quality or durability and other garment/fabric characteristics (including price) as well as pressure on the critical path timeline. Tight margins also inhibit innovation and the adoption of new technology. Similarly, making garments that last longer is not a priority where this impacts upon garment aesthetics. A further constraint is the lack of traceability upstream in the supply chain, in which case fabrics and yarns bought through intermediaries or third parties may not be traceable, or lack accompanying detailed technical information.

For those items designed for durability, guarantees that clothing will last for a specific 'lifetime' (such as 100 or 200 days) are considered, by most consumer and testing panel experts, to be meaningless unless backed by systematic monitoring and some form of agreed industry protocol. The benefit to retailers is in reduced returns, although commercially this depends on consumers not increasingly returning faulty items that have failed to last for the specified time. There is some support from the consumer panel for a 'Traffic Light' system, but it would be very challenging to implement because of style turnover and defining criteria relating to longevity. At best, such a system could provide very basic information for core items, the testing of which would need to be compliant and transnational, perhaps part of a voluntary code backed by the Textile Institute, British Standards Institution or a European equivalent. A potential nationwide campaign to promote clothing longevity received more support from the consumer panel, but some experts suggested that this should be backed by a reputable campaigning and not-for-profit organisation like the Ethical Trading Initiative or Sustainable Apparel Coalition. Good Housekeeping/Which etc. could also provide consumer guidance, but for all such initiatives, clear performance indicators should be established first.

Some of the academic expert panel illustrated alternative business model propositions such as the 'slow fashion' approach where consumption is reduced by designing fashion collections that promote more considered purchasing behaviour and reduced consumption. Clothes swapping, 'swishing' (organised events for clothes swapping with friends and neighbours) and leasing models were also proposed. These were considered relevant mainly for high value purchases and niche brands, where there is evidence of leasing, such as formal dress, or where brand reputation is attached to durability. Marks and Spencer pioneered the concept of 'shwopping' (i.e. bringing back unwanted items into store and receiving a discount voucher) and such circular economy models are considered by the consumer panel to be more appropriate to the mainstream high street than to smaller niche brands because scale is important. However, evidence of their impact is lacking. Similarly, adding renewal or repair as a service within a retail business model might appeal in some circumstances (for example where haberdashery is sold), but success requires use of communications technology to encourage consumer engagement and upskilling of workers to provide craft services or guidance. Producer responsibility targets in some areas could initiate change in recycling and take back schemes, as has been seen in the US carpet industry.

New business models may benefit from partnerships (such as that between Marks and Spencer and Oxfam). Third sector involvement could kick start change and small scale initiatives could be scaled up through partnership. Retailers and brands could usefully identify both short- and long-term initiatives. It is anticipated that key messages to consumers could relate to sustainability and quality, while new technology could help to reduce batch sizes, minimising the impact of poor quality and obsolescence on a large scale.

There is a need for academics to collaborate with businesses to explore the business case for 'slow' or 'sustainable' fashion, and even slow fashion combined with fast but recyclable fashion, as well as new combinations of the product/service mix. This should be a priority in order to overcome the prevailing volume based business model, which allows clothing longevity failings to drive additional sales.

It is important to understand whether and to what extent small scale/niche changes have an impact on clothing sustainability and whether the business models employed can be cascaded or scaled up. For example, the panel experts identified alternative user models such as leasing, exchanging and shared ownership that are effective in specific contexts, such as communal living and high value items, but it is not clear whether they could influence practice on a larger scale. It would be beneficial to provide incentives to enable small-scale initiatives to become established or larger companies to make the infrastructural changes necessary to support business model innovation.

New models need to reflect the need for consumers to replace what they lose by replacing clothes less often. Schemes to professionally refresh clothing or to take-back and refashion with a new look provide an opportunity to support both revenue generation and customer needs.

Earlier some interview respondents had questioned whether designers have adequate knowledge to affect garment longevity, but experts assert that, in reality it is the whole NPD process and supply chain that need to be addressed, since it is generally accepted that product sustainability and longevity is heavily influenced by decisions made at the design stage. The capacity of design teams to make changes is often influenced by the size, structure and resources of their organisations. For example, in a small company the designer may represent the whole NPD process and have influence but lack financial resources, while in a large company the whole design team may lack strategic influence.

For all of the changes discussed by the panels, there is a consistent concern that better knowledge and skills are needed throughout the supply chain, within retail teams and among consumers in terms of practical skills and understanding why these are important. Aligned to knowledge and skills, there are associated needs for better education, for example of consumers regarding clothing care, maintenance and repair and, in higher and further education, to upskill technical and design teams in order to embed knowledge and understanding of product longevity aspects in the future workforce. Design education increasingly needs to encompass a combination of product and service design-thinking.

All of the expert panels agree that industry practitioners should be better empowered to use knowledge in their organisations, especially where this involves linking commercial and technical knowledge, and taking a cross functional approach to setting priorities and making decisions around them (i.e. sustainability led). At present, there is often no effective mechanism for capturing and recording tacit knowledge, and this is a concern in a mature industry as those with technical knowledge and experience age. Technology could be used to capture data and analyse what works in terms of product longevity and which products, materials and components fail. Such data could be used to enhance knowledge and inform innovations, for example into more durable and aesthetic materials. Senior decision makers need to better understand the technical, environmental and consumer issues in order to plan for the future, as the issue of garment longevity has the potential to grow in prominence as global clothing and materials consumption increases.

6 Pilot exercises

The rationale underlying each of the four pilots, the problem identified and the findings are described below.

6.1 Longevity testing to support Brand A's guarantee of clothing longevity.

6.1.1 Background and rationale

The pilot facilitated an exploration of longevity testing to support Brand A's potential '200-day guarantee' marketing campaign.

The UK childrenswear market is highly competitive and dominated by the supermarkets which remain the most popular places to buy baby and children's clothing. A recent survey carried out by Mintel (2014) found that both price and quality are important to parents when purchasing children's clothes leading UK retailers, in this specific product area, to focus their efforts on optimising clothing durability at low prices and promote the longevity of their products. For example, George at Asda offer a 100-day guarantee and Sainsbury's claim that their schoolwear is 'tested to destruction'. The Brand A pilot investigated possible longevity testing to support a planned marketing campaign offering a 200 day 'hand me down' guarantee, which suggests that once the wearer has outgrown

the garment it is expected to last well enough to be passed on to a younger sibling. This includes all childrenswear garments, in order for the retailer to differentiate their clothing offer within a competitive market. Whilst the testing and quality procedures carried out on Brand A's products are to the usual industry standards (i.e. they assess initial fitness for purpose), it was evident that there is currently no test that will support a 200-day guarantee. The following objectives were identified:

- to establish a longevity testing regime that could provide the basis for a 200-day guarantee with particular focus on the potential for colour fading;
- to compare and benchmark the performance of selected Brand A garments with like-for-like competitor products using the same longevity testing regime;
- to assess whether the competitor products met their own promotional claims (where relevant) during longevity testing;
- to assess the effect of using retail 'own brand' detergents in longevity testing; this could afford the opportunity for a combined marketing strategy that promotes both the durability of the garment and the effectiveness of the detergent.

6.1.2 Methodology

Two of the three competitor brands were chosen on the basis of their childrenswear product offer, price and market position being judged to be similar to that of Brand A. The third competitor was chosen as a market leader in childrenswear with a reputation for quality and durability, but whose products were on average three to four times more expensive than the other brands. A total of 16 garments, in two styles of knitted product (8 sweatshirts and 8 T-shirts), were selected from each brand for comparison: a dark coloured school sweatshirt (6 navy and 2 red) and similar coloured t-shirts, each with a motif print. Previous research (Cooper *et al.*, 2014) had shown that knitted products are generally more susceptible to shrinkage and pilling than woven items and that colour loss is more obvious in dark shades. Furthermore, durability of prints is often an issue and is routinely tested for during the NPD phase.

The testing regime, described below, was based on the WRAP Clothing Longevity Protocol (CLP) (Cooper *et al.*, 2014) guidelines.

All garments (Brand A's and the competitor garments) were tested in an accredited textile testing laboratory using standard tests to identify a base level of performance, as recommended by the testing laboratory since each retailer's own tests are confidential. The tests included a 'Resistance to Pilling' test using the modified Martindale method; 'Dimensional Stability to Washing'; 'Colour Fastness to Washing'; 'Colour Fastness to Light'; and 'Colour Fastness to Rubbing'.

All garments underwent longevity testing of repeated wash and dry cycles in an accredited textile testing laboratory. Each style underwent 40 cycles to represent approximately 200 days or 28.5 weeks of wear and washing. (In order to arrive at this figure, it was estimated that the clothing would be washed on average between 1 and 1.5 times per week in that 200-day period, equating to between 28 and 42 washes). The garments were washed according to the garments' care label instructions using commercial detergents in order to replicate customer practice as far as possible. Ariel Colour was used in test 1, Persil non-bio in Test 2, and the supermarkets' own brands in tests 3 and 4 (other than competitor 2, for which a popular retail own-brand product was chosen, as they did not have their own detergent range).

