Rethinking the Fashion Value Chain: How Reshoring Can Create a Localised Product Lifecycle and Support Sustainable Economic Growth

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Abstract Historically, the UK was internationally renowned as a thriving manufacturing hub within fashion and textiles, with production being steeped in quality, heritage and craftsmanship. Although it is no longer a country synonymous with fashion manufacture, current industry activity contributes £20bn annually to the economy, with 34,045 businesses in operation, employing 500,000 people across manufacturing, wholesale, and retail. While this seemingly healthy industry is economically sustainable, the market continues to source products overseas, with a heavy reliance on countries such as China, Bangladesh, and Turkey. This level of global sourcing has significant environmental and social impact, the majority of which is largely unknown to stakeholders such as brands, retailers, and consumers. Despite these negative consequences, the import of fashion products continues to increase annually with £27.7bn of goods being imported in 2020, compared to £25.9bn in 2019. Meanwhile, exports remain relatively low at £8.9bn in 2020, creating a significant imbalance of the flow of goods in a post-Brexit environment.

The consumption of fashion has also continued to rise, with the UK having the highest level across Europe. Annually, consumers spend more than £45bn, catalysed by the fast, and ultra-fast fashion business models providing accessibility across multiple platforms and channels. Low costs and high volumes have decreased the consumer value of clothing resulting in short-term ownership and premature disposal. Consumer understanding of global fashion supply chains remain minimal, creating a disconnect between clothing production and consumption. The imbalance of imports and exports in the UK, coupled with increasing levels of consumer purchasing, presents a significant opportunity for future innovation. Challenging

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current systemic norms through the reshoring of production would have positive economic impact nationally, creating a thriving, sustainable industry.

This chapter challenges traditional, linear methods of overseas production and questions the reliance on overseas supply chains as opposed to more localised manufacturing options. Furthermore, it explores how advancements in technology can help fill a gap in the skilled labour force, natural resources and equipment needed for garment manufacturing at scale. Rethinking the production and consumption of fashion is long overdue, with current methods no longer practical for staying within the Earth's planetary boundaries. Radical transformation is needed, with novel and innovative solutions required to drive forward meaningful change towards a responsible future.

Keywords Reshoring · Systemic change · Sustainable business models · Textiles · Innovation

1 Introduction

Due to human and industrial activity, the earth is warming. The consequences of a 0.5 °C temperature increase can be the difference between life and death for some species and could render large areas of the earth completely uninhabitable. The evidence of climate change is already being witnessed globally: deadly hurricanes in America, wildfires across the Arctic Tundra and Artic ice sheet melt, occurring 90 years ahead of the predicted schedule (Stand.earth, 2019). However, further warming means that these events will only escalate: at 2 °C of warming the ice sheets will begin to collapse, 400 million more people will suffer water scarcity and major cities situated near the equator will become unliveable; at 3 °C of warming, southern Europe would be in a state of permanent drought and the areas burned each year by wildfires would double in the Mediterranean and sextuple in the United States; at 4 °C there would be 9% more heat-related deaths and in some places up to six climate-driven natural disasters could strike simultaneously with damages surpassing $600 trillion (Wallace-Wells, 2019).

In response to this urgent climate call, many conflicting agreements have been made in recent years to try and reduce warming levels through carbon pollution reduction. The Paris Agreement developed in 2016 states a 40% reduction in global carbon pollution to remain below 1.5 °C of warming, while the UN Fashion Charter members have agreed to a 30% reduction by 2024 (Stand.earth, 2019). However, these reductions are being challenged, with many Member States choosing to offset their carbon emissions as opposed to addressing the original cause, counteracting the potential good these global targets could have. In 2019, United Nations addressed their general assembly stressing the urgency for states to act collectively and responsibly, stating that we have just 11 years to change our ways before irreversible damage is caused to the planet through the catastrophic effects of climate change (United Nations, 2019). However, more recent reports have emphasised the urgency of such

action in what is being labelled as *The Closing Window* (United Nations, 2022), referring on the limited time remaining to make meaningful action. While the reduction amounts and timescales are disputed, what is not disputed, is the need to change to avoid horrifying environmental consequences.

Despite glamourous connotations, fashion's linear lifecycle operations and exponential growth in consumption, contributes more to climate change than aviation and shipping combined (Environmental Select Committee, 2019). The processes undertaken during the manufacture, use and disposal of garments utilises a large volume of natural resources, emits harmful, toxic pollution and generates vast quantities of both pre- and post-consumer waste. Furthermore, contemporary modes of consumption contribute to a lack of care and conservation of garments, meaning that premature disposal is prevalent within the value and mid-level markets. Consequently, fashion has been labelled as the second most polluting industry in the world, causing 8.1% of the world's total carbon emissions (Stand.earth, 2019) across the product value chain.

To meet the consumer demand for fashion, product manufacture relies heavily on global supply chains, with environmental and social compromise being common, and often required to meet short deadlines and high volumes. The consumer's desire for large amounts of clothing, purchased at cheap prices has been exacerbated by the development of the fast, and ultra-fast fashion business models, with some brands driving retail price down to just a few pence per garment. Annually, UK consumers spend more that £45bn purchasing 26.7 kg per capita reflecting the highest level across Europe. This compares to 16.7 kg in Germany, 16.0 kg in Denmark, 14.5 kg in Italy, 14.0 kg in the Netherlands and 12.6 kg in Sweden (Commons Select Committee, 2018). Consequential of cheap prices and levels of accessibility, consumer value of clothing remains low, instilling a lack of care and little incentive for maintenance, resulting in short-term ownership and premature disposal. This linear model of production and consumption is unsustainable and no longer fit for the contemporary world, with the resource of three planet earths needed by 2050 if current levels are to be sustained (Environmental Select Committee, 2019).

