

# Strategies to improve design and testing for clothing longevity

Report for Defra by

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## 1 Executive summary

The report presents 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 several elements: a comprehensive literature review; primary research including interviews with 31 industry practitioners; four consumer focus groups; and a series of three industry and consumer round tables, and an expert workshop. Building on this preparatory research, four pilot exercises 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 its customers' behaviour.
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 research confirmed that it is technically possible to produce clothing that lasts for longer, but highlighted 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, by enhancing their approach to user-centred design, and by 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 throughout 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 wide ranging benefits of adopting a range of new technologies (product, NPD and communications) when designing, producing, distributing and promoting longer lasting clothes, within a 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 persuasive, short term initiatives that promote the longevity agenda within business and consumer contexts.
2. The provision of resources and infrastructure that support education, training, knowledge-sharing and collaboration, both within and between organisations in the supply chain.
3. Applied research on (i) commercialisation of the business case, innovation in technologies, processes and testing related to 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 improve the clarity and reduce the complexity of garment labelling and to improve re-use and recycling initiatives, encouraging retailers and brands to take greater responsibility for their products within the context of a circular economy.

## 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. The report presents a literature review, key findings from primary data collection and pilot exercises, 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 built on previous research (Cooper *et al.*, 2013; WRAP, 2013; Cooper *et al.*, 2014) by exploring 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.

The project sought to understand how existing processes and behaviours relating to clothing NPD impact on clothing supply chain performance, particularly in terms of cost, time and product longevity. It proceeded to explore how technological innovation 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, skills and knowledge relating to clothing longevity within organisations, throughout the supply chain and with consumers, and to understand to what extent this could impact on behaviour 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 excessive amount 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 increasing longevity as a 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, by enhancing their 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 throughout the supply chain to promote better design practices, from fibre to end-use, noting the benefits of a multi-disciplinary 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

This short review of relevant literature highlights 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; retailer/brand responses to the challenge of extending clothing lifetimes; the clothing supply chain; new technologies and business model innovation.

Our 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. Greater understanding of how consumers maintain and retain garments could impact upon industry 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: WRAP's *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% (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."

In research by WRAP (2012) more than one half of survey respondents (56%) considered buying good quality clothes to represent 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 longevity is hard to measure, not widely tested and dependent upon the complexities of consumer usage. Fisher *et al.* (2008) 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.



### 3.2 Consumer perspectives on longevity

Clothing durability, care and disposal are important influences on sustainability through clothing longevity. WRAP's research revealed that many UK consumers regard cheap clothes as disposable, with frequent reference made to 'throwaway clothes.' The main purchase criterion is value for money, and yet at the same time one third of UK consumers prefer to buy clothes that are made to last (WRAP, 2012). More than half (57%) of UK consumers regard quality clothes as an investment, although few know how to judge or measure quality. Similarly, in a Scandinavian survey, over 60% of consumers suggested that 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 garments in the average UK wardrobe are not worn because they no longer fit, 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, 36% of consumers own items that are unworn because they no longer like the style and 10% have items that they no longer wear because of damage during laundry (WRAP, 2012). 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' responses to different garment types also varies. In Scandinavia, trousers, jeans, underwear, socks, hosiery and 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).

In another Scandinavian survey, around 80% of respondents indicated that they were "ready to buy a long-lifetime, repairable and more expensive garment and use it for a long time" in order to minimize their environmental impact (Niinimäki and Hassi, 2011, p.1881). However, the same consumers were more ready to accept familiar practices of repair and recycling than more radical interventions. 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. The extent to which these findings apply to consumers in the UK or elsewhere in Europe is unclear, however, and there is a lack of firm evidence of the extent to which such services have a positive impact on longevity and, more generally, sustainable production and consumption.

Attitudes and behaviour 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 (cf. 36% for all UK consumers) (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 reduced waste sent to landfill, it appears that young consumers engage readily in services such as swapping, rental and fashion updates, while more mature consumers are more likely to favour redesign, repair and customisation (Armstrong *et al.*, 2015). However, 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 to sustainable behaviour by economic factors as much as by environmental concern (Defra, 2008).

### 3.3 Brand perspectives on longevity

The approach of retailers and brands is evidently somewhat at odds to that of their consumers. Retailers have reduced product quality over time to meet 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 may perceive garment failure as 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 use (Laitala and Boks, 2012).

### 3.4 Material durability

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

- Marks and Spencer's *Stay New™* 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 menswear and ladies' lingerie styles.
- Schoolwear by Marks and Spencer (2014b) and George features adjustable hems and waistbands to accommodate growth in body size, a special thread that bonds with fabric to prevent hems unravelling, non-iron shirts to reduce the effects of heat, and heat-sealed buttons to prevent the need for mending. Marks and Spencer applies finishes such as *Stormwear+™* and *Stainaway™* to promote durability, while George incorporates *Teflon™* 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 Life™*, 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-lived clothing in order to facilitate recycling has also 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. However, extended tests were perceived to take too long and be too costly in what is a highly competitive industry. 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 slower decision making and added product testing (Brun and Castelli, 2008; Pisano and Adams, 2009), but this in turn fosters 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, our report for WRAP (2014) concluded that closer 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 retailer/brand product-service mix, where the service element includes design input as well as aspects of customisation and repair, leading to longer active clothing lifetimes (Niinimäki, 2012).

Initiatives such as swapping, rental, redesign, repair and customisation have implications for garment lifetimes. If garments made and used in these ways are to achieve a longer active life, the challenges for designers not only include improving technical quality, but designing items to fit better, adapt to body size (including children's growth) and offer flexibility to style or fashion. Such an approach can offer emotional reward as well as environmental and social benefits (Laitala and Klepp, 2011; Armstrong *et al.*, 2015).

### 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 (Hong *et al.*, 2009; Curwen *et al.*, 2012). The apparently conflicting approaches to longevity of consumers and retailers/brands, described above, suggest that a more pro-active, visionary and far-sighted design approach is needed to create customer satisfaction, enhance product lifetimes and promote sustainable consumption (Niinimäki, 2012). A 'systems thinking' approach across life cycle phases 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 environmental 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 development 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 company case study has revealed how a proactive business culture, objectives, structure and processes can support 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 have been 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 acquire fashion and technical knowledge more effectively, but traditional apparel supply chain clusters have fragmented because retailers have assumed greater responsibility for design and increasingly outsource 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, 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). 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 may seek 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 the following: 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 the following: 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; robust measurement of test results, such as rub and colour fastness, rather than visual judgement; clarification of test specifications and associated international standards (Annis *et al.*, 2012). There is 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 their 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.

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 convert 3D design into 2D pattern pieces for production. From a commercial perspective 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 also 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 centralised usage is 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) represent another technology with potential significance to clothing longevity. For example, 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 choose new garments that co-ordinate (Blasigh, 2013). Other mobile application 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 important 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 new business models are:

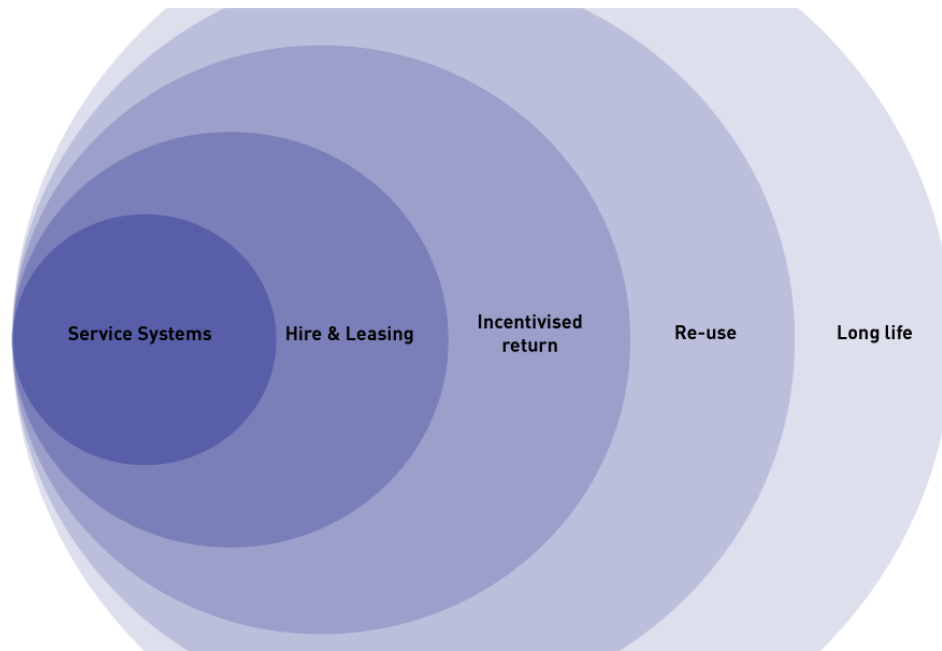
- broadening revenue generation beyond the sale of products by improving service support and performance, or monetising intellectual property
- encouraging value co-creation from inside and beyond the organisation
- enabling external suppliers and research organisations to contribute to the R&D process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