Tests 1 and 2 compared selected Brand A garments with like-for-like competitor products using the same longevity testing regime. A set of 8 garments (4 sweatshirts in test 1 and 4 T-shirts in test 2;

one pair from each brand) were washed, tumble dried and assessed at intervals of 1, 10, 20, 30 and 40 washes to evaluate pilling, colour loss and the physical durability of other relevant features such as stitching, trims and print. The comparative findings were then evaluated in terms of their performance against each criteria.

In tests 3 and 4, a further set of 8 garments (4 sweatshirts in test 3 and 4 T-shirts in test 4; one pair from each brand) were tested using the repeated wash and dry cycle longevity testing regime as described in above to evaluate any effect of using the brands' own label detergents on garment longevity. Where possible, the garments were washed using each brands' own label detergent. The tests were intended to show any differences because a detergent supplier suggested that the effects on garment lifetime of using different detergents could vary from brand to brand. Forty wash and dry cycles were carried out and evaluated at intervals as in tests 1 and 2.

A final evaluation and comparison was made of garment performance against each brand's promotional claims for durability. Following the routine standard and additional longevity testing exercises, all the garments were assessed against the claims for product durability promoted on each brands' website.

6.1.3 Research findings

The longevity testing regime described above was judged by technical experts within the project team to be sufficient to represent the washing that the garments might be expected to undergo within a 200-day period. When comparing selected Brand A garments with like-for-like competitor products using the same branded detergents, the findings revealed that:

- All garments tested for colour fastness and print durability initially met or exceeded the required pass grade 4 for colourfastness as advised by the CLP. However, after being washed 40 times, the three navy sweatshirts had dropped to a grade 3-4 and the red sweatshirt to a grade 3. Of the t-shirts, three dropped to a grade 3-4. Two of the print motifs (a flock print and a glitter print) showed more severe deterioration, with the glitter print only achieving a grade 2-3 by the end of the 40 washes. The flock print showed severe loss of pile attributed to being tumbled dried in the test. Since the garment care label advises against this, the test shows that incorrect laundering practice on the part of the customer can exacerbate deterioration. Overall, the level of colour loss was judged to be acceptable in this extended test as the change was not severe and happened gradually and is, therefore, unlikely to be noticed by the customer.
- Three of the eight garments did not meet the initial pass grade of 4 for pilling. All garments showed increased pilling from the repeated washing process, with all sweatshirts and one t-shirt dropping to grade 3-4 and one t-shirt dropping to grade 3. Again, the deterioration was not severe and occurred gradually, although in practice this could be exacerbated by abrasion during wear.
- Although dimensional stability was not a key focus of this pilot, obvious shrinkage was evident by the end of the repeated wash cycles as shown in Figure 6.1. As this was not formerly measured, it is not clear whether the shrinkage was within commercial tolerances.
- All eight garments undergoing this longevity test presented a similar appearance and physical change at the end of the 40 cycles, with Brand A's garments achieving a comparable performance to the competitor brands.

Figure 6.1 Schoolwear analysis following wash trial



Image: NTU research team

Assessment of a further set of the same garments using the brands' own label detergents (where available, for 3 out of the 4 brands) showed that the results were similar to the tests using the same detergent for all garments. There were no significant differences.

The overall evaluation and comparison of garment performance to promotional claims for durability demonstrated that the garments all performed to a similar level of durability irrespective of price and their respective durability guarantees (100 days, 100 washes, 200 days, looks new for longer). This suggests that in terms of 'cost per wear' the less expensive products performed better than the higher priced garments. Although colour fastness at the end of the wash cycles no longer met the pass grade, it was felt that colour loss was not necessarily severe enough to be of concern to the customer in relation to the durability claims. The repeated wash cycles show that pilling can be caused by washing but, in terms of providing evidence for durability claims, should be evaluated in conjunction with wearer trials (as advised by the CLP).

6.1.4 Analysis and Implications:

Overall, the performance of Brand A's garments was comparable with the competitor brands in terms of the initial appearance and quality of the fabric and manufacture. Although colour loss was evident within all garments by the 40th wash, after which none of them passed the testing standard of grade 4, this was judged to be commercially acceptable on the basis that the change happened gradually and was not severe. However, the results for pilling performance were inconclusive in terms of meeting the 200-day guarantee on the basis of the extended wash tests as this would also need to be evaluated in wearer trials. In any case, three of the garments, including one from Brand A, failed to meet the required pass grade for pilling at the initial base test stage prior to the wash cycles. These garments may have passed the retailer's own commercially protected pilling tests, but since companies use slightly different test methods this points to the desirability of greater consistency across the industry.

The extended wash tests were carried out using the same washing method with the intention of simulating customer practice and making a direct comparison between garments. Care labels showed that the garments were all of similar fibre composition and could all be classed as dark in colour, but were all labelled with slightly different care instructions. There were no significant differences in garment performance during the tests, on which basis the care labels could have all been the same for consumer ease. This reinforces the need for a more consistent approach to care labelling across the industry. Standardising washing instructions in relation to fibre/fabric types would be useful for customers.

The pilot was initially conceived to explore the opportunities and risks of claiming that clothing could be used for 200 days or more. The company did not have access to a formal testing protocol to represent extended use, while the absence of an independent review of competitors' products combined with feedback from the earlier consumer focus groups demonstrated that consumers were confused and seeking reassurance about the value of such guarantees. Furthermore, discussions with industry practitioners during the project and at the SCAP (Sustainable Clothing Action Plan) Design for Life Working Group, have reinforced the need to develop a more consistent approach to product guarantees.

The findings were, therefore, of value to the retailer, providing reassurance for marketing and product development, while highlighting some areas for improvement. Overall, the pilling results were as anticipated by Brand A but, following the pilot, the technical team are specifically investigating the dye process to ensure that colour retention is improved.

A significant limitation was uncovered during the pilot as the testing took 6-8 weeks to complete, which would challenge the NPD critical path of classic or non-fashion items particularly if a large number of products were to be tested. Carrying out extended wearer trials or simulation on the selected garments would be useful to fully assess the garment lifetime under normal wear and tear conditions, in addition to the wash tests (as advised in the CLP).

6.2 Supporting Brand B to explore customer views on clothing longevity

6.2.1 Background and rationale

The pilot facilitated an investigation into the views of Brand B's customers on the durability/longevity of clothing in order to establish opportunities to influence behaviour change and inform potential business initiatives that can lead to longer clothing lifetimes.

The research interviews revealed a lack of knowledge and understanding of consumer perspectives on purchase, care, repair and disposal of garments at brand level. This pilot sought to identify consumers' views of the brands' products in terms of durability and garment lifetimes in order to establish key topics to be addressed, which could lead to behaviour change in customers and initiatives by Brand B, resulting in prolonging the life of clothing.

6.2.2 Methodology

A series of polls and discussions with Brand B's customers via an in-house consumer research panel of 1,500 customers were conducted. This included:

• an online discussion with 92 participants;

- an online poll of simple questions in which 197-212 self-selecting respondents took part. The polls were launched to find out more about how Brand B consumers wash their clothes and how this impacts upon how long they last;
- a 'live chat' with 3-4 customers from each of the three most sustainably engaged consumer categories 'Positive Greens', 'Concerned Consumers' and 'Waste Watchers' (based on Defra's consumer categories, 2008) in Brand B's core target group (aged 35-55);
- a pinboard-task in which 79 consumers uploaded images and stories.

The questions were devised by a market research consultancy employed by Brand B in conjunction with the NTU project team, and informed by previous published research, which would otherwise not have been accessed by the Brand and its PR agent.

6.2.3 Research findings

Clothes from Brand B were generally expected by the respondents to be of good quality and made to last. Customers expected to see a positive correlation between the price of an item and its lifespan. Many of them were prepared to pay more for an item perceived to be of good quality (except for basic items and holiday clothing), with 80% stating that they took into consideration whether a retailer 'makes quality clothes that last longer' when buying garments. Indeed, the responses revealed an expectation that the brand's clothes are of good quality and will last. Many respondents recognised that fabric affected the longevity of a garment. Longevity was associated with quality and maximising the use of a garment, rather than environmental sustainability.

Brand B customers did not actively aim to prolong the life of clothing when washing, in fact they admit to doing little to prolong the life of their clothes. That said, 94% of respondents separated whites from dark colours when laundering, 74% use softener and 55% use spot cleaner, though less than 33% separated clothes into hot/cold or short/long wash and less than half use low temperature wash claiming that it does not clean. Respondents otherwise generally expected clothes to last for a reasonable amount of time without needing much effort to care for them.