The vast scale of the business remains both an economic asset and a key challenge, with revenue contributing £20bn annually to the UK. However, the reliance on overseas production has imposed an imbalance between imports and exports of clothing within the market, with £27.7bn of clothing imported in 2020, while only £8.9bn exported. This presents a significant global market opportunity for future innovation, with the need to explore sustainable methods to increase UK garment manufacturing as an alternative to overseas production.

This chapter presents an analysis of the fashion value chain, highlighting key areas of environmental and social concern within current practices, from both a production and consumption perspective. It aims to challenge current thinking on sustainability and proposes possible approaches to *re-shore* textile and garment manufacture to the UK as a feasible and commercial opportunity. The integration of advanced technology within the supply chain will be integral to the success of the proposal, harnessing new manufacturing methods to restore the UK's reputation in textile innovation and offer sustainable economic prosperity.

2 The Clothing and Textile Economy

This imbalance between the planet and its human inhabitants has been labelled as the Anthropocene, a geological term which refers to the global scale of environmental changes brought about my agricultural and industrial activity. This level of human influence is said to have had a powerful and permanent impact on the history on the earth, with both technology and social change needing to be part of the future (Brooks et al., 2018).

The start of the Anthropocene has been heavily debated, with many believing it to align with the start of the industrial revolution in 1760, where the use of fossil fuels such as coal, oil and gas, became common practice. During this time, key machinery for the creation of textiles were developed such as the spinning jenny (1765), power loom (1785) and the cotton gin (1793). With industrial machinery, textiles can be manufactured in much larger quantities than before due to increased speed and efficiency. By 1870, textile manufacturing operated more steam engines than other sectors of the economy, utilising fossil fuels in preference to more traditional waterpower methods used in earlier textile mills. This shift was again an efficiency measure, as waterpower was often seasonally affected and relied on a waterside location. By the 1920s, new materials had begun to emerge and were increasingly being used for fashion purposes. Synthetic fibres such as acrylic, polyester and nylon were being widely produced, indicating the expansion of the oil industry, and signalling a shift in the use of natural, finite resources for fashion production. Before the 1980s, the manufacture of fashion and textile products were predominantly done in-country, with areas of the UK such as London, Manchester, and the Scottish Borders housing healthy production hubs, providing hundreds of thousands of jobs for local workers. However, by the early 1980s, globalisation facilitated a move of large quantities of this production to move offshore to countries such as China, aiding brands to cut costs and increase their margins. By the mid-1990s, most of the production had moved abroad and by the early 2000s, the UK clothing and textiles sector employed its lowest number of workers with only 90,000 remaining in operational mills and factories (Bearne, 2018). While offshoring may have made good business sense at the time, it brought with it a multitude of challenges, many of which were regarding sustainable and ethical practices. The economic crash and period of recession in the UK in 2008 saw a new model of consumption emerge within fashion, one that favoured large quantities of low-cost clothing in preference to quality. Fast fashion acted as a catalyst for the speed and the volume of fashion consumption, facilitated by an abundance of synthetic fibres and a cheap labour force in countries such as Bangladesh, India, China and Morocco.

Geographical patterns in overseas production can be evidenced with the growth of manufacturing regions in response to the increasing demand for large quantities of clothing at ever-cheaper prices. This phenomenon has been described as *chasing the cheap needle around the planet* (Environmental Select Committee, 2019), meaning that fashion retailers continuously seek countries with a lower minimum wage to facilitate competitively priced products in the market. However, this top-down

pressure can often result in a compromise in social working conditions and standards including forced and non-paid overtime. Working in opposition to this direction of travel from many mass-market retailers is a consumer movement which reflects a growing awareness of social and environmental impact from the fashion industry. This consumer uprising has in contrast been labelled as *chasing the ethical pound,* indicating that there is an increasing consumer demand for their clothing to be made under fair working conditions and with minimum impact to the planet. Despite this positive body of consumer action, there remains a dichotomy between fashion and sustainability, with the need for the market to grow and economic activity to expand or face an uncertain future for the industry (Brooks et al., 2018).

2.1 The Fashion Value Chain

The lifecycle of a garment is a complex system, involving many resource intensive processes, multiple geographical locations and the production of harmful emissions and waste. From concept to disposal, a garment undertakes a long and intense journey which differs significantly from product to product, each following a unique path determined by many variables. However, the intricacies of the garment lifecycle do not reflect the lifespan of a garment, nor the speed under which this process is undertaken, with a series of extremes evidenced across the fashion industry. Many variables are determined by the market sector, including price, quality, and material. These factors can also infer the intended lifecycle of the product, influencing the consequential consumer-product value, longevity and disposal methods.

The traditional fashion industry operates a very linear lifecycle, often expressed as the *make, take, dispose* model of production and consumption, and is said to no longer be fit for the contemporary world (McDonough & Braungart, 2010). This refers to the use of resources (energy, water, and raw materials) needed to create a fashion product, which is then purchased and used by the consumer, leading to the product being disposed of at the end of its desirable or useable life. This systematic approach to fashion means that value in the garment is retained for a constraint period before it is discarded by the owner. The period this linear production process occupies can again vary wildly, with fast fashion retailers such as Zara taking only five weeks from catwalk to consumer. Alternative lifecycle models attempt to prolong the lifespan and value of a garment by providing different end-of-life options to the user opposing the discarding of the garment to landfill. These options range from repurposing the garment to extend the desirability and usefulness of the product, to donating the product to charity or a friend to create a multiple ownership model and thus extending the lifespan of the garment. Unlike the linear lifecycle model, this model creates multiple ownership loops, extending the lifespan of the product to a certain degree before the product is eventually disposed of. Often referred to as the recycling model, this series of one or more loops provides the opportunity for a new usable life to be created preventing premature disposal. The final lifecycle model often discussed within a fashion context is a cyclical model

which retains the value of a product indefinitely within the lifecycle. This model adopts the iterations evidenced within the recycling lifecycle model, but instead of the product eventually ending with disposal, the circular model suggests that the material resources in the product will be reused, in one form or another, time and time again. This approach negates the additional input of raw materials, energy and water needed in the creation of new products, favouring the use of existing materials through reuse, repair or repurpose methods. The possibility of this model being applied within a fashion setting has in the past been questioned due to the limitations of recycling textile fibres, especially those derived from man-made resources. This is partially due to the energy and resource intensity required for reuse methods, but also the heavy use of mixed fibre blends in the production of mass-market fashion, deeming the disassembly for recycling purposes void.