WRAP's five-year plan suggests how businesses and consumers can be part of a 'resource revolution' that will re-invent, re-think and re-define how materials are used (WRAP, 2015). Alternative or innovative business models can extend product life, conserve resources and prevent materials from becoming waste. A range of alternative business model propositions have attracted particular

interest (Figure 3.1). The REBus Project (WRAP, 2016a) has profiled a small number of clothing cases, including:

- Rentez-Vous – a UK based peer-to-peer rental market place for special occasion and designer clothes.
- 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 clothes 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**



Source: WRAP, 2016b

While service systems, hire and leasing are also key features of Scandinavian research into clothing longevity (see Section 3.2), it is not clear to what extent these examples have been commercially tested, and are scalable and transferable into other markets such as the UK, where current market representation is modest. Earlier WRAP research (2013b) evaluated the financial viability of different product-service clothing business models and concluded that those that are financially viable in 5 years have little 'resource impact' (Table 3.1). Even in the long term, after 10 years, and based on a conservative scenario, only the retailer buy-back and resale of 'pre-owned' clothing model performed well on both counts.

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

**Table 3.1 Business model financial appraisal and resource impact (conservative scenario)**

	After 5 years		After 10 years	
	Financial viability	Resource impact	Financial viability	Resource impact
Repair workshops	No	Acceptable	No	Good
Baby clothes leasing	No	Good	Maybe	Good
Formal clothing hire	Yes	Unacceptable	Yes	Acceptable
Buy-back and resale	Yes	Acceptable	Yes	Good
Peer to peer	No	Unacceptable	No	Unacceptable

Source: WRAP (2013b)

**Table 3.2 Business model financial appraisal and resource impact (tipping point scenario)**

	After 5 years		After 10 years	
	Financial viability	Resource impact	Financial viability	Resource impact
Repair workshops	No	Acceptable	No	Good
Baby clothes leasing	Maybe	Acceptable	Yes	Good
Formal clothing hire	Yes	Unacceptable	Yes	Unacceptable
Buy-back and resale	Yes	Acceptable	Yes	Good
Peer to peer	No	Acceptable	Maybe	Good

Source: 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 added-value 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; Hoejmoose 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 clothing longevity; much published research focuses on fast fashion case-studies on companies such as H&M and Zara. A report by Kurt Salmon Associates (2014) suggests that retailer innovation priorities include adopting a multi-channel approach; geographical differentiation; mass-customisation; speed of product innovation and information integration; and changes to the sourcing landscape. These 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 (Cooper *et al.*, 2013; Cooper *et al.*, 2014; WRAP, 2013a) 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 methods used in each of the stages are 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 to discuss opportunities and obstacles 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 companies 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 complementary summary notes prepared by the interviewers (Bryman and Bell, 2015).

Key themes covered during the interviews included the following: the business context for sustainability, longevity and durability, and challenges to achieving these goals; design for durability; product testing; clothing care, including labelling; skills and knowledge, and the supply chain. The findings from the industry interviews are discussed in Section 5.1.

### 4.2 Consumer research

#### 4.2.1 Focus groups

Four focus groups were undertaken in November and December 2014 with a total of 29 participants in order to better understand consumer perspectives on clothing longevity and the role of consumers in achieving longer clothing lifetimes. 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 UK population) (Hennink, 2014; Bryman and Bell, 2015).



The groups were segmented according to age, social grade<sup>1</sup> and personal/family circumstances as follows:

- F1: Young participants aged 18-30 years old associated with fast fashion consumption: six students from mixed disciplines and social grade C1 (NTU; November 2014).
- F2: Young participants aged 18-30 years old associated with fast fashion consumption and in social grade B-D: five full-time employed administrative staff targeted through university support services and external businesses (NTU; December 2014).
- P: Parents of school aged children in social grades A-D: eight participants recruited at a local sports club (Arnold, Nottinghamshire; December, 2014).
- S: Employees aged 30-60 years who associate with classic styles and clothing durability, in social grades B-C2. Eight 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, use, 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 factors that limit 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 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 (Armstrong *et al.*, 2015).

#### 4.2.2 Clothing diaries

In order 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 six participants, reflecting consumer focus groups F1/F2 and S, 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.

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<sup>1</sup> Social Grade classifications with percentage of each in the UK: 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.

**Figure 4.1 Clothing diary packs**

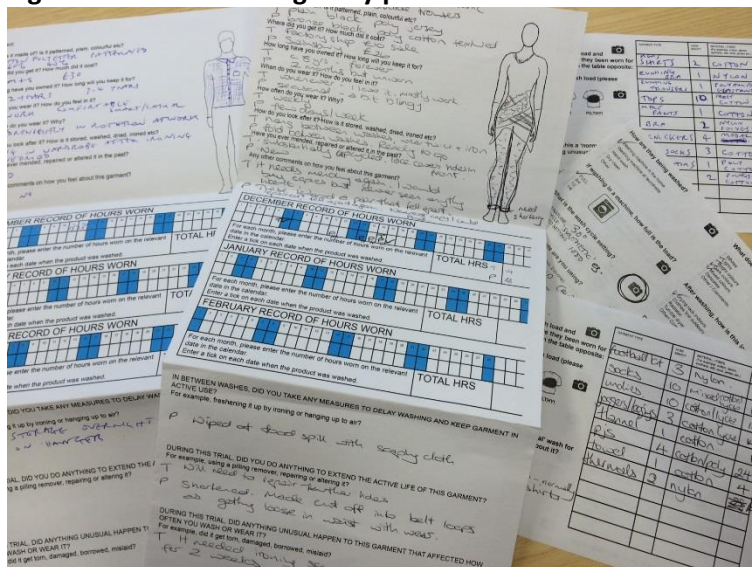


Image: NTU

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 from the consumer research are discussed in Section 5.2.

### 4.3 Expert round tables and workshop

The industry interviews, focus groups and clothing diaries revealed a number of unresolved issues and contradictions concerning the practical implementation of strategies to enhance clothing longevity. In order to explore potential solutions, a series of three 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 were product testing, pilling, and understanding and informing consumer behaviour. Each round table was attended by between four and 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 initial findings from the research, along with examples of good practice. Participants were then presented with a series of specific sub-questions for discussion (Hennink, 2014). The 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 academic panel was invited to lead an expert workshop at the *Product Lifetimes and the Environment* (PLATE) conference in order to 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 exercises

Four pilot exercises with retailers and brands were carried out 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 pilot exercises were identified as a result of the engagement with retailers and brands through interviews and round table discussions that explored the barriers to designing, testing and manufacturing products for 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 practices were effective, what were not and why, to provide evidence and recommendations for improved practice and future research, and to produce findings that could feed into a final toolkit.

The pilot exercises covered the following issues:

- 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 fabric softener that represents consumer practice in laundering.
- Brand C (a niche luxury knitwear brand with its own manufacturing facility): Investigation of a quality problem in manufacturing to identify the cause of severe pilling in cashmere knitwear.

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

## 5 Research findings

### 5.1 Interviews

Findings from interviews with industry representatives are summarised below based on a series of key themes (see Section 4.1). The interviewees were coded according to their role (designer, director, technical, etc.) and the type of organisation they represented: retailer, 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.). The coding 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.