Respondents tended to do at least three washes per week, perceiving that clothing was dirty after being worn once or twice. Jeans were usually washed after more than one wear, but tops tended to be washed each time they were worn. Understanding of care labels was limited, with only 50% of the poll saying that they followed care instructions. Only the more well-known care symbols were familiar to the respondents, with less knowledge of iron/tumble dry temperatures and the 'do not bleach' symbol. Similarly, knowledge of any variation in wash detergent performance is limited, with most respondents choosing the best value laundry products or choosing their preferred scent. Encouragingly, use of tumble dryers falls considerably from 55% to 12% in summer - largely for cost reasons as well as freshness.

In general, the higher the price, the longer customers expected garments to last, e.g. winter coats and boots being expected to have a lifespan of several years, in contrast to T-shirts and evening dresses. Generally consumers cleared out clothes once per year, primarily to make space, sending undamaged items that they no longer wanted to friends, family or charity outlets or selling them. Brand B customers were unlikely to have the skills or willingness to repair damaged clothing. Motivations for the method of disposal were more socially orientated, rather than being influenced by environmental concerns. In a poll of 362 respondents, the primary reason for disposal was that clothes were worn or shabby (67%), and no longer fitting being another key reason (60%). Of the respondents, 45% disposed of clothing because they were bored of it and 44% because they considered it to be out of fashion. Clothing that was damaged or well-worn was generally discarded with household waste because customers were embarrassed or unwilling to donate it to charity. However, a similar number of respondents said that they recycled clothing.

6.2.4 Analysis and implications

The expectation from the sample was that clothing that lasts longer will cost more and be of good quality. Larger items such as coats are automatically expected to be long-lasting but smaller items like T-shirts could also offer longer-lasting versions, particularly as their styling is often classic and they could still be affordable if engineered for longer life. This offers an opportunity to promote garments that have longer-lasting properties in terms of fabric or construction. These properties should not be overstated, but customers could find this information useful and it could therefore affect their purchase behaviour. Clothing longevity could be estimated and a guarantee could be offered (e.g. similar to guarantees for kitchen utensils).

The findings confirm that consumers are washing clothing more than required suggesting that clothing needs to be made of durable materials and manufactured effectively to endure or reduce washing, while consumers require more information about appropriate washing frequency for clothes. Another important finding is that consumers are confused about wash care, perceiving that retailers offer inconsistent guidance in this respect. Detergent companies could collaborate with retailers, with the aim of developing a consistent set of standards and to test the effects of detergents.

Customers discarded clothing when it looked worn (for example if the colour had faded or there was significant pilling or abrasion) or no longer fitted. Clothing could therefore be designed to offer some flexibility in terms of fit to help prolong its life. Although clothing disposal clearly takes place after ownership of garments has passed from retailers to customers, retailers could retain some of the responsibility for clothing that they have developed, throughout its lifetime. Customers have limited awareness or willingness to repair and dispose of clothing in ways that prolong its life and retailers could offer guidance and facilities for this. For example, consumers have set up Facebook pages dedicated to selling second-hand garments from specific brands. Retailers could take ownership of this system by offering customers to sell their products back to them after use and creating an online forum for re-selling the products via a link from the company website.

The pilot was initiated following discussions that provoked the personal interest of the marketing and sustainability managers, and led to surprising findings arising from informal, internal discussions within various functional teams, demonstrating the importance of personal champions. The commercial drivers included the opportunity to reinvigorate the consumer panel, see which of the behavioural change segments (Defra, 2008) Brand B's consumers aligned to, and evaluate how Brand B was perceived by consumers compared to competitors in terms of sustainability. The pilot tested a number of processes in consumer research, some of which were subsequently used elsewhere and contributed to the project toolkit. Findings broadly confirmed Brand B's preconceived impression of consumer behaviours, though some behaviours were surprising to managers, and should be addressed, such as providing clearer care instructions and better information to consumers. Findings also influenced subsequent wash trials, but were considered unlikely to influence the NPD process in the short term because of prevailing commercial pressures and the relatively positive response of consumers in terms of the perceived longevity of Brand B's products – even though a direct competitor was deemed to do more for sustainability per se. The findings also strongly reinforced the message that consumers are looking for companies to make it easy for them to do their bit and avoid buying items that appear hard to care for, pushing the onus for clothing longevity firmly back in the hands of companies like Brand B.

6.3 Developing a regime for testing colour durability based on Brand B's consumer laundering behaviour

6.3.1 Background and rationale

In this instance Brand B were supported to develop and trial a testing regime to evaluate colour durability using a range of domestic detergents and softeners, representing consumer practice in laundering and building on Pilot 2.

A survey of discarded clothing from recent research (Cooper *et al.*, 2014) found that colour fading and loss of colour are recurrent reasons why clothes are discarded, and whilst it is important to recognise that the dyeing process used in manufacturing may be one of the causes, the consumer laundry process can also have an effect. Brand B's customer survey (discussed in section 5.2) provided information about how the Brand's customers care for their clothes and how this relates to their views and expectations of garment lifetimes.

Routine testing undertaken by brands uses specified industrial detergents in a standard wash cycle to evaluate a garment's fitness for purpose in terms of physical performance and colour fastness. It may not adequately represent the consumer's use of commercial detergents and softeners, of which there is a wide range developed for specific applications. These include those formulated to preserve dark colours, others to brighten light and white colours, biological and non-biological detergents, some with stain removers and most of these varieties appearing with and without integral fabric softener. Consumers are normally advised to separate laundry by colour in order to obtain the best results in the washing process (for instance the chemicals contained in detergents formulated for brightening white fabrics may cause fading in medium to dark coloured garments). Softeners are widely used to enhance the feel of the garment and give a sense of freshness through the fragrance. The earlier trial found that 75% of consumers add fabric softeners to their wash loads and only 50% read the care label, suggesting that they are potentially not washing clothes as advised by the retailer. While a high proportion of Brand B's consumers separate washing by colour, the focus groups show that families and those living alone do not always do so due to cost or time constraints, or unduly small loads. Furthermore, there is slight variation in washing and care instructions across different brands, which has the potential to cause confusion to the customer.

The pilot aimed to replicate customer laundry habits more accurately than existing tests, in terms of the range of detergents and softeners used, and to evaluate the effects on colour fastness across a variety of garments – some, especially black trousers, identified as vulnerable to failure. Results could provide the basis for potential improvements to laundry instructions to help to reduce premature garment failure and provide recommendations for consumer engagement in washing and care of clothing, as well as improvements to the specification of garments at the design stage.

6.3.2 Methodology

Six different adult styles were selected in dark shades: two men's black casual trousers of different design but the same fibre composition (98% cotton 2% Elastane); two men's navy printed casual shirts of the same fibre composition (100% woven cotton) and two ladies' red, casual t –shirts of different styles but the same fibre composition (100% knitted cotton).

A repeated wash cycle test was devised where the garments were washed 20 times using a variety of detergents with and without a fabric conditioner in order to evaluate the effect of the laundry process on colour fastness.

The testing was carried out in Brand B's in-house testing laboratory using domestic washing machines. The trial compared the use of eight different commercial detergents and one fabric softener through evaluation of the product performance and test results. The detergents included a range of formulations including biological, non-biological, colour care, and a combined detergent and fabric softener. A 5A (standard agitation/duration/spin at 40°C) wash cycle was used for each garment with a cool tumble dry after each wash. Colour assessment and grading took place after the 1st, 5th, 10th, 15th and 20th wash cycles, with swatches retained for direct comparison.

6.3.3 Research findings

All six garments achieved a grade 4/5 for the initial colour fastness test which is higher than the grade 4 pass specified by the CLP. Nearly all of the garments evidenced some colour loss by the end of the 20th wash cycle, with the red garments showing the least colour loss overall.

The repeated wash test cycle was effective in showing the progression of colour loss within the garments; for instance, one of the black garments only lost a significant amount of colour after the 15th wash. The most significant colour loss after the 20th wash was seen on the two black styles across all the detergents used; for instance, one of the black garments was assessed at a grade 1 for colour fastness after 20 washes in one of the biological detergents. The key conclusion was that there was no consistent pattern in terms of detergent performance: different detergents performed better or worse on different styles/colours. Furthermore, there was significant evidence across all styles that using fabric conditioner in addition to detergent did not have a detrimental effect on colour fastness; in fact using fabric conditioner, particularly on the two styles of men's black trousers, reduced the level of colour loss in comparison to using detergent on its own.

6.3.4 Analysis and implications

The test results showed that commercial detergents vary in their effect on colour fastness of clothing during the washing process across different styles, colours and fabrics; no clear conclusions could be made about the comparative performance of the different brands. However, using fabric conditioner in addition to detergent reduced colour loss in many cases. Further research could be undertaken in this area to evaluate the use of fabric softener across a wider range of fibres and fabric types. The tests demonstrate that there is an opportunity to develop a laboratory colour fastness test method that represents consumer practice more accurately, since the current industrial test uses no fabric conditioner whereas 75% of the respondents to Brand B's survey do add softener to their wash.