The shape that the lifecycle model adopts can be debated; however, the systematic approach within the fashion industry remains standardised, providing the general sense of the journey a garment undertakes from the start of its lifespan to the end. Where the varying stages of the product lifecycle do differ however is in the levels of negative environmental and social impact created. From an environmental perspective, the analysis of impact will depend on two key elements: the resources needed to execute the core function (input) and the waste produced as a result of this process (output), whereas in a social context, the analysis is far more complex and subjective, void of the scientific measurement tools utilised in environmental impact. The conditions of workers within the product lifecycle often relies on in-country policies and regulations, with the governance and auditing of these standards adding further complexity to an already difficult and sensitive debate.

2.1.1 Design

Many existing lifecycle models in fashion begin with the sourcing of natural or man-made materials, indicating that this is the first stage of product development. However, with 80% of the environmental impact of a garment determined at the design phase, this model details design as the primary stage, reflective of its importance and prominence in the creation of a garment. Many of the decisions made during the creative design process create impact at later stages of the fashion lifecycle. An example of this would be the amount of microfibres a garment sheds during washing in the use phase. An estimated 6490 to 87,165 tonnes of microfibres are released annually in the UK from washing alone (Hazlehurst et al., 2023). A single polyester fleece can release between 0.95–2.47 g of polyester microfibres during a single 5 kg wash (ibid). Variables that can help reduce the amount of fibres shed include the yarn type, fabric construction methods, dyeing techniques and the application of chemical and/or mechanical finishing all of which are determined during the design phase. While this results in the designer being in a unique and powerful position to create sustainable change, it relies on their knowledge and understanding of the impact created by clothing. Although restrained by many other factors, such

as price and season, small adaptations can be made during the design process to reduce environmental impact in later stages of the lifecycle.

From a geographical perspective, the design process remains fairly contained, with many of the actions being conducted by a team within a primary location. These actions will follow the steps undertaken in the design process including primary and secondary research, ideation, concept development, design development and range planning. In isolation, these actions create relatively little impact; however, the creation of garment samples, often carried out by their supplier, create extensive waste, and carry a heavy carbon emission price tag from the shipping of products between the design and manufacturing locations. The sampling process acts as a trial-and-error process, taking garment designs from 2D graphic drawings to physical 3D forms, ensuring any production errors are overcome prior to the product going into final mass-manufacture. This process also ensures that communication between design teams and overseas manufacturers has been successful and that they have achieved a mutual understanding of the garment being produced. A series of stages are undertaken during this sampling process which creates a high-volume of products, these include initial sample, pre-production sample, size set (often two garment samples in every size offered) and final production sample (often referred to as the gold sample). This back-and-forth process facilitates comments and iterative loops, further increasing the shipping costs, emissions and the quantity of garments produced. It is estimated that £5–7bn pounds are spent on physical sampling in the fashion industry every year, with the majority of product being of little to no value once assessed by the design team. This waste product is then largely thrown to landfill or incinerated, creating negative environmental impact on a very short-lived garment (Roberts-Islam, 2019).

Advancements in technology is facilitating the digitisation of this 3D sampling process to help combat these resource intensive functions, software such as Clo-3D focuses on 3D simulation of garments to help solve any errors with fit or aesthetics prior to physical garments being produced. The use of their software aims to increase speed and accuracy, eliminating unnecessary physical sampling and shipping costs using 3D, computer generated visualisations. Similar packages are being produced by Lectra who combine software, cutting equipment, data and services to meet the specific needs of fashion. Apparel brands such as Adidas have been utilising digital prototyping for many years now, enabling them to eliminate nearly 1.5 million sample garments from their development process in just a three-year period. Likewise, American fashion retailer Target has reduced their physical sampling output by approximately 65% through the utilisation of 3D software technology (Roberts-Islam, 2019).

2.1.2 The Supply Chain

The following three stages of the fashion lifecycle: *materials, manufacturing* and *distribution*, create the garment supply chain which includes the processes accountable for the sourcing of raw materials, the manufacture of garments and the

distribution of the finished products to retail. It is the supply chain which takes a garment from an initial design idea into mass-manufacture, scaling the production from sample stage to often thousands of finished products. These three stages also document some of the most significant environmental and social impact within the product lifecycle due to many intricate operations being carried out in often multiple geographical locations. When broken down, these processes require huge quantities of resource and energy and as a result create harmful emissions and large amounts of waste. Due to the complexity and impact of these processes, many consumer action groups and non-governmental organisations (NGOs) are putting pressure on brands to be more transparent and open about the actions carried out in their supply chains. The focus of this activism is often calling for a greater level of accountability and responsibility for the standards of practice carried out in their supply chain, which requires brands to have a greater level of control and traceability of their manufacturing methods. However, due to the disconnected nature of garment workers within the supply chain, brands can pass on their responsibility for social exploitation down the supply chain to their contracted suppliers with no accountability.