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 factor is offset by the proportion of goods designed and made for short-life and fast style turnover. Supplier interviewees 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 interviewees sell products with a guarantee that they will last for 100 washes or 200-days, 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 one supplier negative about the commercial case for durability, but a retailer, a brand and a supplier each claiming that durability enhances brand value. There is no clear correlation between those supporting durability and market level of brand, as the retailer is considered low value, while the brand and the supplier 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 range 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 retailer/brand 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, illustrating the imperative to command a higher price for an item that is more easily repairable. However, the trade-off issues raised by several others regarding cost and aesthetics are also contributing factors. The same retailer highlighted trade-offs between longevity and other sustainability attributes, such as using recycled materials or improving factory working conditions.

### 5.1.3 Design for durability

Design for durability is associated with choice of materials and their various functional qualities. Most interviewees agreed that it is desirable to ensure that yarns and fabrics are durable, but disagreed in the way to achieve this. Among those supportive of durable materials there was a clear divide between retailers, brands and suppliers who seek to use the most durable yarns with long fibres for stability and those who favour application of the growing range of special finishes and processes that help to make yarns and fibres of average quality last 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 (a supplier) or too rigid (a retailer), or in other ways alter the feel and aesthetics such that they are not desirable. 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 may include greater use of 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, but commercial pressure means that underlying problems are not addressed. This is especially a fast fashion problem because of the rapid adoption of new fabrics and the time/cost pressure associated with introducing 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 one supplier indicated that they anticipate more testing will be carried out at global supply locations in future and the company is equipping laboratories 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°C' care instruction to protect vulnerable items and reduce environmental impact. Others claim that customers do not follow care instructions and that this is damaging to clothing longevity. One brand revealed that specialist international service providers supply generic care label standards for a range of products.

#### 5.1.5 Skills and knowledge

Design for longevity depends on knowledge of technical and durability criteria. Most supplier firms claim that they retain a significant range of skills and knowledge, often acquired over many years, but that retailer/ brand buying teams are deficient in the skills and knowledge needed to influence design decisions positively. This was confirmed by one niche brand 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 issue was the overall loss of skills in the UK resulting from the off-shoring of manufacture and global nature of most supply chains, and a lack of confidence that appropriate technical skills and knowledge are available among off-shore suppliers, an assertion consistently supported by anecdotal evidence from interviewees.

#### 5.1.6 The supply chain

There appears to be a level of distrust between retailers and their suppliers, for example with regard to sharing knowledge and adherence to test standards. Some buying organisations allow 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 could affect quality and consistency and compromise durability (e.g. in the case of luxury yarns). 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 obstacles. Communication to upstream suppliers of expectations and improved practices 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 of limited, short term benefit.

### 5.1.7 Other key findings

Four key areas of focus emerged through the interviews:

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, 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 requiring a degree of technical knowledge and expertise that is currently lacking in many global supply chains. This issue was raised as a limitation in several discussions and reinforces the gap between theory and practice.

## 5.2 Focus group and diary findings

The research carried out with consumers through the four focus groups and experimental clothing diaries was designed to explore findings revealed by previous consumer research in more detail. They helped to explain consumer attitudes, particularly to longevity and clothing care, and this helped to inform subsequent research. The key findings are summarised below.

The focus groups confirmed that consumer segments have differing needs and priorities. For example, they indicated very strongly 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 consumers, visible indicators of longevity considerations may be valued at the point of purchase (such as 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 longevity is influenced by factors beyond technical failure. The focus groups illustrated how unsatisfying user experiences lead to garments having a shorter active life (i.e. are 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 are less likely to have prolonged use. Pilling was identified as a particular problem, and one which both curtails active clothing life from new and inhibits 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 to be more durable and have more lasting appeal as they soften and wear well over time. One focus group observed that these are items which often have a lifetime extended through re-use. However, consumers reported a number of reservations to buying and wearing pre-owned (i.e. second-hand) clothes, such as hygiene, being uncomfortable wearing strangers' clothes, questions of quality, disliking the shopping experience, and perceived prices as unduly high. Perhaps surprisingly, members of the younger (F1) group discussed how they thought older clothes were of better quality, made with more craftsmanship and care, and consequently liable to last longer. Some indicated that they feel trapped by the prevailing fast system of cheap, short-life garments, which 'obliges' them to buy new items frequently. Participants concluded that 'trend-led' should not have to mean poor quality, and good construction and material gives garments potential for longevity despite short-lived trends.

Some of the liveliest discussions were about the mundane, everyday issue of laundering clothes. One aspect common to all of the focus 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 and 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 saving energy, water or time. Few participants were fully conversant with appropriate detergent choices for different fibres, varying wash and spin cycles to preserve clothing quality, or the importance of measuring detergent. Participants suggested that more care is taken with new items, for which labels are checked and items washed separately, and that washing machine programme choices are restricted by limited or unclear machine settings, which vary according to the age of the machine.

Once consumers have decided that clothing items have reached the end of their useful life, some evidently experience a sense of guilt about their disposal. Participants acknowledged that it is not good to act in a throwaway manner but feel restricted by lifestyle factors such as time restraints and a limited and unclear re-use and recycling infrastructure which leaves them with 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 the focus groups and clothing diaries suggest that improved education and information could have a positive impact on clothing care, and encouraging consumers to value all clothing 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 lights' durability labelling system; textile recycling collections; and TV programmes/media promoting vintage clothes and sewing/DIY clothing techniques. The least favourably received were: longer guarantees; online platforms; mending, alteration and repair classes; and 'swishing events'. 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 that they match consumers' expectations and needs in this regard, as well as aesthetics. However, as user experience also



influences emotional attachment and motivates consumers to want to wear items more often and for longer, clothes are more likely to have a long active life if they are both functionally and materially durable, providing a satisfying experience through comfort, style, ease of care, and graceful ageing. Wearing items for longer is important, since the participants lacked enthusiasm for wearing pre-owned clothes. Improving their perspectives of such items and the associated shopping experience could lead to prolonged clothing lifetimes through increased re-use. Higher quality garments are liable have a greater environmental impact if emotional durability and re-use and recycling systems are not addressed. Brands could do more to make care labelling clearer and matched to consumers' relatively standardised laundry practices. Clothing recycling is another 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 Round table and expert workshop findings

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

- physical and emotional durability (encompassing issues of design and product features/performance)
- durability testing and trials
- consumers and care (behaviour encompassing aspects of purchase and care, and communicating with consumers through labelling)
- business strategies for clothing longevity (including new product development, supply chain management, new business models, and associated skills and knowledge).

#### 5.3.1 Physical and emotional durability

Consumer round table participants indicated 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: it can enable garments to be adjusted, disassembled or repaired, or make them easier to care for, or even indestructible, using fused hems and buttons. Testing products in use, such as through extended wearer trials, can generate data to evaluate impact, while better data could also be generated from (design-related) returns and recurring faults; this can inform future fast fashion and shorter NPD cycles to avoid repeating poor design choices.

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

- designing appropriately for both long and short garment lifetimes
- designing for longer use, not just durable products which 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.

An example addressed by the workshop experts was 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 guarantees is difficult.

In order to avoid pilling it is 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 throughout the supply chain is an inhibiting factor. Experts agreed that 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 workshop experts and industry practitioners identified protective finishes that could be applied in production or during washing to prevent pilling, but more evidence is needed to know how well these work in different product contexts and to 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 has greater potential than trying to influence consumer behaviour to avoid pilling; 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 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 garments. 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 using garments for longer. However, some experts suggested that, in order to ensure that both consumer and commercial interests are met, initiatives that promote longevity need to include aspects of 'newness' to alleviate consumer boredom with their clothes and to generate new business or 'add-on' sales and services for retailers and brands. Suggestions included incorporating features that change as the garment ages, adjustable fit, renewal services (repair, freshening, deep cleaning etc.) and 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 colour fastness, stability and shrinkage, and indicating whether an item is fit for sale and short term use prior to being displayed in-store. Many garments are discarded because of poor fit lack of or emotional durability, before physical failure. Items are therefore tested to an anticipated lifetime, rather than to destruction. 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. An agreed standard for comparable tests would be beneficial.

Furthermore, fabric and garment tests and wash tests are considered outdated by some industry experts, inadequate to reflect modern construction, care and 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 today's 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 garment failure. Experts in testing and fabric technology felt that a review of the relative effectiveness of these test methods would be beneficial in order to identify and adopt a consistent test method and pass standard, though it would be necessary to ensure this standard was subsequently 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 greater 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 five 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 in sports and outdoor wear explained that experienced users are engaged in trials but they report mainly on fit and comfort rather than durability. Wearer trials require skilled and experienced testers and a systematic process in order to be objective. 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 are used in specific areas such as car seats and upholstery, rather than clothing, although they could be adapted.