Figure 6.2 Swatches following repeated wash tests

Image: NTU research team

Even after 20 washes, some of the garments had maintained a pass grade 4 for colour fastness confirming the industry perception that some colours perform better than others. It was felt that some of the garments that experienced colour loss after 20 washes to around grade 3 could be commercially acceptable to both brands and consumers even though the pass grade of 4 was no longer achieved, especially as the colour loss happened very gradually. There is an opportunity to develop a standardised durability test within the industry that includes assessment of colour fastness over the life of the garment with a clear pass grade set after a pre-determined number of washes.

The black garments in particular performed inconsistently with one failing to meet expectations, as illustrated in Figure 6.2). It is recommended that NPD teams and the testing industry risk assess colours and investigate tests that can evaluate and predict dye recipe performance to support the specification of more effective dye fastness recipes to use in the manufacturing process. This is particularly important for core/classic styles, such as black trousers, where longevity and durability are key.

The test confirmed the need to issue clearer and revised laundry instructions to consumers, though wider scale testing is required to establish the most accurate guidance. The process also confirmed the desirability of testing fibre, fabric and garments over a prolonged lifetime in order to accurately predict their performance in wear. The test highlighted the potential failure of some product lines when exposed to 20 wash cycles. However, for Brand B there were cost and time implications – the

pilot cost in the region of £19,000 and occupied the testing facility for several weeks. In addition, the repeated wash and dry process contributed to one of the technicians being treated for dermatitis. This suggests the need to develop a commercially viable and safe approach to such testing in controlled laboratory conditions.

6.4 Investigating the cause of pilling in Brand C's cashmere knitwear

6.4.1 Rationale and objectives

This pilot enabled an investigation into the causes of a quality problem in manufacturing which resulted in severe pilling in Brand C's luxury cashmere knitwear.

Brand C is a small specialised upper market knitwear brand selling in the UK and China direct to consumers via their website and through independent retailers and high end department stores. The company owns a fibre processing plant and knitting factory in China, while the yarn dyeing and spinning is outsourced to an external supplier.

There were a higher number of customer complaints and returns for pilling than is usual for the Autumn /Winter 2014-15 season and Brand C wished to investigate where this was occurring in the production process. In the short term they made alterations to the wet finishing process (scour, mill and soften) by using better detergents that create a buffer within the scouring bath to prevent the garments from rubbing against each other, along with a durable softener to reduce pilling propensity. However, it was suspected that there was a problem occurring with the yarn quality and their objective was to investigate the testing carried out at various stages of the fibre and yarn manufacturing processes in order to pinpoint any issues in manufacturing transparency and control.

6.4.2 Methodology

Samples of fibre were taken at various stages in the fibre processing and yarn production process as shown in Figure 6.3 and tested for average fibre length, length distribution and average fibre diameter, to identify whether damage was occurring at a particular stage in the process. The fibre tested was as follows:

- 1. Raw white fibre tested at pre-dyeing stage (post sorting, scouring and de-hairing).
- 2. Dyed fibre in two shades (pink and black) tested after dyeing and before carding.
- 3. Dyed yarn in two shades (pink and black) tested after carding and spinning.

Fibre is normally tested at the raw white stage (a) but not normally after dyeing (b and c). These tests would show whether there is anything happening in the dyeing, carding and spinning processes to degrade the fibre.

6.4.3 Research findings

The test results show that there is no significant impact on fibre diameter in the dyeing/carding/spinning process, and no significant damage to fibre length after the dyeing stage, but before carding, for either colour. However, the percentage of fibres under 20mm in length increased substantially after dyeing during the carding and/or yarn spinning stages, showing that damage has occurred. The increase in short fibre length significantly increases the propensity of the finished garment to pill or shed fibre during wear.

Figure 6.3 Yarn and Fibre ready for testing



Image: NTU research team

6.4.4 Analysis and implications

In order to pinpoint more accurately where the damage is occurring, Brand C will visit the spinner to test the fibre in sliver form after carding. Control of processes in dyeing and spinning will be reviewed: possible causes of the damage include over-drying of the fibre after dyeing, causing brittleness, and insufficient lubrication of the fibres before carding. For future production the company will request additional testing for fibre length after carding/spinning once the exact cause of the damage is known to ensure this is minimised.

Traceability is a potential issue as spinners mostly buy natural fibres through merchants rather than direct from the producer. As Brand C supply their own fibre there is some confidence in the quality of the raw material, however they may not be able to consistently monitor the dyeing and spinning processes in yarn production. In future they will spot check and test the fibre quality on received yarn which will be a new quality procedure for them.

In terms of addressing these potential issues, a traceability tool could be developed that includes a set of questions for technologists to ask suppliers when mapping the manufacturing and sourcing process of products to identify where testing/quality assurance occurs. A new testing protocol that evaluates the impact of dyeing and carding on fibre quality could be introduced; it is usual for the raw white fibre to be tested for quality and included on specifications, but not after dyeing, carding or spinning. Yarn specifications could be revised to include this, and would be useful, particularly for garments that are made from 100% animal hair, for which propensity to pill is common.

The pilot, to some extent, confirmed the suspicion that a problem is being created at some point in the processing of the fibre and helped to narrow down the precise cause of the problem, making subsequent exploration more viable. The results highlight vulnerability of the process within a global supply chain, even though this is vertically integrated and well controlled. The technical director of Brand C also consults for other UK brands on cashmere quality and production. While the pilot provides some evidence to support improvements, experience highlights the difficulty facing brands trying to enforce good practice and process control in the garment and spinning factories when price is such an influential issue. Processes that improve quality generally take longer or cost more, which impacts upon price. Brand C's Director has found that some factories have collaborated to improve the product aesthetics or performance in the short-term, only to revert to their former procedures to save money. Evidence from the pilot has helped to reinforce knowledge and strengthen the

recommendations passed on to other brands and suppliers and may lead to more widespread improvements.

6.5 Summary of findings

The findings from the above multi-faceted research process are drawn together and summarised in section 6, under a series of pervasive key headings, ranging from aspects of the product itself and how it is designed, tested and cared for; understanding of consumer needs and behaviours and aspects of the product development and supply chain processes, together with how responsibility is shared. Potential innovations and limitations are also identified.

6.6 Implications for design strategy and policy

Table 6.1 below illustrates how the key findings lead to recommendations to improve and develop industry practices, as well as key policy indications. The slow pace of adoption within the sector, conflicting priorities and the complex nature of multi-agency solutions suggest that policy is essential to drive change, while also maintaining the prominence of issues concerned with product longevity and its potential to impact positively on sustainability.

Table 6.1 Summary of key findings and recommendations for industry and policy

1. Physical and Emotional Durability

Key findings	Industry recommendations/solutions	Policy implications
Product	I	I
Too many retailers have devalued and reduced the quality of products over time. Longevity is often regarded as a care issue. Product failure through pilling, shrinkage and colour loss is of most concern to consumers and designers, especially in knitwear and jersey tops. Pilling particularly leads to premature disposal as pilled items are less likely to be handed down or donated.	Design for longevity depends upon durability and quality but should also be seen in terms of style, fit and emotional durability to support active use for longer. Producing garments that last longer (e.g. do not pill or shrink), requires a higher level of technical skill and knowledge in the specification and selection of upstream materials and processes.	The policy landscape for sustainable products, specifically clothing, needs to promote the broader longevity agenda and encourage business initiatives to support this.
Design influences quality, care and re-use or recycling potential of items of clothing, but the priority for designers is designing for cost and aesthetics. The original specification has a major impact on the products' propensity to fail but products are often re-engineered to meet cost thresholds, rather than to enhance product durability. Some products are accepted for sale having failed quality or durability tests in order to maintain ranges and replenish stock of fashion lines.	Design for longevity should account for a range of product/garment and brand options regarding lifetime expectations, re-use and recycling. This could include ease of re-cycling for fast fashion or longer active use for higher value and core products. However, this approach requires an infrastructure through which to provide information throughout the end-to-end supply chain and for collecting used fashion items for resale or recycling. Companies may utilise WRAP's online guidance on design for longevity of clothing to help design with longevity in mind, set and maintain specifications.	End-to-end initiatives in the form of demonstrator projects ('proof of concept' including research, evaluation and an element of financial modelling) would be a good way to appraise the combined sustainability, commercial and infrastructural implications of more sustainable clothing. However, these need to be extensive and of an adequate timescale to research and adopt innovation, implement change, measure and predict impact.
Dye methods can be a major cause of colour loss through laundering which leads to premature failure and poor longevity.	Ensure dye methods are consistent across the industry and methods are tested to ensure colour loss is minimal.	Further research is needed to identify dye methods that can minimise colour loss.