2.1.3 Materials

The second stage of the fashion lifecycle focuses on materials, which documents several processes from the sourcing of raw materials to the final finished fabric ready for garment manufacture. Again, depending on the type of product being produced, this stage can vary significantly and again each and every product will track its unique journey through this stage. The beginning of this stage starts with fibre sourcing with garments most commonly being produced from either natural, man-made or cellulosic materials:

- Natural fibres – are sourced from their ecological origins, cultivated fibres such as cotton or flax will be grown in large areas of farmed land (often found in America, China, etc.), whereas animal derived fibres such as wool and silk will be obtained from the living specimens
- Synthetic fibres – are traditionally derived from finite resources such as oil (although bio-based synthetics are emerging into the market), creating plastic-based polymers produced through chemical processes and extruded in a single yarn form ready to be either combined with other materials or created into fabric
- Cellulosic fibres – created from a fibrous plant origin, cellulose (a polymeric sugar polysaccharide) forms the basis of all natural and man-made cellulosic fibres. Natural forms are vegetable, animal or mineral-based, combined with the cellulose chemical compound. Man-made cellulosic fibres (e.g. Rayon) is produced by the regeneration of dissolved forms of cellulose

Once the raw fibre has been obtained, it must be processed into a usable fibre to be utilised in the creation of a yarn. Next, yarn preparation occurs, taking the original fibre and transforming it into a useable yarn through spinning of filament and

staple fibres ready to be utilised in the construction of the material (knitted or woven). This results in the materials being in fabric greige form which can then be dyed and finished ready for garment manufacture.

The levels of social and environmental impact in this stage of the fashion lifecycle differs significantly; however, material consumption levels alone mean that substantial resource use is inevitable. By 2030, global apparel consumption is set to rise by 63% from 62 million tonnes to 102 million tonnes, which equates to 500 billion more t-shirts (Environmental Select Committee, 2019). Fibre production, dyeing, finishing and yarn preparation require vast quantities of water; however, a true assessment of environmental impact depends on the fibre, yarn and fabric preparation methods utilised. Therefore, it is difficult to compare the impact of different fibre types in a like-for like manner. However, many misconceptions exist around the positive connotations around natural fabrics as opposed to synthetic. For example, although a naturally derived product, cotton requires large quantities of water, insecticides and nitrogen rich fertilisers which increase the acidity of the soil. Polyester on the other hand, derives from petroleum, a non-renewable resource which is produced through an energy intensive process but requires relatively little water in the production process. While synthetic fibres have less impact on water and land, they emit more greenhouse gases. A polyester shirt has more than double the carbon footprint than one made from cotton (5.5 kg compared to 2.1 kg CO_2); however, the water usage in the production of one cotton shirt is between 3 and6000 L. Approximately, 60% of all fashion garments produced are made from polyester, a figure that has doubled since 2000, with exponential growth evidenced since the emergence of fashion and the growth of the value sector (Quantis, 2018). A further theoretical environmental advantage to natural fibres is that they are able to biodegrade after disposal. To add to the complexities, some synthetics can also biodegrade either as a result of a chemical interaction/modification or because of their bio-based nature (although not all bio-based synthetics are naturally biodegradable). I biodegradability of natural fibres however relies on it being used in a 100% pure form and not being utilised in mixed-fibre blends, which remains common in fashion. This is common practice as blended yarn can change the properties of the final fabric to better suit the needs or wants of the customer. This approach is also often adopted for financial reasons, commonly utilised in knitwear for example, where acrylic (a synthetic fibre) may be used for the majority of a garment for cost purposes and ease of care for the consumer, but a small percentage of merino wool (a high quality, more expensive natural fibre) may be added to make the garment feel softer and more luxurious. In this instance, the disassembly of fibre types for recycling or disposal purposes is not possible.

2.1.4 Manufacturing

Once the fabric is in final, finished state, it is transported to the garment manufacturing location, which can be a journey of many thousands of miles, again contributing heavily in carbon emissions. Overall, the fashion industry is responsible for 8.1% of

the world's total carbon emissions, a figure which is set to grow by up to 60% by 2030 (Stand.earth, 2019). The manufacturing stage of the product lifecycle transforms the fabric into the finished 3D garment, ready to be sold to the customer. The processes undertaken involve extensive human interaction, as garment construction, more than any other stage of the supply chain, requires garment workers as opposed to relying on technological advancements. The act of physically sewing a garment has changed relatively little over the past century, with many of the social issues encountered still lagging in contemporary standards. The primary functions of the manufacturing stage of the fashion lifecycle are to cut and construct the fabric pieces into garment form. Cutting fabric in mass-manufacturing is mostly automated to ensure efficiency through the cutting of hundreds of layers of fabric simultaneously and although carried out by machinery, the process will be overseen by a human operative. Again, depending on the type of garment (fabric type, construction methods and finishing techniques) the complexity of construction, machinery needed and time consumption will vary significantly. A range of operations will be conducted on a production line, which will see many workers, organised by their performing operation, working in unison. Due to the human heavy processes undertaken throughout the supply chain, social issues encountered remain common, including child labour, forced labour, excessive working hours, compulsory overtime, unsanitary and unsafe working conditions and no rights to freedom of association (being permitted to be part of a trade union). Of the 71 leading retailers in the UK, 77% believe there is a likelihood that there is modern slavery in some stage of their supply chain, with 90% of workers having no opportunity to negotiate their wages and working conditions (Environmental Select Committee, 2019).

Fashion is in the third largest manufacturing industry globally after the automotive and technology sectors, generating $2.5 trillion in global annual revenue and employing 890,000 people in the UK alone (The Business of Fashion, 2020). Unrealistic pricing throughout the supply chain is the main cause for social compromise, with fashion brands posing unrealistic requirements on suppliers to compete to offer the lowest prices, with the shortest lead times. While many fashion companies attempt to adhere to a set of responsible standards, the risk of being caught not complying to these standards remains relatively low and therefore the incentive to do so remains high (Environmental Select Committee, 2019). Non-compliance of many of these standards will help increase speed of delivery to market and quantity of garments produced. This applied pressure on the supply chain often results in compromise occurring at the expense of either the environment or garment workers. Journalist Lucy Siegle (2011) summarised this point, 'fast is not free, someone, somewhere is paying'. In response to this, it has become common practice for fashion brands to implement some level of governance in their supply chains through Corporate Social Responsibility (CSR) programmes. This begins with an assessment of a business and their customers, suppliers, communities and employees to assess their impact on society (Lindgreen & Swaen, 2010). CSR however lacks definition and boundaries, with varying levels of brand commitment to responsible change being encompassed under the same umbrella terminology (Burchell, 2008). Some companies, as an alternative to the term CSR, use terms such as *sustainable*

business practice, corporate citizenship and *corporate accountability*. However, these alternative terms take away the social meaning behind CSR, to encompass more sustainable connotations to the term. It is thought however that CSR programmes have largely failed to improve social working conditions due to their success relying heavily on auditing and compliance (Environmental Select Committee, 2019).