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 across functional roles and throughout the supply chain. The testing round table admitted to a lack of knowledge of any UK or 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 remarked that as demand from retailers is in its infancy test houses are reluctant to embark on what could prove to be a lengthy process.

### 5.3.3 Understanding consumers

While previous studies (e.g. Birtwistle and Moore, 2007; Fisher *et al.*, 2008; Laitala and Klepp, 2011; WRAP, 2012) provide information about consumer behaviours, some industry participants admitted that businesses could do more to improve their understanding of how their specific consumer segments use and care for clothes. Furthermore, consumer round table participants felt 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 behaviour as currently understood, and more importance placed on understanding how consumer behaviours and expectations may change in the future. As brands become increasingly international this applies both to the UK and globally. Past studies show that there are conflicting messages from brands and consumers of how people are perceived to care for their clothes and how they actually do in practice. 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 evidently far more likely than fashion

designers to evaluate products during and after use, and the academic workshop experts suggested that the NPD process in clothing should be informed by 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 this 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. Dry educational campaigns are unlikely to 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 clothes more often than in other cultures (some of which also rely on cold wash systems, as in Spain). In order to change laundry behaviour, finishes can be applied that keep clothes fresh without laundering, and R&D is underway to develop better spot stain removal treatments that could reduce laundering and provide an up-selling opportunity for clothing retailers. A textile-finishing expert agreed that applying finishes could extend clothing lifetimes by reducing the frequency or agitation of washing. Experts at the consumer round table suggested that perceptions of cleanliness also affect consumer acceptance of pre-owned 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 consumer education could help to change this.

Care labelling and guidance for consumers is considered by technicians to be a persistent problem. 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, accessible, non-technical guidance, supported by readily available technology such as 'mobile-friendly' online guidance backed up by RFID or QR codes, could help consumers to make informed decisions and extend clothing lifetimes. For example, guidance to prevent pilling and colour loss, such as washing in bags and with appropriate detergent and fabric softener, could help consumers keep garments in use for longer. For young consumers such information also needs to be culturally relevant and 'cool'. However, it is not clear to which care guidance consumers pay most attention (i.e. garment labels, swing tags, online information, etc.).

#### 5.3.4 Business strategies for clothing longevity

Technical experts admit that currently available durability 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 round table experts agreed that pressure on margins is one of the main constraints. Retail prices for clothing have been static over many years, so retailers and brands increase profits by reducing costs, which in turn threatens quality and premature 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/durability and other

garment/fabric characteristics (including price), putting pressure on the critical path timeline. Tight margins also inhibit innovation and the adoption of new technology. Similarly, making longer lasting clothes is not a priority where this impacts upon 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 of accompanying detailed technical information.

For items designed for durability, guarantees that clothing will last for a specific 'lifetime' (such as 100 or 200-days) were considered by consumer and testing experts to be meaningless unless backed by systematic monitoring and some form of agreed industry protocol. In principle the benefit to retailers would be reduced returns, although commercially this depends on consumers not increasingly returning faulty items that have failed to last for the specified time.

There was some support from the consumer round table for a 'traffic light' system, but this would be very challenging to implement because of style turnover and defining criteria relating to longevity. At best, such a system could provide a very basic guide 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. The potential for a nationwide campaign to promote clothing longevity received more support from consumer round table experts, although some suggested that it would need to be backed by a reputable campaigning and not-for-profit organisation such as the Ethical Trading Initiative or Sustainable Apparel Coalition. Good Housekeeping or Which? could provide consumer guidance, but for all such initiatives clear performance indicators need to be established.

Some members of the academic expert workshop illustrated alternative business model propositions such as the 'slow fashion' approach in which consumption is reduced by designing fashion collections that promote more considered purchasing behaviour. Clothes swapping, 'swishing' (organised events for clothes swapping with friends and neighbours) and hire/lease models were also proposed. These were considered relevant mainly for high value purchases and niche brands, where there is already evidence of a market (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 because scale is important such circular economy models were considered by members of the consumer round table to be more appropriate to the mainstream high street than to smaller niche brands. However, evidence of their impact is currently lacking. Similarly, adding renewal or repair as a service within a retail business model might appeal in some circumstances (e.g. 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 could stimulate change in 'take back' and re-use and recycling schemes.

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. 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, through which clothing longevity failings drive additional sales.

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

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

Earlier, some industry interviewees had questioned whether designers have adequate knowledge to affect clothing longevity, but experts assert that the whole NPD process and supply chain need to be addressed since it is generally accepted that product sustainability, including 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.

There was a consistent concern that, despite the changes discussed by round table and workshop experts, better skills and knowledge are needed throughout the supply chain, within retail teams and among consumers, including understanding why practical skills 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 to upskill technical and design teams in higher and further education in order to embed understanding of product longevity aspects in the future workforce. Design education increasingly needs to encompass a combination of product and service design-thinking.

The round table and workshop experts agreed that industry practitioners should be better empowered to use knowledge in their organisations, especially where this involves linking commercial and technical knowledge, and should take a cross functional approach to setting sustainability-led priorities. At present, there is often no effective mechanism for capturing and recording tacit knowledge and this is a concern in a mature industry as people with technical knowledge and experience approach retirement. Technology could be used to capture data and analyse what is effective 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 in more durable and aesthetic materials. Senior decision makers need to understand the technical, environmental and consumer issues better in order to plan for the future, as the issue of clothing longevity is liable to grow in prominence as global consumption increases.

## 6 Pilot exercises

The rationale underlying the four pilot exercises, the problem identified and the findings are each described below.

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

### 6.1.1 Background and rationale

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

The UK childrenswear market is highly competitive and dominated by supermarkets, which remain the most popular places to buy baby and children's clothing. A survey carried out by Mintel (2014) found that both price and quality are important to parents when purchasing children's clothes, which leads 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 the potential for 'extended' durability testing to support a planned marketing campaign offering a 200-day 'hand me down' guarantee, which would suggest that once the wearer has outgrown the garment it is expected to last long enough to be passed on to a younger sibling. This would include all childrenswear garments and enable the retailer to differentiate its clothing offer within a competitive market. Whilst the testing and quality procedures currently carried out on Brand A's products are to the usual industry standards (i.e. they assess initial fitness for purpose), at present there is no test that will support a 200-day guarantee. The following objectives were thus identified:

- to establish a durability testing regime that could provide the basis for a 200-day guarantee with a 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 durability testing regime
- to assess whether the competitor products met their own promotional claims (where relevant) during durability testing
- to assess the effect of using retailer 'own brand' detergents in durability testing; this could afford the opportunity for a combined marketing strategy promoting both the durability of the garment and the effectiveness of the detergent.

### 6.1.2 Methodology

Two of the three main 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 sixteen 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 during the NPD phase.

The extended test regime, described below, was based on the WRAP Clothing Longevity Protocol guidelines (Cooper *et al.*, 2014). All garments (i.e. 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 durability testing of repeated wash and dry cycles in the laboratory. Each style underwent 40 cycles to represent approximately 200-days or 28.5 weeks of wear and washing; it was estimated that the garment would be washed, on average, between 1 and 1.5 times per week in the 200-day period, equating to between 28 and 42 washes. The garments were washed according to the 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 retailer own-brand product was used as lacks its own detergent range).

Tests 1 and 2 compared selected Brand A garments with like-for-like competitor products using the same durability testing regime. A set of eight 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 findings were then evaluated in terms of their performance against each criteria.

In tests 3 and 4, a further set of eight 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 durability testing regime, as described above, to evaluate any effect of using the brands' own label detergents on clothing 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 durability testing exercises, all the garments were assessed against the claims for product durability promoted on each brand's website.

### 6.1.3 Research findings

The durability 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 grade 4 for colour fastness as advised in the Clothing Longevity Protocol. 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. Three of the T-shirts 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 confirmed 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 therefore unlikely to be noticed by the customer.