Some product areas are moving towards adopting technical finishes and processes to support longevity. Examples include 'Lycra Xtra-Life' and M&S 'Stay New' which are being extended across product ranges and core products.	The potential of similar finishes and processes to extend clothing lifetime should be evaluated by all companies and product developers.	Further objective research is required to understand the implications of similar finishes on product lifecycle, aesthetics, wear, cost and the environment (e.g. through LCA). Technical research could help to develop such finishes and applications to be more acceptable to consumers.
While durability affects the consumer's desire to retain and use clothing for longer, there are a wider set of influences that support emotional engagement and influence use/reuse/recycling/disposal behaviours. These are seen as increasingly important to ensure that clothing has a longer active life.	Companies need to understand emotional durability and its relevance to their specific consumer segments. The design process should encompass user-centred design principles to evaluate how garments perform in use and how this encourages consumers to use them for longer. The impact of fit on emotional durability suggests a need to periodically evaluate basic blocks to ensure garment fit is aligned with customer requirements, and encompass features that can be adjusted for size variation.	Further research is needed into emotional durability. Much of the existing research is from Scandinavia and this needs to be tested and extended into other cultures and markets. Further research into how evaluation of size and fit can be embedded into the critical path and how this relates to emotional durability.
Re-use and Re-cycling		
Textile waste recycling schemes are inconsistent geographically and across collection streams. Consumers are resistant to purchasing pre-used items due to concerns about hygiene, cost compared to new items and lack of attractiveness of second hand outlets.	Clearer disposal instructions should be provided on garment labels, while clothing banks and collection schemes for well-worn items should be made more widely available and visible – currently many schemes request "quality clothing and paired shoes". Retailers should take more responsibility for the return of their own products into the recycling system.	Local Authorities should be encouraged to provide more widespread textile waste collection. Campaigns should make clearer the options for recycling well-worn clothing alongside the collection of garments for re-sale.

2. Durability Testing and Trials

Key findings	Industry recommendations/solutions	Policy implications
Testing and Trials	,	
An emerging trend among certain brands is to specify product durability expectations or guarantees, and such claims require more systematic testing and comparable measures. Examples are found in products such as leisurewear, underwear and schoolwear.	Product durability guarantees could trigger greater demand for testing to back-up such claims. A testing protocol, like that already developed for WRAP, should be adopted more widely, enhanced and professionally verified. External/independent bodies could be involved in comparisons and measuring longevity in terms such as cost per wear and benefit to the customer.	Initiatives that bring together third sector organisations, business press and independent evaluators could enhance the effectiveness and profile of schemes to extend and guarantee clothing durability.
Standard tests for durability/longevity are not routinely carried out, but the pilots suggest that extended tests carry substantial resource implications. In practice, the testing and design processes are challenged by commercial pressures. Extended tests could therefore face resistance.	Tests help to inform successful sourcing of materials/dyestuffs/processes and establish future specifications. The findings of extended tests would help to provide information for consumers on how to care for vulnerable items and for retailers to make some specific items more durable. Opportunities for simulated testing that could shorten the testing process should be explored.	Research support for extended durability tests and a comprehensive set of standards is needed, since the age, range and process of available tests represents a market failure.
There is a need to update and modernise clothing and fibre/fabric tests but the process for developing and standardising new testing procedures is lengthy and will be subject to commercial decisions regarding demand. At the time of writing demand is in its infancy. Tests for longevity need to be capable of testing to destruction, in typical wear and care conditions.	The testing infrastructure needs to be updated if tests for longevity are to become more widespread, and there is a need to explore the business case for developing new tests and standardising expectations across the sector. Tests that can simulate wear to avoid lengthy and unscientific wearer trials need to be developed and new technology should be adopted	Research to understand the business case for clothing longevity needs to encompass the testing industry too. Public policy is needed to ensure that the testing of clothing, as with other products, is representative of actual use and that results are clear and objective. Research to develop new and improved tests for durability is needed at transnational level to reflect the international

Tests and design need to reflect in-use behaviours and better synthesise wear and care.	to evaluate the results objectively. The testing landscape needs to develop and accredit tests that reflect the reality of consumer use; reflect wash repetitions and practices; synthesise wear and tear as accurately and scientifically as possible.	nature of the testing industry; the globalisation of the supply chain and apparent cultural and regional differences in consumer behaviours with regard to garment care and use.
Extending typical wash and wear trials is possible, but highlights some shortcomings in terms of both process and measurable outcomes. The resource implications are also considerable.	To test garments over time requires a benchmark for acceptable degradation of dye, pilling, print, shape etc. (for example an expected performance standard after 5/10/20 washes).	
	There is a need for an accelerated and safely defined test protocol for longevity tests of garments as well as yarn and fibre. Economies in the process are needed as repetitive washing is expensive and time consuming.	

3. Consumers and Care

Key findings	Industry recommendations/solutions	Policy implications
Consumers		
Focus groups confirm that there is a willingness of consumers to change, at least in some consumer segments.	Better knowledge would help to identify those consumer segments most likely to respond to specific business approaches to longevity – such as promoting investment pieces, repair or recycling.	Accessible research to maintain knowledge of consumers' sustainability behaviours should be regular/ongoing for clothing and other product areas to encourage brands/retailers to respond more quickly and to forecast future needs/opportunities.
Consumers are blamed for poor garment care while companies place considerable emphasis on changing their behaviour without full understanding of the actions and motivations of their specific target groups.	Knowledge would enable retailers to distinguish between consumer behaviour that they can influence and that to which they themselves need to respond, for example by improving garment care guidance or providing	Retailers and brands should be encouraged to clarify and simplify labelling information, particularly for multiple and international markets. Legislation should take into account clarity when reviewing

Brands need better understanding of their consumers, specifically around sustainability issues. Large retailers do not routinely undertake market research specifically about clothing longevity. To do so effectively would require a co-ordinated approach between marketing and product departments, as well as external service providers.	adjustable fit to accommodate weight gain/loss and comfort. Sustainability 'Champions' are a valuable means of implementing change within a business - the personal experiences of influential individuals, combined with cross-functional activities, can influence the decision to explore consumer behaviour.	the information required on product labels.
Care and Labelling		
Consumers report that the way they care for their clothes is not consistent with garment labelling. Most wash for convenience or economy. Confusing, and sometimes conflicting, messages mean that consumers often do what they feel (or have been taught) is best, rather than acting from an informed perspective. Routine product testing is not consistent with everyday wear and care of clothing, commercially available wash detergent or wash-machine programmes. Garments are designed for aesthetics rather than their ability to withstand 'standard' care conditions (e.g. a dark or white 40° wash)	Design for longevity should include practical care guidelines. Clarification of care needs to be simplified and standardised so that wash 'batches' (e.g. dark and light) and realistic instructions can be easily identified. Consumers need better advice in terms of care and laundry, such as differences between detergent products and when/why to use different programmes. Care instructions should reflect real world conditions and could be standardised across garments and retailers.	Standardisation of care instructions requires external influence to ensure objectivity where part of a voluntary scheme. Improved infrastructure is needed to support additional information for consumers that is both consumer friendly and appropriate/accessible for all target consumer groups.

4. Business Strategies for Longevity

Key findings	Industry recommendations/solutions	Policy implications
New Product Development		
A systems thinking approach is utilised in design for sustainability in other product sectors, exemplified by a few niche clothing cases, such as Eileen Fisher. It is not yet clear whether this is transferable to	A consistent multi-disciplinary approach to design for longevity is essential, that takes into account cost and aesthetics, as well as emotional and material	Initiatives to explore and enhance longevity in clothing should incorporate opportunities to exchange approaches and share findings

mainstream clothing design	durability and environmental	and good practice across
	Clothing design therefore needs to be 'user-centred' and reflect the wide range of longevity features, such as fit, ease of care, comfort, adaptability, repairability and post-use.	product sectors.
Businesses report a lack of technical skills and knowledge to support NPD for longevity, exacerbated by the lengthening and fragmentation of the global supply chain. Some retailers and brands are dependent on domestic and/or overseas suppliers for detailed technical knowledge.	Businesses need to address the gap in skills and knowledge by providing internal training, and selecting suppliers with appropriate skills and knowledge or the ability to enhance these. Upskilling needs to extend to multi- functional teams and extend to commercial functions to develop approaches to costing product failure and evaluating the business case for longevity. Knowledge and education for all groups (young to mature consumers; designers; retail staff; technical teams; senior managers, etc.) needs to be provided in user-friendly and accessible ways.	Training schemes and training and education providers need to include technical skills and design for longevity in their taught programmes for designers and buyers as well as garment and textile technologists. Initiatives to promote upskilling of the clothing industry should address potential re-shoring to ensure highly skilled UK clothing manufacturing, but also need to be consistent with a global agenda to upskill the supply chain and improve standards.
Supply Chain		
Change in the clothing industry is retail and brand led, and manufacturers can feel cut out and devalued. Messages to manufacturers from their retail customers focus on cost and product features.	Cross-functional working within and between organisations should be encouraged. There is a case for companies to adopt new business models and a need for greater exchange of knowledge and information across functional departments and between buyers and suppliers to ensure that these are appropriate and effective.	Research is needed to identify workable and commercially attractive business models appropriate to the clothing industry, in the UK and internationally.
Strategic objectives differ between retailers and suppliers. Suppliers are not always consulted on choice of	Success in improving end product durability requires better traceability throughout the supply chain. Better	Leading edge research needs to take into account opportunities for the clothing industry to adopt new