Traceability of garment supply chains remains a substantial social challenge within the fashion industry, with many suppliers outsourcing work to other factories to meet the increasing demand of quantity in short time frames. This again provides evidence of social compromise in the supply chain to meet the requirements of current fashion consumption levels. This new layer of suppliers, often referred to as shadow factories (Harney, 2008), presents a new set of challenges as they are not legally employed by the fashion brand, thus standards (as outlined in the CSR policy of the brand) are no longer applicable or able to be implemented. Not all manufacturing in fashion is limited to in-house factory work, but also encompasses thousands of home-workers across the global supply chain. This presents further challenges with governance and auditing, with the working conditions and safety being out with the control of fashion brand. Furthermore, who is carrying out the work being provided can also be questioned, with child labour being commonly used to again meet tight deadlines and demanding volumes of work. Despite progressive improvement in supply chain transparency in recent years, only 58% of brands reveal information about their primary tier suppliers. From the 200 fashion brands surveyed by market research agency Mintel, in 2017 only 32 brands disclosed this level of information, in comparison to 70 in 2019. However, when these figures are compared to the level of information disclosed about raw material suppliers, they begin to look positive. From the same companies surveyed, no brand disclosed any information publicly in 2017, with only ten doing so in 2019 (Mintel, 2019a).

2.1.5 Distribution

The offshoring of UK garment manufacturing has been made possible by a 90% reduction in shipping costs since the 1950s (Environmental Select Committee, 2019). Consequently, geographical distribution of garments can be a distance of thousands of miles requiring extensive transportation logistics to take the goods from one country to another. Despite the significant emissions occurred during this stage of the lifecycle, transport accounts for only 3% of the apparel industry's impact on climate change; however, this remains in a delicate balance, where shifting only 1% of transport from shipping to air-freight would cause a 35% increase in carbon emissions (Quantis, 2018).

Not all garment manufacture is housed overseas however, with Leicester in the East Midlands still operating 700 garment factories, providing work to over 10,000 local people. Despite being governed under the UK law, some of the social issues encountered in overseas manufacturing locations are also prevalent in garment

factories in the UK. Media coverage over the past few years has reported extensive *sweatshop*-like activity with unsafe working conditions evidenced by blocked fire exits and wages between £1–3 per hour (Blanchard, 2017). As a result of this non-compliance with UK minimum wage levels, owners of the factories have recently been forced to pay workers £90,000 for reimbursement of non-payments (Environmental Select Committee, 2019). Internet retailers such as Boohoo and Misguided source approximately 50% of their product from these Leicester-based factories, utilising UK-based manufacturing to increase the speed of delivery to market by producing the garment in the same country as they will be retailed. While this approach dramatically cuts down emissions from transport to overseas facilities, it does rely on social compromise to deliver very large quantities of clothing retailed as cheaply as £5 for a dress from Boohoo (Environmental Select Committee, 2019).

Transport is required at almost all stages of the garment lifecycle, facilitating the movement of goods and products from one geographical location to another. Considering a simple cotton t-shirt for example, two billion of which are bought and sold globally every year, cotton as a raw material is sourced from one of the three biggest cotton regions in the world; America, India or China. Once the cotton has been picked and put in to bales, it is ready to leave the farm and be shipped by textile mills to a spinning facility to create yarn, commonly in China or India. The yarns are then sent to a mill to be knitted into fabric. The finished fabric then travels from the textile mill to a garment factory often in Bangladesh (the largest exporter cotton t-shirts with 4.5 million employees in the t-shirt industry), India, China or Turkey. Once complete, they travel by ship, train and truck to their final point of sale, often to western, high-income countries. By the end of the product lifecycle, that garment has travelled thousands of miles, contributing heavily to the carbon emissions generated by the fashion industry.

2.1.6 Consumer Use

Once the garment has reached the point of retail, the product is ready to be purchased by customers, moving the garment from the supply chain and into the consumer use phase. This stage of the fashion lifecycle utilises large volumes of energy and water due to the washing and drying methods implemented by individuals in their homes. While in the possession of the consumer, 75–80% of the overall lifecycle impact of a garment is created (Treehugger, 2019) and 25% of the garment's total carbon footprint (Fashion Revolution, 2017). There are many variables which dictate this level of impact during washing, including frequency and temperature, with the average household in the EU doing 6.2 washes per week (European Clothing Action Plan, 2017). With this level of washing frequency, an average household utilises approximately 60,000 L of water per year, with 90% of the energy consumed to heat the water (Treehugger, 2019). A study conducted by the European Clothing Action Plan (ECAP) to investigate the environmental impact of clothing indicated average washing temperatures of European consumers being

40° C, with 43% of survey participants favouring this as their preferred setting. Additionally, 24% of participants indicated that they usually washed at 30° C and only 12% being at 60° C (European Clothing Action Plan, 2017). Many fashion brands and retailers are now using garment labelling to encourage their customers to wash at lower temperatures and less frequently, in a bid to reduce the overall environmental impact created by garment washing.