- Three of the eight garments failed to 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 (Figure 6.1). As formal measurement had not been undertaken it is uncertain whether the shrinkage was within commercial tolerances.
- All eight garments 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 test**



Image: NTU

Assessment of a further set of the same garments using the brands' own label detergents (where available, i.e. for 3 of the 4 brands) showed results 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 the colour loss was not 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, needs to be evaluated in conjunction with wearer trials, as advised by the Clothing Longevity Protocol.

#### 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 40<sup>th</sup> wash, after which none of them passed the test 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 it 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 (i.e. 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 highlights 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 each 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 helpful to 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 consumer focus groups, demonstrated that consumers needed reassurance about the value of such claims. Furthermore, discussions with industry practitioners during the project, and at the SCAP (Sustainable Clothing Action Plan) Design for Life Working Group, have suggested a need to develop a more consistent approach to product guarantees.

The findings therefore proved 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 decided to investigate the dye process to ensure that colour retention is improved.

A significant limitation was uncovered during the pilot in that 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. Moreover, carrying out extended wearer trials or simulation on the selected garments, in addition to wash tests, would be useful to fully assess the garment lifetime under normal wear and tear conditions, as advised in the Clothing Longevity Protocol.

## 6.2 Exploring Brand B customer's views on clothing durability and longevity

### 6.2.1 Background and rationale

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

The research interviews revealed a lack of knowledge and understanding at brand level of consumer perspectives on the purchase, care, repair and disposal of garments. This pilot sought to identify customers' views of Brand B's products in terms of durability and garment lifetimes, to establish key topics with implications for behaviour change in order to inform initiatives by Brand B aimed at prolonging clothing lifetimes.

### 6.2.2 Methodology

A series of polls and discussions with Brand B's customers were conducted using an in-house consumer research panel. The research included:

- a series of online polls through which to find out about how Brand B customers wash their clothes and how this impacts upon clothing lifetimes
- an online discussion forum to discuss these issues in more detail
- 'live chat' discussion with selected customers from the three most sustainably engaged consumer categories, Positive Greens, Concerned Consumers and Waste Watchers (Defra, 2008), in Brand B's core target group (i.e. aged 35-55)
- an online task in which customers were invited to upload garment 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.

### 6.2.3 Research findings

Clothes from Brand B were generally expected by 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 life-span. Many were prepared to pay more for an item perceived to be of good quality, with around four fifths of poll respondents stating that they took into consideration whether a retailer 'makes quality clothes that last longer' when buying garments. Many respondents recognised that fabric affects 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 consider the life of clothing when washing; indeed, they admitted to doing little to prolong the life of their clothes. That said, nearly all poll respondents separated whites from dark colours when laundering, three quarters used fabric softener and more than one half used spot cleaner. By contrast, less than a third separated clothes into a hot/cold or short/long wash, and less than half used a low temperature wash, many claiming that it does not clean. Respondents generally expected clothes to last for a reasonable duration and not to require much care effort.

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

In general, there was a direct relationship between price and the duration garments were expected to last. For example, winter coats and boots were expected to have a life-span of several years, in contrast to T-shirts and evening dresses. Generally, consumers cleared out unwanted clothes only once per year, primarily to make space and either selling those in good condition or passing them to friends, family or charity outlets. Brand B customers were unlikely to have the skills or willingness to repair damaged clothing. The method of disposal appeared to be influenced more by social factors than environmental concern. Around two thirds of consumers had disposed of garments that were well-worn or shabby and more than one half because they no longer fitted; others had discarded garments because they were bored of them or considered them out of fashion. Clothes that were damaged, well-worn or shabby was often discarded with household waste because owners were embarrassed, or unwilling to donate them to charity in the belief that they had no value.

#### 6.2.4 Analysis and implications

There was an expectation across the consumer research panel respondents that clothing that lasts longer will cost more because it is of good quality. Larger items such as coats are automatically expected to be durable but smaller items like T-shirts could also have longer-lasting versions, particularly as their styling is often classic and they could still be affordable even if engineered for a longer life. This offers an opportunity to promote garments that have longer-lasting properties in terms of fabric or construction. Such properties should not be overstated, but customers could find information about them useful and it could therefore affect their purchase behaviour. Clothing longevity could be estimated and some form of guarantee offered.

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

Brand B customers often discarded clothing when it looked worn (for example, if the colour had faded or there was significant pilling or abrasion) or no longer fitted. Clothes could therefore be designed to offer some flexibility in terms of fit in order to help prolong its life. Although ownership of garments passes from retailers to customers, retailers could retain some responsibility for the clothes that they have developed throughout their lifetime. Customers have limited awareness of how to repair and dispose of clothing in ways that prolong its life (or willingness to do so), and retailers could offer guidance and facilities for this. For example, some consumers have set up Facebook pages dedicated to selling pre-owned garments from specific brands: retailers could take ownership of this system by offering to buy back their products from customers after use and create an online forum to re-sell them through the company website.

The pilot was initiated following discussions that provoked the personal interest of the marketing and sustainability managers, and raised significant surprising findings from informal, internal discussions within different functional teams, demonstrating the importance of personal champions. Commercial drivers included the opportunity to reinvigorate the company's consumer research panel, identify the behaviour change segments (Defra, 2008) to which Brand B customers are aligned, and evaluate how Brand B is perceived by customers, compared to its competitors, in terms of sustainability. The pilot exercise tested various processes in consumer research, some of which subsequently proved useful and informed the final toolkit.

The findings broadly confirmed Brand B's preconceived impression of consumer behaviour, though some were surprising to managers and reinforced the need for clearer care instructions and better information to consumers. The findings influenced subsequent wash tests, although they were considered unlikely to influence the NPD process in the short term because of 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). 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.

## 6.3 Developing a regime for testing colour fastness based on Brand B customer laundering behaviour

### 6.3.1 Background and rationale

In this pilot exercise, Brand B developed and trialled a testing regime to evaluate colour durability using a range of domestic detergents and fabric softener, representing consumer practice in laundering and building on the second pilot exercise.

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 while the dyeing process used in manufacturing may be one of the causes, the laundry process can also have an effect. Brand B's customer survey (discussed in Section 6.2) provided information about how its 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, including colour fastness. It may not, however, adequately represent consumers' use of detergents and softener, of which a wide range has been developed for specific applications. Some are formulated to preserve dark colours, others to brighten light and white colours. There are biological and non-biological detergents, some with stain removers. Most of these appear with or without integral softener.

Consumers are normally advised to separate laundry by colour in order to obtain the best results in the washing process; the chemicals contained in detergents formulated for brightening white fabrics may cause fading in medium to dark coloured garments. Softener is widely used to enhance the feel of garments and give a sense of freshness through the fragrance. The online poll for Brand B found that three quarters of consumers add fabric softener to their wash loads and only one half read the care label, suggesting that they are potentially not washing clothes as advised by the retailer. While a high proportion of Brand B customers separate washing by colour, the focus groups suggested that families and individuals living alone do not always do so, either due to cost/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.

The pilot aimed to replicate customer laundry habits more accurately than existing tests, in terms of the range of detergents and softener used, and to evaluate the effects on colour fastness across a variety of garments, some of which were identified as vulnerable to failure (e.g. black trousers). It was identified that results could provide the basis for potential improvements to laundry instructions, to help to reduce premature garment failure, and 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 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 in which the garments were washed 20 times using a variety of detergents, with and without a fabric softener, 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 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 in the Clothing Longevity Protocol. 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 garments across all of the detergents used; one of the black garments was assessed at a grade 1 for colour fastness after 20 washes using 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 softener in addition to detergent did not have a detrimental effect on colour fastness; in fact, using a softener, 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

softener in addition to detergent reduced colour loss in many cases. Further research could be undertaken in this area to evaluate the use of 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 softener, whereas three quarters of respondents to Brand B's survey add it to their wash.

**Figure 6.2 Swatches following repeated wash tests**



Image: NTU

Even after 20 washes, some of the garments had maintained a pass grade 4 for colour fastness, confirming the industry perception that certain dye colours perform better than others. It was felt that some 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 after a pre-determined number of washes.

The black garments, in particular, performed inconsistently, with one failing to meet expectations (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 in order to support the specification of more effective dye fastness recipes for use in the manufacturing process. This is particularly important for core/classic styles, such as black trousers, where longevity and durability are key.

The pilot confirmed the need to issue clearer and revised laundry instructions to consumers, though wider scale testing would be 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 predict their performance in wear accurately. 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. There is a need to develop an approach to such testing in controlled laboratory conditions that is both commercially viable and safe.