materials, or feel that their recommendations are not always taken into account. Limiting factors include lack of trust, cultural barriers, inadequate commitment and critical path pressures which inhibit knowledge sharing and transparency. Smaller and niche brands lack impact on the supply chain, where lack of scale can compromise their influence on materials and process choice,	monitoring information is needed to improve knowledge of both the product and the processes applied. This needs to be in parallel with improved specifications and greater reliability of products against these standards. This could be part of a drive to improve standards and transparency of upstream aspects of the supply chain generally. The impact of legislation affecting the materials used in clothing exported to China shows how	innovations and practices. This could include: technology to trace products and processes throughout the supply chain; technology to automatically instruct recycling processes how to deal with specific items; scanning technologies to predict product failure; mass customisation to enhance emotional durability; and 'big data' to measure consumer purchasing behaviour. The UK Government's Industry 4.0
adherence to standards and transparency.	this can improve quality across product ranges, and has already promoted change within some brands.	agenda needs to be positively associated with opportunities to enhance clothing longevity.
Third party organisations have been influential in promoting improvements with regard to CSR issues such as ethical sourcing (e.g. the Ethical Trading Initiative) as well as environmental sustainability (e.g. WRAP's SCAP). Expanding this approach could help to generate and endorse supply chain practices that support design for longevity.	Small firms need help to introduce new initiatives that support clothing longevity, whereas larger ones need incentives, such as a convincing business case or financial benefit, to pilot new approaches. Partnerships with Third Sector organisations and between large and small retailers should be encouraged to facilitate change and help to publicise and commercialise new initiatives.	Incentivise small retailers/brands, such as through business rates for retail outlets that offer repair and recycling services. Research to evaluate novel business model applications piloted by larger brands could lead to workable demonstrator projects and wider-scale adoption. Those being developed by REBus (WRAP, 2016b) provide an example. Cross-brand initiatives would benefit from the involvement and endorsement of commercially neutral Third Sector organisations.
Technology and Innovation		
Innovation in technology and business models will impact on the ability of retailers and brands to design and commercialise clothing with a longer life.	Businesses need to accelerate the pace of adoption of innovative processes in order to keep pace with and respond to changing consumer expectations and take advantage of future opportunities.	Initiatives that research sustainability and garment longevity need to address issues beyond the technical case for clothing longevity since issues such as business modelling and supply chain challenges appear harder to resolve than the physical longevity of the product.

Available technology solutions include: apps and online information; fabric detergents/finishes; digital and virtual planning and design tools; traceability tools; testing technologies including objective measurement and simulation; data management regarding product performance and consumer preferences; communication tools and social media.	There is an opportunity to use new technology to compile a databank of fabric and component tests and performance specifications that could inform the item level design process. Better use of data analytics and knowledge banks, can increasingly be aided by and integrated with new technologies, since 3D CAD and visualisation could help to predict problems with yarns, fabrics and garments before samples are made.	Resources that research garment longevity need to address the adoption of new technologies. There is scope to bridge the gap between research into new technologies <i>per se</i> and their use in providing solutions to sustainability issues. Demonstrator projects are needed to test and evaluate the impact of technologies on enhancing garment longevity.
Business Models and the Busine	ess Case	
At present, the case for producing fewer, higher value products is compelling to some, but commercially unproven, while to others it is considered commercially damaging, depending on brand niche and target consumer segments in the UK and internationally.	Businesses need to develop internal cross-functional teams including design, technical, marketing and finance expertise, to evaluate objectively the potential costs and benefits of designing for longevity. The EU and wider international perspective needs to be considered, especially as many retailers/brands have international markets and are increasingly targeting emerging markets.	There is a critical need to research the scalability and commercial opportunity of alternative business models and to develop and communicate the business case for designing for clothing longevity in association with the industry.
Sharing knowledge with customers promotes repair and better care. WRAP's 'Love Your Clothes' helps to promote better clothing care, but supplementary or different offers and communication channels may be required to enhance awareness and target additional consumer segments.	Services to extend garment life need to be represented in new business models that mix product sales with service. More retailers and brands should collaborate with initiatives such as 'Love Your Clothes' to encourage consumers to change their behaviour. Services need to match brand image and target relevant consumer segments, providing a sense of newness and 'feel- good' factor, as well as being	While public resources may be required to promote consumer facing initiatives and campaigns, these need to be effective in targeting the widest possible range of different consumer segments. Engaging celebrity and cultural icons and embracing the latest technologies and effective social media, such as 'vlogging' and YouTube, is a necessity.

	'cool', motivating and rewarding.	
Agency and Governance		
There is, as yet, no clear case for scaling up the 'slow fashion' model and no clear avenue for addressing this at executive level. Governance behind sustainability generally, and longevity in particular, is inconsistent and lacks strategic priority. Actions that support clothing longevity take place at all stages of the supply chain and consumption. All organisations and consumers are involved in some way in extending clothing lifetimes.	Senior managers need to understand the strategic significance of clothing longevity in terms of business responsibility and the wider impact on landfill and material security.	Even though some organisations are SCAP signatories, sustainability policy lacks "teeth" in a commercial setting, unless there is a clear commercial benefit. A more strategic approach to clothing longevity is required. Campaigns need to address this at the highest level if change is to be implemented on a wider scale.
Through the information on their care labels, retailers pass responsibility to the consumer to care and recycle in a way that makes garments last for longer, even when the instructions provided by retailers/brands are confusing or do not match normal consumer behaviours.	While consumers can do more to value and care for their clothing for longer, retailers and brands need to take more responsibility for the design of clothing that endures accepted behavioural norms (regarding care and recycling), and provide clearer information and services to enable consumers to act differently where this is most appropriate.	Retailers and brands need to be encouraged to take responsibility for the impact of their own products during use and at the end of their useful life.
Technical knowledge to support longevity, such as selection of durable materials, is passed to suppliers, who may have limited knowledge of consumer expectations and anticipated product use. Conversely, suppliers sometimes feel that their knowledge is over-looked. There is a lack of clarity regarding demand/supply for new tests for longevity. It is unclear whether retailers or the testing industry should initiate new developments.	A multi-functional approach to design for longevity is required that takes into account the skills, knowledge and contribution that organisations throughout the supply chain can make, supported by consistent objectives and information sharing. The testing industry needs to be more closely involved in the process of design for longevity.	

There is a perception that	A multi-functional approach in	Research is needed to
small brands/retailers have	larger organisations could help	understand the impact of
greater flexibility to change	to increase understanding of	small scale initiatives that
their products and processes	the impact of clothing	support clothing longevity and
and are better able to benefit	longevity and clarify the	the extent to which they are
commercially from doing so,	contribution that design and	scalable.
but have limited influence over	technical teams can make to	
their supply chain. Designers in	reducing environmental	
many large firms experience a	impact.	
lack of influence.		

7 Conclusions

7.1 Summary of findings

Recommendations arising from the project are intended to address technical and commercial limitations and facilitate a more pro-active, future-facing approach to design for longevity. It is clear that, in principle, garments can be made to last longer.

The decision as to how change should be co-ordinated across the supply chain and commercialised, and by whom, is less clear, as the issues are embedded in a context where cost and aesthetics dominate design decisions. The detriment of longevity is evidenced by premature garment failure and a systemic lack of capability to address obstacles to introducing longevity as a scalable solution to excessive garment waste. Conflicting priorities are persistent and systemic, and contribute to business strategies that sometimes appear 'anti-longevity' and not merely hard to implement.

The research revealed a range of insights about processes to support clothing longevity:

- Textile and yarn finishes and garment production techniques are available that can support longevity. These include anti-pill finishes, treatments that can reduce wash frequency, and fused seams, hems and buttons that enhance garment durability, as illustrated in sections 3.4, 5.1.3, and 5.3.1. Not all are readily accepted within the UK clothing market by buyers and consumers, in part because the underlying technical complexity gives variable results which, when combined with cost, time and market limitations, constrain their use (section 5.1.3). Lack of collaboration across the various actors within the supply chain means that these issues are unresolved (as discussed in sections 5.1.5, 5.1.6 and 6.4.1), while their impact on product lifecycle, aesthetics, cost and the environment are not fully understood.
- 2. Extended product tests and trials for durability are not routinely carried out. Obstacles include the substantial resource implications and critical path pressures. Standard tests only assess fitness for purpose at the early stage of the garment lifecycle and there is variation across the industry in the interpretation of test results and pass/fail criteria, as discussed in section 3.5. New or revised tests are needed that represent consumer behaviour and prolonged clothing use, and that incorporate and meet commercial needs. While the findings acknowledge the complexity of establishing new tests, there is a need to define the nature of tests, suitable metrics and objective measurement techniques, consistency of application, and relevance to real-life consumer behaviour (sections 5.3.2, 5.2.3, 6.3). There is an opportunity to make use of historic data to predict complexity and inform future seasonal ranges, although here, too, obstacles exist.