In addition to energy and water, there are other environmental considerations during the use phase, including the volume of wastewater created, which will contain chemicals from detergents and microfibres shed from the fabric. Washing detergents contain phosphates which can cause algal blooms that negatively affect ecosystems and marine life (Treehugger, 2019). To help prevent this damage, consumers can choose to use eco-friendly alternatives, which are biodegradable and phosphate free. Textile fibres—or 'microfibres' as they are now more commonly termed—is a generic term for the basic elements of natural, synthetic and cellulosic textile materials. They are very small in size, often invisible to the naked eye, and can be defined as having flexibility, fineness, and a high ratio of length to thickness. Fibres fragment from textiles during the manufacturing, consumer use and end of life phases of a product lifecycle. The consumer use phase includes general handling and wear, laundering and drying. Up to 95% of microfibres released during washing are filtered out and captured in the sludge at wastewater treatment plants, although many are released into the ocean (Ramasamy et al., 2022). These tiny plastic particles can then find themselves into the diet of marine life and eventually into the food chain of humans (Resnick, 2019). A study conducted in 2018 evidenced approximately 73% of fish caught in the Northwest Atlantic had microplastics in their stomachs (Wieczorek et al., 2018), a large proportion of which will have originated from garments in consumer wardrobes.

Researchers have attempted to determine the magnitude of the release of microfibres to the environment as a result of washing. However, quantification is challenging and often figures quoted in the media and used in reports are provided without context and create misunderstanding. One myth is that microfibre pollution is caused only by petroleum derived synthetic fibres, such as polyester and acrylic, that come from synthetic clothing (Paddison, 2016). Recent estimations believe that up to 35% of global contribution of ocean microplastics comes from clothing, meaning they are the predominant contributor. However, this overlooks the significance and prevalence of natural fibres, such as cotton and wool, in the ocean, which are often found in much greater quantities (Stanton et al., 2019; Kechi-Okafor et al., 2023). Due to their plant and animal origins, natural fibres are often thought to be harmless because of their biodegradability. However, the processing, dyeing and chemical finishing applied to natural fibres during the production of fabric means they are no longer in their natural state and therefore are not as readily biodegradable. Ecotoxicology studies indicate It is the size and shape of a microfibre that makes it dangerous to our ecosystems, not the type of fibre itself (Thornton Hampton et al., 2022).

All clothing has the potential to shed microfibres, regardless of what they are made from. The amount of fibres shed during a wash cycle can significantly vary

due to fibre type, their yarn twist structure, fabric construction methods (knitting, weaving, etc.) and dyeing and finishing processes. Washing studies have been conducted to determine the most influence variables. Garments made from cotton can shed more fibres than a polyester fleece, although not always (Lant et al., 2020). Knitted fabrics tend to shed more than woven fabrics (Balasaraswathi & Rathinamoorthy, 2022), while staple yarns tend to shed more than filament yarns (Choi et al., 2021). The introduction of mechanical finishing techniques such as brushing or peaching will likely mean increased shedding, yet the application of chemical finishes can reduce it. Lower temperatures tend to result in less microfibre release, as do shorter durations (Cotton et al., 2020). Counterintuitively, smaller wash loads increase microfibre loss, thought to be due to increased agitation of the clothing in the drum (Lant et al., 2020). However, the methodology of the studies varies significantly, the choice of textile; the load, temperature, agitation and duration of the wash; the washing method itself, be it a washing machine or small-scale simulated washing equipment; presence or absence of detergent/fabric softener; and finally, the measurement used for quantification (number of microfibres or mass loss per kg). The multitude of potential factors influencing microfibre loss makes quantification across multiple studies challenging. As such, an industry standard test methodology has been developed (Tiffin et al.) that provides reliable, comparable, microfibre loss data enabling root cause understanding. Furthermore, the data can then be used to derive reliable quantification of microfibre release to the environment through wastewater. Estimations indicate that between 6490 tonnes to 87,165 tonnes of microfibre is discharged in the UK each year from domestic washing (Hazlehurst et al., 2023).

While this level of environmental damage from one stage of the value chain is alarming, the ability to create substantial change is in the hands of the consumer, with their choice of actions being crucial in the amount of impact created. Small, considered changes in their actions such as washing less frequently at lower temperatures could significantly reduce the effect of garment maintenance. Furthermore, utilising additional products such as the Guppyfriend wash bag, which captures approximately 50% of microfibres shed during washing (Napper et al., 2020) enabling them to be disposed of responsibly rather than in wastewater. Increasing the lifespan of a garment is also said to be the most effective way to reduce the environmental impact of a garment, where if a garment is retained for nine months longer than planned, the waste and water footprint would be reduced by 20–30% (Environmental Select Committee, 2019). To facilitate this increase in garment longevity, both the consumer value of the product needs to be considered and where necessary, the extension of the usable life of the garment. Product life extension methods, such as repair or repurposing, can begin to give a garment a new lease of life, from both a practical and desirable perspective. However, this method relies on the individual having the skill, time and equipment to do so, with a lack of skill or expense said to put people off repairing their garments (Environmental Select Committee, 2019). In a recent survey issued by Mintel, gauging sustainable behaviours in fashion, 72% of participants said they had repaired a garment in the past 12 months, while 35% had made an alteration (Mintel, 2019a). While the skill level

can vary considerably between basic repairs and alterations, this research does evidence a consumer commitment to actively extending the lifespan of a product they already own.

2.1.7 End-of-Life

At the end of a garment's usable or desirable life, a consumer has a series of options in which to dispose of the item; however, responsible action at this stage of the lifecycle relies on the individual being informed of not only the range of options available to them but also of the impact of those choices. This considered action is often referred to as the three 'Rs' of fashion: reduce (the amount of clothing being purchased), reuse (garments in their original form) and recycle (by making new from old). While these are all viable options, presented in order of favour, textile recycling is the least favourable due to the energy intensive and complex processes required (Brooks et al., 2018).