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

### 6.4.1 Rationale and objectives

This pilot exercise involved 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 its 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 softener to reduce pilling propensity. However, it was suspected that there was a problem occurring with the yarn quality and Brand C's 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 (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:

- a) Raw white fibre tested at pre-dyeing stage (post sorting, scouring and de-hairing).
- b) Dyed fibre in two shades (pink and black) tested after dyeing and before carding.
- c) 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). Such tests are able to indicate whether there is any fault in the dyeing, carding and spinning processes causing the fibre to degrade.

### 6.4.3 Research findings

The test results showed that there was no significant impact on fibre diameter in the dyeing, carding and 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 had occurred. An increase in short fibre length significantly increases the propensity of the finished garment to pill or shed fibre during wear.

#### 6.4.4 Analysis and implications

In order to identify more accurately where the damage was occurring, Brand C planned to visit the spinner to test the fibre in sliver form after carding. Control of processes in dyeing and spinning would 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 intends to request additional testing for fibre length after carding and spinning, once the exact cause of the damage is known, to ensure that the problem is minimised.

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

In terms of addressing these potential concern, 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 at what point testing and quality assurance occurs. A new testing protocol to evaluate 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 particularly useful for garments that are made from 100% animal hair, for which propensity to pill is common.

**Figure 6.3 Yarn and Fibre ready for testing**



Image: NTU

The pilot provided evidence that the problem was 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. It highlighted the vulnerability of the process within a global supply chain, even when 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 provided evidence to support improvements, experience highlights the difficulty facing brands trying to enforce good practice and process control in 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 had found that some factories collaborate to improve product aesthetics or performance in the short term, only to revert to their former procedures to save money. Evidence from the pilot helped to reinforce knowledge and strengthen the recommendations passed on to other brands and suppliers, and may lead to more widespread improvements.

## 7 Summary of research findings

The findings from the multi-faceted research process are drawn together and presented in this section. They address the product and how it is designed, tested and cared for, consumer needs and behaviour, and innovation, product development and supply chain processes. Obstacles are also identified: the slow pace of adoption within the clothing sector, conflicting priorities and the complex nature of multi-agency solutions suggest that policy is essential to drive change and maintain the prominence of issues concerned with product longevity and its potential to impact positively on sustainability.

### 7.1 Implications for industry, policy and research

The practical implications of the research are presented in Table 7.1 in the form of recommendations to develop and improve industry practice and implications for policy and research. The table has four sections: (1) Physical and Emotional Durability, (2) Durability Testing and Trials, (3) Consumers and Care, and (4) Business Strategies for Longevity.

**Table 7.1 Key findings, industry recommendations and implications for policy and research**

#### 1. Physical and Emotional Durability

Key findings	Industry recommendations	Policy / research implications
<b>Product</b>		
<p>Too many retailers have devalued and reduced the quality of products over time. Longevity is often regarded as a care issue.</p> <p>Product failure through pilling, shrinkage and colour loss is of most concern to consumers and designers, especially in knitwear and jersey tops. Pilling in particular leads to premature disposal, as pilled items are less likely to be handed down or donated.</p>	<p>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.</p> <p>Producing clothes 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 materials and processes.</p>	<p>The policy landscape for sustainable products, specifically clothing, needs to promote the longevity agenda and encourage business initiatives to support this.</p>

<p>Design influences the quality, care and re-use/recycling potential of garments, but the priority for most 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 enhance product durability.</p> <p>Some products are accepted for sale having failed quality or durability tests in order to maintain ranges and replenish stock of fashion lines.</p>	<p>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 recycling for fast fashion and longer active use for higher value and core products. However, this approach requires an infrastructure through which to provide information throughout the supply chain and for collecting used fashion items for resale or recycling.</p> <p>Companies may utilise online guidance notes produced by WRAP (2016c), <i>Design for Extending Clothing Life</i> to design different categories of clothes with longevity in mind, and set and maintain specifications.</p>	<p>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 use an adequate timescale to research and adopt innovation, implement change, and measure impact.</p>
<p>Dye methods can be a major cause of colour loss through laundering, which leads to premature failure and inadequate longevity.</p>	<p>Ensure dye methods are consistent across the industry and methods are tested to minimise colour loss.</p>	<p>Further research is needed to identify dye methods that can minimise colour loss.</p>
<p>Some product areas are moving towards adopting technical finishes and processes to support longevity. Examples include <i>Lycra Xtra-Life</i> and <i>M&amp;S Stay New</i> which are being extended across product ranges and core products.</p>	<p>The potential of technical finishes and processes to extend clothing lifetimes should be evaluated by all companies and product developers.</p>	<p>Further independent research is required to understand the implications of technical finishes on product lifetimes, aesthetics, wear, cost and the environment (e.g. through LCA).</p> <p>Technical research could help to make such finishes and applications more acceptable to consumers.</p>
<p>While durability affects the desire of consumers to retain and use clothing for longer, there is a wider set of influences that support emotional engagement and influence use, re-use, recycling and disposal behaviour. These</p>	<p>Companies need to understand emotional durability and its relevance to their specific consumer segments.</p> <p>The design process should encompass user-centred design principles to evaluate</p>	<p>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.</p>

are seen as increasingly important to ensure that garments have a longer active life.	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.	Research is also required into how evaluation of size and fit can be embedded into the critical path and how this relates to emotional durability.
<b>Re-use and Recycling</b>		
Consumers are resistant to purchasing pre-owned items due to concerns about hygiene, cost compared to new items, and lack of attractiveness of pre-owned outlets.  Textile waste recycling schemes are inconsistent geographically and across collection streams.	Clearer disposal instructions should be provided on garment labels. Clothing banks and collection schemes for well-worn items should be made more widely available and visible.  Retailers should take greater responsibility for the return of their own products into the re-use/recycling system.	Local Authorities should be encouraged to provide more widespread textile waste collection.  Alongside the collection of garments for re-sale, campaigns should make clearer the potential for recycling well-worn clothing.

## 2. Durability Testing and Trials

Key findings	Industry recommendations	Policy / research implications
<b>Testing and Trials</b>		
An emerging trend among certain brands is to specify product durability expectations or guarantees. Such claims require more systematic testing and comparable measures. Examples are found in product categories such as leisurewear, underwear and schoolwear.	Product guarantees could trigger greater demand for testing to back-up such claims. A testing protocol, such as that already developed for WRAP, should be adopted more widely, enhanced and professionally verified.  External/independent bodies could be involved in comparisons and measuring durability in terms such as cost per wear and benefit to the customer.	Initiatives that bring together third sector organisations, business media and independent evaluators could enhance the effectiveness and profile of schemes to extend and guarantee clothing durability.
Standard tests for durability are not routinely carried out,	Testing helps to inform successful sourcing of	Research support for extended durability tests and a

<p>and the pilot exercises suggested that extended tests carry substantial resource implications.</p> <p>In practice, testing and design processes are challenged by commercial pressures. Extended tests could therefore face resistance.</p>	<p>materials, dyestuffs and processes, and establish future specifications. Findings from extended tests could help to provide information for consumers on how to care for items and for retailers on how to make some specific items more durable.</p> <p>Opportunities for simulated testing that could shorten the testing process should be explored.</p>	<p>comprehensive set of standards is needed, since the current age, range and process of available tests represents a market failure.</p>
<p>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 present time, demand is in its infancy.</p> <p>Tests for durability need to be capable of testing garments to destruction, in typical wear and care conditions.</p> <p>Tests (and design) need to reflect in-use behaviours and better synthesise wear and care, taking account of detergents and washing machine programmes.</p>	<p>The testing infrastructure needs to be updated if tests for durability are to become more widespread. There is a need to explore the business case for developing new tests and standardising expectations across the sector.</p> <p>Tests that can simulate wear need to be developed, to avoid lengthy and unscientific wearer trials. New technology should be adopted to evaluate the results objectively.</p> <p>The testing landscape needs to develop and accredit tests that reflect the reality of consumer use i.e. reflect wash repetitions and practices, and synthesise wear and tear as accurately and scientifically as possible.</p>	<p>Research to understand the business case for clothing longevity needs to encompass testing organisations.</p> <p>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.</p> <p>Research to develop new and improved tests for durability is needed to reflect the international nature of the testing industry; the globalisation of the supply chain and apparent cultural and regional differences in consumer behaviour with regard to garment care and use.</p>
<p>Extending traditional wash and wear trials is possible, but highlights some shortcomings in terms of both process and measurable outcomes. The resource implications are also considerable.</p>	<p>To test garments over time requires a benchmark for acceptable degradation of dye, pilling, print, shape etc. (e.g. an expected performance standard after 5/10/20 washes).</p> <p>There is a need for an accelerated and robust test protocol for durability tests of garments, as well as yarn and fibre. Economies in the process are needed as</p>	<p>Industry collaboration to develop a benchmark standard needs to be encouraged.</p>

	repetitive washing is expensive and time consuming.	
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### 3. Consumers and Care