- 3. Retailers and brands can do much more to encourage consumers to care, repair and recycle their clothes to prolong garment life. They could also improve their approach to user-centred design in order to develop products that consumers can (and want to) use for longer and care for more effectively (sections 5.2 and 6.2). Emotional attachment is an under-researched aspect of promoting clothing longevity (section 5.3.1).
- 4. Care instructions and labelling could be standardised and simplified, with clearer and better guidance to enable consumers to make informed decisions about garment care that would also meet their needs in terms of cost, convenience and energy and water use (section 3.5). There is a need to change messages relating to garment care in order to respond to prevailing care behaviours, rather than expect consumers to change unilaterally (section 6.2.4). Scope exists for standardisation of care guidelines across garment/fabric types and a system of labelling which would aid legibility and communication of care instructions and ensure that more garments comply with standard care practices (sections 5.1.4, 5.2 and 6.1).
- 5. There is a lack of broader NPD knowledge and skills within some retail and brand teams and throughout the supply chain. This is exacerbated by globalisation of production and, in some cases, the absence of trusting buyer-supplier relationships and confidence in the valuable knowledge and experience that suppliers can provide (sections 5.1.5 and 5.3.4). To address this, improvements are needed in skills training (within and pre-industry and apprenticeships), acquiring and retaining technically skilled staff, and greater emphasis on practical training, problem-solving and experiential learning and CPD within the retail sector. In parallel there is an opportunity to acknowledge the value of technologists' skills and experience, recognise the wealth of technical knowledge within manufacturing, and create opportunities for knowledge exchange. Action should include developing systems and applied technologies to capture historical knowledge that can be drawn upon to inform future decision making (section 3.9).
- 6. Design decisions early in the new product development process have an impact on clothing durability, as do the materials and processes deployed upstream in the supply chain at the fibre, yarn, fabric, finishing and garment production stages (section 3.7). Responsibility for design is not always clear and there is an opportunity to embed better working practices that identify potential problems and impact on durability at an earlier stage in the NPD process (section 3.7. Retailers and brands should adopt the Clothing Longevity Protocol checklist devised for WRAP (Cooper *et al.*, 2014) and ensure that the materials, components and garments selected for sale support garment durability (sections 5.3.1 and 6.4).
- 7. A range of technical innovations could lead to increased longevity, including improvements in laundry and care products, and fabric finishes that support durability or reduce the need to wash, dry and iron clothing. New communication tools, including RFID and traceability systems, apps and social media could improve co-ordination and knowledge-sharing throughout the supply chain and the quality, clarity and consistency of information provided to consumers (sections 3.9 and 5.2. There is also scope for new technologies to be used in the product testing process and for new tests to be developed (section 5.3.2).
- 8. Further research is needed to expand on pilot exercises (such as those undertaken during this study) and scale up to workable trials. For example, Company A's pilot (section 6.1) could be a starting point for a much wider study across a broader range of products and brands. Bearing in mind the time and resource implications uncovered, further research would need to identify potential efficiencies in the simulation process. Extended wash trials such as those undertaken by Company B (section 6.3) could usefully be complemented by simulated or actual wearer trials and new industrial tests to reflect current laundry practices and evaluate the effect of using different detergents and fabric conditioner on pilling and dimensional stability.

- 9. The major constraint to designing and making clothes that last for longer is the challenge that this poses to established commercial interests. Business model innovations are needed to provide viable ways to commercialise and scale up the production of longer lasting clothes, but there are persistent doubts over the commercial viability of alternatives (sections 3.10 and 5.3.4). The prevailing focus on cost is an inhibitor to change.
- 10. Solutions require a multi-functional approach, with commercial, design and technical input, better co-ordination throughout the supply chain, and shared responsibility between suppliers, retailers (or brands) and their customers (sections 5.1 and 5.3).

At the outset, the research set out to resolve a number of key questions concerning clothing longevity. In understanding how existing processes and behaviours of clothing NPD impact on current clothing supply chain performance in terms of cost, time and product longevity it remains the case that cost is a dominant factor. Design decisions are predicated upon cost, with time a secondary concern in some markets, especially fast fashion, though often compromised by lengthening global supply chains. There are, however, signs that NPD increasingly attempts to address product longevity, often to support brand values or demonstrate competitive value.

A range of technological innovations could be incorporated into the NPD process and supply chain to address issues such as the lack of reliable data on materials performance and pilling due to short fibre composition in yarns. Obstacles to their use include lack of priority placed on clothing longevity, uncertainty regarding their advantages and disadvantages in a variety of products and markets and, in some cases, cost. Innovations in the testing process could be adopted to help improve product durability, but these often face limitations, not least the requirement for a commercial case to be made before the complex and resource-intensive process of establishing and accrediting new test methods can be undertaken. Clarification of existing test protocols and standards is more readily achievable.

Innovations in clothing NPD, testing and the supply chain can go some way to support the communications, knowledge and skills necessary to design and produce clothing that lasts for longer. Such developments need to be inclusive across multi-functional teams and at key stages throughout the supply chain, including fibre, yarn and materials supply. However, the effectiveness of such developments is contingent on improved governance structures that enable more effective utilisation of skills and knowledge and a more clearly articulated commercial case. Consumer behaviour could be positively influenced by relatively straightforward developments in the communication of clothing care and options for post-use behaviour. Enhancing emotional durability to entice consumers to keep clothing in active use for longer which require more considered design and marketing approaches.

These findings suggest a number of policy recommendations, summarised below (see also Table 6.1).

- 1. Support for direct, short-term initiatives that promote the longevity agenda more broadly within business and consumer contexts. There is scope to improve promotional messages for different target groups, but also to better use marketing techniques, celebrity endorsement, social media and new technologies to engage consumers.
- 2. Resources and infrastructure are needed that support education, training, knowledge sharing and collaboration, within and between organisations in the supply chain. Facilitation could support the exchange of knowledge across the sector and between clothing and other sectors. There is considerable scope to re-educate consumers in the way that they buy, care for and dispose of clothing, and this requires intervention to overcome the conflict with commercial priorities.

- 3. Support for applied research into commercialisation of the business case, adoption of new technologies, processes and product testing related to the design of longer lasting clothes is needed in the form of longer, proof of concept trials. Further research, both in the UK and internationally, could help to understand emotional durability and user-centred design and the potential to strengthen the business case and influence consumer behaviour.
- 4. There is a need for top level guidance and legislation to improve the clarity and reduce complexity of garment labelling specifically. Improved infrastructure and awareness of public and private recycling initiatives is needed to help consumers to make informed choices. Requiring (or encouraging) retailers and brands to take more responsibility for their products within the circular economy would help to reduce waste and avoid materials scarcity.

7.2 Dissemination

The project has resulted in a toolkit to encourage industry practitioners, trainees and educators to adopt practical approaches to design for clothing longevity. The key themes of the toolkit are shown in Appendix 9.1. A range of activities have been undertaken to disseminate key project findings in order to provoke discussion, inform industry practice and further academic research. These are summarised in Appendix 9.2.

7.3 Further research implications

The project uncovered several key issues, discussed below, that merit further research if the policy objective to reduce the environmental impact of clothing through enhancing garment lifetimes is to be achieved.

- There is a need to extend conceptual models and short pilot actions into wider scale demonstrator or proof of concept models designed to implement and evaluate real change over a prolonged period in a commercial context. The objective should be to establish the current or potential business case, assess the environmental impacts, and develop strategies to resolve any trade-offs between commercial, consumer and sustainability requirements.
- Further research is required to understand the potential for adopting new technologies that could support the business case for adopting design for clothing longevity. This research identified that there is potential to enhance the technical design and testing of longer lasting garments, improve collaboration throughout the supply chain and facilitate the sharing of communications and knowledge with customers and stakeholder groups. Few of these initiatives are operational on any scale and technology is evolving rapidly, so ongoing specialist research and evaluation is required.
- New finishes and treatments exist that may help to maintain longer garment life. At present, however, their sustainability and aesthetic impacts are not widely understood. Moreover, it is not clear to what extent these processes could support the commercial and scalable business case. Both areas are worthy of specialist research.
- The project has been informed not only by previous research in the UK context but by international research, particularly from Scandinavia. There is an opportunity to extend research to the wider international context, which is especially important because of the global context of the textiles and clothing supply chain (and the brands that control this) and the emerging importance of global markets. Wider scale research could help to establish the transferability of UK and Scandinavian findings and explore the international dimension, including opportunities and limitations associated with global retailers, brands and testing services, and the global supply chain.