As a direct consequence of significant consumption levels, 300,000 tonnes of textile waste end up in household waste every year, 20% heading to landfill while the remaining 80% is incinerated (Environmental Select Committee, 2019). However, aside from landfill, there are multiple end-of-life options for garments, reflecting the different lifecycle models previously discussed (*linear, recycling* and *circular*). Landfill is a typical disposal option for the linear lifecycle model, where a garment is made, used and discarded as waste. When considering disposal options from the perspective of a recycling lifecycle model, the options become much more abundant and varied with common methods such as donation to charity, second-hand selling or passing on to a family member or friend. Alternative methods include consumers engaging in retailer take-back schemes (where old clothing is returned to participating clothing stores), recycling and swapping with friends, family or at an organised swishing event. In a 2019 consumer survey, 72% of participants surveyed claimed they had donated to charity in the past 12 months, with 48% having purchased second-hand items. 35% stated they had sold on their unwanted garments, 19% had swapped an item, 22% had engaged in a retailer take-back scheme and 19% had rented a garment from a garment rental service (Mintel, 2019a).

Donation to charity is a heavily favoured method of disposal by society but the second-hand economy has some negative connotations often unknown to individuals. Every year, 650,000 tonnes of clothing go to charity in the UK, with 11,000 charity shops diverting 330,000 tonnes of clothing which would otherwise likely be sent to landfill (Environmental Select Committee, 2019). However, of this extraordinary amount, only 10–30% of donated clothing remains in the UK to be sold in charity shops (Brooks, 2015), with the remainder being exported to marketplaces in low-income countries, which is often the most profitable outlet from the perspective of the charity. Second-hand western clothing is seen as more desirable than in-country products, which is having a significant effect on local garment production and the economy (Brooks et al., 2018).

Textile recycling schemes are becoming increasingly available, with some areas of the UK now having a household option for textile products. Other collection methods include recycling centres and local recycling points with 90% of the garments collected being either reused (59.4%) or recycled (31.8%) (Environmental Select Committee, 2019). Clothing donation systems rely on garments being collected and taken to a sorting centre, which requires the garments to be segregated by hand into fibre type categories. While this labour-intensive system has created 1400 at UK-based sorting plants (Environmental Select Committee, 2019), it also faces several challenges including faded tags, making fibre identification almost impossible and blended fibre products, which cannot be recycled (Brooks et al., 2018). The cost-effectiveness of this systems has in the past been questioned; however, an additional charge of just one pence per garment on producers, could raise £35 million to invest in better clothing collection and sorting in the UK (Environmental Select Committee, 2019). This additional funding could aid in overcoming some of the current challenges presented in closed-loop garment recycling and help increase the overall number of garments recycled.

2.2 Fashion Consumption

Consumption levels of fashion are higher than ever before, with future predicted figures on a constant upwards trajectory. As shopping becomes ever simpler and more convenient, consumers are losing a sense of value in their purchases, with impulsive buys resulting in short-term ownership and premature disposal. It is the number of garments being produced, purchased and discarded that is thought to be the main issue when assessing the environmental impact of fashion. The ownership of garments has increased exponentially over the past two decades, which has coincided with the emergence of both the fast fashion model and the recent wave of ultra-fast fashion retailers entering the fashion market. In 2005, there was an estimated 74.3 billion items of clothing produced, in comparison to 2019, where 130.6 billion items were produced, equating to every person on the planet buying 15 garments and two pairs of shoes each (Fashion Revolution, 2020). While the reality of fashion ownership is far more imbalanced between the developed and developing worlds, this increase in production volume is driven by consumer greed and not necessity. However, this path is not showing any signs of slowing with the annual value of fashion and footwear being estimated to reach £2 trillion by 2030, an anticipated growth of £500bn in the next decade (Environmental Select Committee, 2019).

2.2.1 How We Got to This?

The escalation of fashion production and ownership has occurred over many decades and can be attributed to many contributing factors, including technological advancements, changing consumer habits and developments in the global economy. As

previously discussed, a combination of access to synthetic fibres, manufacturing being moved offshore and consequential declining prices in fashion have driven the fashion market to grow rapidly. While the invention of textile machinery during the industrial revolution provided the equipment to start manufacturing materials and garments in large quantities, it has been a shift in consumer culture which has signified an appetite for consumption at contemporary levels.

In recent history, this can be traced back to the 1950s, where high-end department stores began hosting ready-to-wear fashion shows, enabling society to buy in to these exclusive fashion collections. Before this, fashion had been made to order, produced by local tailors in small numbers, as opposed to larger quantities in a variety of sizes being accessible. The 1960s has been described as the retail revolution, with independent boutiques emerging on the UK high street, changing the retail experience from an essential to a social activity, dismantling the boundaries between work and play (Fogg, 2013). An opposite from the familiar department store, the development of the boutique culture allowed youths to express their identity and their opinions through their choices of fashion. It was also this decade where fashion photography and advertising began to play a big role in influencing consumers to buy in to certain subcultures or brands. At this stage, garments were being mass-produced but were manufactured in-country and often local to the point of retail. In 1974, the Multi Fibre Arrangement (MFA) was introduced to allow developed countries to receive imports from the developing work. From the perspective of garment manufacture, developing countries, such as Bangladesh, had the competitive advantage as their labour costs are much lower than that of developed countries such as the UK and the US. This was the start of the offshoring of garments, with textile products and garment manufacture increasingly being made overseas meaning that the price of fashion plummeted. This was also a period where brands started to copy designs from the catwalk, replicating diluted versions of luxury, catwalk fashion. It is thought that this was where the fast fashion model as it is known today began to develop, with the cost of manufacturing in decline and consumer appetite increasing. This model continued to gain momentum, with the replacement of the MFA in 2005 with The World Trade Organisation agreement which removed the quota system previously imposed. This removed restrictions on the amount of imports from developing countries and only added further fuel to the escalation of the delivery of large quantities of cheap clothing to the UK fashion market. By the mid-2000s, the fast fashion market sector dominated the industry, with traditional high-streets being predominantly occupied by low value brands and retailers. The past decade has seen fast fashion being superseded with the emergence of ultra-fast fashion, taking the speed and volume of clothing production to the extreme. These e-commerce brands retail only online to facilitate a direct-to-consumer route to market to further reduce overhead costs. This new breed of fashion retailer is again changing the retail landscape as the industry continue to evolve as a reflection of societal changes.