Key findings	Industry recommendations	Policy / research implications
<b>Consumers</b>		
Focus groups confirm that there is a willingness among consumers to change, at least in certain consumer segments.	Better knowledge would help to identify consumer segments most likely to respond to specific business approaches to longevity (such as promoting 'investment pieces', repair or recycling).	Research to increase knowledge of consumer behaviours regarding sustainability should be ongoing in the clothing sector to encourage brands/retailers to respond more quickly and to forecast future opportunities.
Consumers are blamed for poor garment care, while companies place considerable emphasis on changing their behaviour without fully understanding the actions and motivations of their target groups.  Brands need better understanding of their customers, specifically around sustainability issues. Large retailers do not routinely undertake market research on clothing longevity. To do so effectively would require a co-ordinated approach between marketing and product departments, as well as external service providers.	Increased knowledge would enable retailers to distinguish between consumer behaviour that they can influence and that to which they must respond themselves - for example, improving care guidance cf. providing adjustable fit to accommodate weight gain/loss and comfort.  Designating 'sustainability champions' is a means of implementing change within a business. The personal experiences of influential individuals with a cross-functional role can influence decisions to explore consumer behaviour.	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 the information required on product labels is reviewed.
<b>Care and Labelling</b>		
Consumers report that the way they care for their clothes is not consistent with garment labelling; most of them wash for convenience or economy. Confusing (and sometimes conflicting) messages mean that consumers often do what they feel (or have been taught)	Design for longevity should include practical care guidelines.  Care guidance needs to be simplified and standardised so that instructions to wash specific 'batches' (e.g. dark and light) are easily identified.	Standardisation of care instructions requires external influence to ensure objectivity where it is part of a voluntary scheme.  Improved infrastructure is needed to support additional information for consumers that is appropriate and

<p>is best, rather than acting from an informed perspective.</p> <p>Routine product testing does not reflect typical care behaviour. Garments are designed for aesthetics rather than their ability to withstand 'standard' care conditions (e.g. a dark or white 40°C wash) used in tests.</p>	<p>Consumers need better advice on laundering, such as differences between detergent products and when/why to use different programmes.</p> <p>Care instructions should reflect real world conditions and could be standardised across garments and retailers.</p>	<p>accessible for all target consumer groups.</p>
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#### 4. Business Strategies for Clothing Longevity

Key findings	Industry recommendations	Research / policy implications
<b><i>New Product Development</i></b>		
<p>A 'systems thinking' approach is utilised in design for sustainability in other product sectors. Currently it is exemplified by a few niche clothing cases, such as Eileen Fisher. It is not yet clear whether this is transferable to mainstream clothing design and scalable.</p>	<p>A consistent, multi-disciplinary approach to design for longevity is essential. It must take into account cost and aesthetics, as well as emotional and material durability and environmental impact.</p> <p>Clothing design 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 options.</p>	<p>Initiatives to explore and enhance longevity in clothing should incorporate opportunities to exchange approaches and share findings and good practice across product sectors.</p> <p>The biennial PLATE (Product Lifetimes and the Environment) conference is a forum where this is already evident.</p>
<p>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.</p>	<p>Businesses need to address the gap in skills and knowledge by improving 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 to commercial functions, to develop approaches to costing product failure and evaluate the business case for longevity.</p> <p>Skills and knowledge for all groups (young to mature consumers; designers; retail</p>	<p>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.</p> <p>Initiatives to promote upskilling of the clothing industry should address potential re-shoring to ensure highly skilled UK clothing manufacturing. They also need to be consistent with a global</p>

	staff; technical teams; senior managers, etc.) should be provided in user-friendly and accessible ways.	agenda to upskill the supply chain and improve standards.
<b>Supply Chain</b>		
Change in the clothing industry is retailer/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 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, both in the UK and internationally.
Strategic objectives differ between retailers and suppliers. Suppliers are not always consulted on choice of materials. Some 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, adherence to standards and transparency.	Success in improving product durability requires better traceability throughout the supply chain. Better monitoring information is needed to improve knowledge of both the product and processes. 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 materials used in clothing exported to China shows how this can improve quality across product ranges, and has already promoted change within some brands.	Research needs to take into account opportunities for the clothing industry to adopt new innovations and practices e.g. technology to trace products and processes throughout the supply chain; technology to instruct recycling processes how to deal with specific items automatically; scanning technologies to predict product failure; mass customisation to enhance emotional durability; 'big data' to measure consumer purchasing behaviour. The UK Government's Industry 4.0 agenda needs to be positively associated with opportunities to enhance clothing longevity.
Third sector 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. Expanding this approach could help to generate and endorse supply	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.	Government policy could incentivise small retailers/brands through favourable business rates for retail outlets that offer repair and recycling services.  Research to evaluate novel business model applications piloted by larger brands could



<p>chain practices that support clothing longevity.</p>	<p>Partnerships with Third sector organisations and between large and small retailers should be encouraged to facilitate change and help publicise and commercialise new initiatives.</p>	<p>lead to workable demonstrator projects and wider-scale adoption. Those being developed by REBus provide an example.</p> <p>Cross-brand supply chain initiatives would benefit from the involvement and endorsement of commercially neutral, third sector organisations.</p>
<p><b>Technology and Innovation</b></p>		
<p>Innovation in technology will impact on the ability of retailers and brands to design and commercialise clothing with a longer life.</p>	<p>Businesses need to accelerate the pace of adoption of innovative processes in order to keep pace with technology, respond to changing consumer expectations and take advantage of future opportunities.</p>	<p>Research on clothing longevity needs to address issues beyond the technical case for longevity, since issues relating to business models and supply chain challenges appear harder to resolve than the physical longevity of the product.</p>
<p>A range of technology solutions exist: 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.</p>	<p>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.</p> <p>Better use of data analytics and knowledge banks could 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.</p>	<p>Research should 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.</p> <p>Demonstrator projects are needed to test and evaluate the potential impact of new technologies on enhancing clothing longevity.</p>
<p><b>Business Models and the Business Case</b></p>		
<p>The case for producing fewer, higher value products is compelling, but commercially unproven, to some observers, while to others it is considered commercially damaging, depending on brand niche and</p>	<p>Businesses need to develop internal cross-functional teams including design, technical, marketing and finance expertise, to evaluate the potential costs and benefits of</p>	<p>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 increased clothing</p>

<p>target consumer segments in the UK and internationally.</p>	<p>designing for increased clothing longevity objectively.</p> <p>The EU and wider international perspective needs to be considered, especially as many retailers/brands have international markets (and are increasingly targeting emerging markets).</p>	<p>longevity in association with industry.</p>
<p>Sharing knowledge with customers promotes repair and better care. WRAP's <i>Love Your Clothes</i> initiative helps to promote better clothing care effectively, but supplementary (or different) offers and communication channels may be required to enhance awareness and target additional consumer segments.</p>	<p>Services to extend garment life need to be represented in new business models that mix product sales with additional services.</p> <p>More retailers and brands should collaborate with initiatives such as <i>Love Your Clothes</i> in order to encourage consumers to change their behaviour.</p> <p>Services need to match brand image and target relevant consumer segments, providing a sense of newness and the 'feel good' factor, as well as being regarded as 'cool', motivating and rewarding.</p>	<p>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.</p> <p>Engaging celebrity and cultural icons and embracing the latest technologies and effective social media (such as 'vlogging' and YouTube) could be effective.</p>
<p><b>Agency and Governance</b></p>		
<p>As yet, the case for scaling up the 'slow fashion' model has not been effective and no clear avenue for addressing it at executive level. Governance behind sustainability generally, and longevity in particular, is inconsistent and lacks strategic priority.</p> <p>Actions that affect clothing longevity take place at all stages along the supply chain and during use. All organisations and consumers need to be involved, in some way, in extending clothing lifetimes.</p>	<p>Senior managers need to understand the strategic significance of clothing longevity in terms of business responsibility and the wider impacts, including material security and landfill waste.</p>	<p>Even though many clothing organisations are SCAP signatories, sustainability policy may need to include mandatory measures unless there is a clear commercial benefit.</p> <p>A more strategic approach to clothing longevity is required. Campaigns need to influence policymakers at the highest level if change is to be implemented on a wider scale.</p>
<p>Retailers/brands pass responsibility to the consumer</p>	<p>Consumers could do more to value and care for clothing for</p>	<p>Retailers and brands may need a policy incentive to encourage</p>