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9 Appendices

9.1 Toolkit use and format

The toolkit is being developed as a resource for businesses and training providers to address the key challenges faced when introducing strategies for clothing longevity. It is intended to be a training resource and point of reference for practitioners and students in fields such as design, new product development, fabric and garment technology and buying. The toolkit is being designed for straightforward access to the respective sections, clear concise materials and links to related or existing materials and will be formatted as a postcard-style printable pdf. There are twelve topics, as illustrated in the draft list and sample double sided card below:

- 1. Designing for Durability
- 2. Understanding Consumers
- 3. Testing for Durability
- 4. Transparent Supply Chains
- 5. Product Labelling
- 6. Lifetime Guarantees

- 7. Cleanliness, Laundry & Care
- 8. Ease of Maintenance
- 9. Designing for Repair and Adaptability
- 10. Adding Emotional Value
- 11. Alternative Business Models
- 12. Communicating and Promoting

11.ALTERNATIVE BUSINESS MODELS

WHAT WE KNOW ...

Clothing retailers and brands have largely geared their sustainability initiatives around prevailing business models based on high volume sales. There is specifically a limited appetite to adapt business models to promote longevity in mainstream markets.

In niche markets, new models have included offering repair services; upselling repair materials and care products; swapping, leasing and recycling schemes. Changing the product-service mix provides an opportunity to maintain revenue, while selling fewer, but longer lasting items.

Business model innovations include revising upstream supply, as well as sales and distribution. Incorporating robust components, accessing technical expertise or introducing modular design, for example, could help to reduce any negative impact of clothing longevity at the point of sale through adding value to the product.

Collaboration between different retailers and organisations in other sectors could be encouraged, to facilitate clothing longevity, e.g. by a retailer donating used clothing to a selected charity. WHY IT MATTERS ...

While commercial business gain takes precedence over environmental impact change is unlikely to take place.

Has potential to improve quality and performance of products, and therefore customer satisfaction, leading to potential growth or spread of new approaches, such as repair services, leasing and vintage.

Collaborative consumption can reduce the amount of unworn clothes / items discarded after one wear, whilst allowing style, versatility and convenience.

Brands associated with stylish, durable items that can be treasured for longer command higher prices and generate customer loyalty.

II.ALTERNATIVE BUSINESS MODELS

COULD WE ..?

Support consumers to share, pass on, swap and donate used clothes? E.g. by hosting clothes swapping events

Return used clothes for re-use or recycling? E.g. H&M and M&S collection schemes.

Collaborate with different retailers, manufacturers or organisations in other sectors to facilitate clothing longevity, e.g. by donating used clothing to a selected charity?

Offer consumers information on disposing of garments in ways that prolong their life, for example through instore recycling facilities, buying back and reselling their products online?

COULD WE ...?

Review the standard business model of aiming to improve sales by volume each year, considering the use of other metrics instead?

Create a leasing business that allows the brand to retain the re-sale value of more physically and emotionally durable clothes.

Re-configure the product service mix and consider alternative ways to generate income through the sale of services or add-on items.

Evaluate the cost-benefits of promoting the sale of fewer, longer lasting products on revenue, brand value and customer loyalty, as well as the benefit to the environment.

9.2 Dissemination Activities

The following dissemination activities have been undertaken to share findings and raise awareness among both academic and industry audiences. Some articles have already been published in industry magazines and conference proceedings, others are subject to review or in process to meet forthcoming deadlines.

9.2.1 PLATE conference, Nottingham, June 2015

Various papers were presented at the Product Lifetimes and the Environment (PLATE) conference by the project team, reflecting on aspects of design for clothing longevity. The paper below, based on findings from the current research project, has been published in the conference proceedings [McLaren, *et al.*, 2015] and opportunities to develop it further for publication will be sought.

Clothing longevity perspectives: exploring consumer expectations, consumption and use, Presented at PLATE conference, 2015

Authors: McLaren, A., Oxborrow, L., Cooper, T., Hill, H. and Goworek, H.

Abstract: The production, distribution, use and end-of-life phases of the clothing lifecycle all have significant environmental impacts, but complete lifecycle assessment has identified that extending the active life of garments through design, use and re-use is the single most effective intervention in reducing the overall impact of the clothing industry (WRAP, 2011). In response, Government funded clothing longevity research seeks to develop and test industry-led design strategies to influence and enable consumers to keep garments in active use for longer (Cooper *et al.*, 2014). While recent UK research has indicated significant potential to influence more sustainable consumer behaviour (Langley *et al.*, 2013; YouGov, 2012), up-to-date qualitative research is required to discover how consumer attitudes, expectations and behaviours in relation to clothing lifetimes affects garment care and clothing use. This will help to inform industry-led strategies by understanding where effective changes can be made that will potentially have most impact.

This paper presents preliminary findings from a Defra funded action based research project, *'Strategies to improve design and testing for clothing longevity'*. Qualitative research methods are used to explore consumer attitudes, expectations and behaviours at purchase, use and disposal stages of garment lifetimes, and gather data on practices of garment wash, wear, care and maintenance in everyday life. The research findings are discussed in relation to industry-led strategies aimed at extending the life of clothes.

9.2.2 Design Research Society conference, Brighton, June 2016

Two 5000 word papers have been accepted, following a peer-reviewed process. The papers explore themes of consumer perspectives for clothing longevity and addressing design and supply chain challenges. The paper titles and abstracts are included below.

The effect of consumer attitudes on design for product longevity: The case of the fashion industry, Presented at Design Research Society conference, 2016

Authors: McLaren, A., Goworek, H. and Cooper, T.

Abstract: Product longevity is a key aspect of sustainability and encouraging consumers to prolong the lifetime of products therefore has a part to play in minimising environmental sustainability impacts. The production, distribution and disposal phases of the clothing life cycle all create environmental impacts, but extending garments' active life via design, maintenance and re-use of clothing is the most effective method of reducing the negative effects of the clothing industry on the

environment. The study took an exploratory approach using mixed qualitative research methods to investigate consumer perspectives on clothing longevity and explore everyday processes and practices of clothing use, e.g. purchase, wear, care, maintenance, repair, re-use and disposal. The research findings showed that numerous factors affect consumers' perspectives of clothing longevity during the purchase, usage and disposal stages of the clothing lifecycle. The conclusion addresses how these factors can influence product design practice in the fashion industry.

Extending clothing lifetimes: an exploration of design and supply chain challenges. Presented at Design Research Society conference, 2016

Authors: Oxborrow, L. and Claxton, S.

Abstract: The impact of clothing on the environment could be reduced if average garment lifetimes were increased. The paper explores the design and supply chain implications of clothing longevity, using models adapted from sustainable clothing design research, and evidence from interviews and expert round tables. The research concludes that the process of design for longevity could be adopted by clothing retailers and brands, but that the principles behind adopting such a strategy lack credence in industry, because the mandate to do so, and a robust business model, are lacking. The paper identifies a range of conflicting priorities between commercial and sustainable practice that must be addressed to reduce the environmental impact of clothing by extending its useful life, and makes recommendations for industry and future research. However, it is acknowledged that the limitations to adopting more sustainable practice are systemic within the clothing supply chain and attempts to resolve these require a commercial imperative.

9.2.3 Scaling Sustainability seminar, Leicester, May 2016.

An extended abstract entitled "Designing for Clothing Longevity – a Problem of Agency" was presented to a seminar at the University of Leicester, within the theme 'Environmentally sustainable design and product development.' The event was held in association with the British Academy of Management (BAM) Sustainable and Responsible Business Special Interest Group and may lead to publication in a special edition of a BAM sponsored journal.

9.2.4 The Conversation article, November 2016.

A short article published in the academic newsfeed entitled 'A circular fashion economy is about more than just clothes' (Oxborrow, 2016) has been circulated to almost 12,000 readers worldwide. The original article was re-published by Scroll.in and Newsweek, among others, and promoted on social media by organisations such as WRAP, attracting readers in India and the USA, as well as in the UK, Canada and beyond.

9.3 Further plans for academic dissemination

Further dissemination activities are planned during the 2016/17 academic year.

Journal of Cleaner Production. Paper(s) to be submitted to a peer reviewed journal from which we have drawn several references. Proposed topics for submission include: design and NPD processes; product testing; consumer behaviour and user-centred design; and/or new and evolving business models.

British Academy of Management. Potential topics for publication such as design management, supply chain management and agency will be explored following the receipt of feedback from the Leicester Conference.

9.3.1 Industry/Professional dissemination

A range of dissemination activities have already taken place to share findings with a professional audience and encourage businesses to adopt new practices, with others planned. These include:

- An article for the Textile Institute magazine published in January 2016 (see Figure 9.1).
- A workshop presentation, aimed at industry-facing organisations, was held in April 2016 for Made-By.
- Events planned for industry audiences in 2017 include an invitied presentation at the ASBCI (Association of Suppliers to the British Clothing Industry annual conference.
- Dissemination of findings through the SCAP 'Design for Life Working Group'. These were organised to follow key stages in the research notably after each of the expert round table events and to inform next steps. A further presentation to demonstrate the toolkit to this group of industry design and technical representatives is planned for 2017.



Figure 9.1 Textile Institute Magazine Article

Image: https://issuu.com/textileinstitute/docs/textile_magazine__issue_3__2015