<p>to care for garments in a way that makes them last longer through information on the care, even when the instructions are confusing or do not match typical consumer behaviour.</p>	<p>longer, but retailers/brands need to take more responsibility for the design of clothing such that it endures behavioural norms. They should also provide clearer information and services to enable consumers to act differently where appropriate.</p>	<p>them to take responsibility for the impact of their products during use and at the end of their life-spans.</p>
<p>Technical knowledge to support longevity, such as the 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.</p> <p>There is a lack of clarity regarding responsibility for new tests for longevity. It is unclear whether retailers or the testing industry should initiate new developments.</p>	<p>A multi-functional approach to design for longevity is required that takes into account the skills, knowledge and contribution that the organisations throughout the supply chain can make, supported by consistent objectives and information sharing.</p> <p>The testing industry needs to be more closely involved in the process of design for longevity.</p>	<p>An industry-wide approach may be needed to improve technical knowledge across the sector.</p>
<p>There is a perception that small retailers/brands have greater flexibility to change their products (and processes) and are more able to benefit commercially from doing so, but have limited influence over their supply chain. Designers in many large firms experience a lack of influence within their companies.</p>	<p>A multi-functional approach in larger organisations could help to increase understanding of the environmental impact of clothing longevity and clarify the contribution that design and technical teams could make to reducing this.</p>	<p>Research is needed to understand the impact of small scale initiatives that support clothing longevity and the extent to which they are scalable.</p>

## 7.2 Conclusions

Recommendations arising from the project are intended to address technical and commercial obstacles and facilitate a more pro-active, future-facing approach to design for longevity. The research confirmed that, in principle, garments could last longer.

The decision as to how change should be co-ordinated throughout 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 increased longevity as a 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 into factors that affect clothing longevity:

1. *Textile and yarn finishes and garment production techniques* are available that can support clothing longevity; these include anti-pill finishes, treatments that enable reduced wash frequency, and fused seams, hems and buttons that enhance durability (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 obstacles, constrain their use (Section 5.1.3). Lack of collaboration across the various actors within the supply chain means that these issues are unresolved (Sections 5.1.5, 5.1.6 and 6.4.1), while their impact on product lifetimes, 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 lifetime and there is variation across the industry in the interpretation of test results and pass/fail criteria (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 research highlighted the complexity of establishing any new test procedures, there is a need to define tests and achieve suitable metrics and objective measurement techniques, consistency of application, and relevance to real-life consumer behaviour (Sections 5.3.2, 5.3.3, 6.3). There is an opportunity to make use of historic data to predict issues and inform future seasonal ranges.
3. *Retailers and brands* could do much more to encourage consumers to carefully maintain, repair, re-use and recycle their clothes to prolong garment lifetimes. 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 maintain 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, as clearer and better guidance would enable consumers to make informed decisions about garment care that would also meet their needs in terms of cost, convenience and energy/water consumption (Section 3.5). There is a need to change messages relating to garment care in response to prevailing care behaviour 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 the 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 *NPD skills and knowledge* in retailer/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). Improvements are needed in skills training (in industry and pre-industry/apprenticeships) and in the acquisition and retention of technically skilled staff, and, within the retail sector, greater emphasis placed on practical training, problem-solving, experiential learning and CPD. In parallel, there is a need 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 NPD 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 process (Section 3.7). Retailers and brands should adopt the Clothing Longevity Protocol checklist devised for WRAP (Cooper *et al.*, 2014; WRAP, 2014) and ensure that the materials, components and garments selected for sale support clothing durability (Sections 5.3.1 and 6.4).
7. A range of *technical innovations* could lead to increased clothing 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 enhance 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. *Research* is needed to expand on pilot exercises, such as those undertaken during this study, and scale them up to workable trials. For example, Brand A's pilot exercise on durability testing (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. Similarly, extended wash tests such as those undertaken by Brand 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 softener on pilling and dimensional stability.
9. The major constraint to designing and making longer lasting clothes 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/brands and their customers (Sections 5.1 and 5.3).

The research sought to resolve a range of questions concerning clothing longevity. In assessing how existing NPD processes and associated behaviours impact on supply chain performance, in terms of cost, time and product longevity, it was evident that cost remains a dominant factor. Design decisions are predicated upon cost, with time a significant 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 a lack of priority placed on clothing

longevity, uncertainty regarding their advantages and disadvantages in different products and markets and, in some cases, cost. Innovations in the testing process could be adopted to improve product durability, but these often face obstacles, not least the requirement for a commercial case to be made before the complex, 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, skills and knowledge necessary to design and produce longer lasting clothing. Such developments need to apply across multi-functional teams and at key stages throughout the supply chain (including fibre, yarn and materials supply). However, their effectiveness will be contingent on improved governance structures that enable appropriate 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 garments in active use for longer will require more carefully considered design and marketing approaches.

These findings suggest a range of policy recommendations, summarised below (see also Table 7.1).

1. Support for persuasive, short term initiatives that promote the longevity agenda within business and consumer contexts. There is scope to improve promotional messages for different target groups, but also to use marketing techniques, celebrity endorsement, social media and new technologies to engage consumers.
2. The provision of resources and infrastructure to support education, training, knowledge-sharing and collaboration, both within and between organisations in the supply chain. This could enable the exchange of knowledge within the sector, and also between clothing and other sectors. There is considerable scope to inform consumers more effectively in how to buy, care for and dispose of clothing, although this may require government intervention to overcome conflict with commercial priorities.
3. Applied research on commercialisation of the business case and the adoption of new technologies, processes and testing related to longer lasting clothes needs to be supported in the form of longer 'proof of concept' trials. Research is also needed (both in the UK and internationally) to increase understanding of emotional durability and user-centred design. Such research is required to strengthen the business case and influence consumer behaviour.
4. Guidance and legislation to improve the clarity and reduce the complexity of garment labelling. Improved infrastructure and awareness of re-use and recycling initiatives is needed to help consumers make informed choices. Retailers and brands should be required to take greater responsibility for their products, within the context of a circular economy, in order to avoid excessive materials consumption and reduce waste.

### 7.3 Dissemination

A range of activities have been undertaken to disseminate project findings in order to provoke discussion, inform industry practice and further academic research.

The project findings have informed the production of a toolkit, the *Clothing Durability Dozen*, aimed at enabling industry practitioners, trainees and educators to adopt practical approaches to clothing longevity.

## 7.4 Further research

The project uncovered several key issues that merit further research if the objective to reduce negative environmental impacts through increased clothing lifetimes is to be achieved:

- Research is required in order to understand the potential for adopting new technologies that could support the business case for increased clothing longevity. This study revealed that there is potential to enhance the technical design and testing of longer lasting clothes, improve collaboration throughout the supply chain, and facilitate the sharing of communications and knowledge with customers and stakeholder groups. As few of these initiatives are operational on any scale and technology is evolving rapidly, ongoing specialist research and evaluation is required. New finishes and treatments exist that may help to maintain longer garment lifetimes. 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.
- There is a need to extend conceptual models and short pilot exercises into wider scale demonstrator or 'proof of concept' trials 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 environmental impacts, and develop strategies to resolve any trade-offs between commercial, consumer and sustainability requirements.
- The project has been informed not only by previous research in the UK 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. Further research should explore the international dimension and establish the transferability of UK and Scandinavian findings, in order to assess opportunities and obstacles associated with global retailers/brands and testing services, and the global supply chain.

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