2.2.2 Fast and Ultra-Fast Fashion

As the fashion lifecycle continues to gain momentum, increasing the speed and volume of products being produced, fast fashion is no longer fast enough for the appetite of some fashion consumers. Ultra-fast fashion retailers deliver 1000+ new styles to market every week, offering a constant cycle of new products available to their customers. This model operates regardless of season or sales, encouraging overconsumption and a disposable consumer attitude towards clothing. The direct-to-consumer sales approach and the lack of bricks-and-mortar stores allows the price of products to also remain very low, aided further by the large volume of production per style. Furthermore, with 50% of production being based in the UK, the speed of delivery to market can also undermine that of overseas supply chains. However, fashion produced at these speeds and in these volumes, often results in social and environmental compromise, with ultra-fast retailers determined to increase the speed of the lifecycle, regardless of *cost*.

This sector of the industry also relies heavily on celebrity culture and social media influencers as their key marketing strategy, with discount codes being offered to their followers as an incentive to purchase. In return, the influencers receive commission (Fashion Revolution, 2020). While celebrity endorsement as a marketing tool is nothing new, the use of influencers begins to challenge these norms, with a celebrity status no longer being necessary to influence people's purchasing behaviour in fashion. This shift has been facilitated by society's increasing reliance on technology and use of the Internet, diversifying the way people can buy and access fashion products. Despite the use of social media in this instance having negative connotations on consumption levels of clothing, evidence suggests that social media can also have a positive impact in the growth of more responsible practices across the fashion sector. Between 2015 and 2018 the use of the hashtag for sustainable fashion (#sustainablefashion) saw an increase in use of 500% (Fashion Revolution, 2020), indicating that consumer awareness, and potentially knowledge, is growing. This was also indicated in the use of search engines, where the term also increased by 66% in 2018 alone (Lyst, 2019).

The recent emergence of the ultra-fast fashion business model is indicative of the current direction of growth within the fashion industry, an area which encourages consumers to gain momentary pleasure from a low quality, inexpensive garment before purchasing again. This target audience are fundamentally gaining pleasure, albeit brief, at the expense of people and the planet (Environmental Select Committee, 2019). With consumption levels rising and the cost of fashion falling, consumers appear to be buying more fashion items but paying a much lower price, despite the effect of inflation on material, labour and transport costs. This is reflected in the average retail price for an item of clothing which in 2005 was $16.47; however, in 2019, this dropped to $13.60 (Fashion Revolution, 2020), despite an annual inflation rate of 3% on average (Bank of England, 2020).

Although negative connotations of fast and ultra-fast fashion are to be acknowledged, a more positive perspective has been considered in terms of demographic accessibility:

> Fast fashion has allowed all segments of society, irrespective of income, class or background, to engage in hedonistic and psychogenic pleasure of fashion. At no other time has fashion been so accessible to so many people across our society. This is the power of fast fashion (Environmental Select Committee, 2019).

A growth in the garment industry has also had certain positive consequences with garment workers. This includes the economic freedom and empowerment of female workers, many of whom are primary providers within their family unit as a reflection of the gender balance of the workforce. The number of families living below the poverty line has decreased, from 44% in 1991 to only 13% in 2018. Additionally, family sizes have declined and consequently the number of maternal deaths, with individuals also living a third longer than they did in the 1980s (Fashion Revolution, 2020).

However, these positives do not outweigh the numerous negative environmental and social consequences induced by of the speed and volume required in the delivery of fast and ultra-fast fashion. This model remains an unsustainable and impractical model for the future and needs to be remodelled to reflect the increasing consumer demand for transparency and higher social and ecological standards.

2.2.3 Fast Is Not Free

In 2013, an eight-storey factory collapse in Dhaka, Bangladesh would forever change the way that the fashion industry perceived social compromise in their supply chains. On the morning of 24 April 2013, thousands of garment factory workers arrived at their machines in the Rana Plaza factory complex as usual, despite owners receiving advice to close the building the previous day due to unsafe building conditions. The pressures being placed on the factory owners to complete orders for western brands such as Primark, Mango and Matalan, were passed on down the value chain, with workers being threatened with their jobs if they did not continue to work. Shortly before 9 am, it took 90 seconds for the factory floors to give way, resulting in 1134 workers being killed, an incident that unions described as ‘mass industrial homicide’ (Safi & Rushe, 2018). The aftermath of Rana Plaza created a focus on the social standards being conducted in global supply chains, with issues such as levels of pay, building fire and safety standards and freedom of association being placed under the spotlight. Despite some progress being made in the seven years since the incident, workers continue to live in poverty, unable to afford the most basic of necessities for their families. Pay for instance, remains critically low, despite a pay increase in 2018 and 11,600 workers were arrested and threatened with their jobs for participating in strikes to fight for their right to be part of a worker’s union, otherwise known as freedom of association (Fashion Revolution, 2020). While this behaviour is often associated with the lower, value-end of the fashion market, these issues are not exclusive to fast fashion retailers alone, with luxury brands now mimicking operations and being newly labelled as *fast luxury* (Environmental Select Committee, 2019).

Fast fashion, a business model based on offering consumers frequent novelty in the form of cheap, trend-led products (Niinimaki et al., 2020) utilises high levels of resource input and results in large quantities of waste, often from garments being prematurely thrown away. As previously discussed, environmental impact can be evidenced at every stage of the garment lifecycle, although when considering this in the context of the fashion business model, the volume of garments being produced alone evidences concerning levels of resource use and waste. However, it is also the speed of production that is the biggest cause for concern, with shortcuts and compromise often occurring due to the pressures of a fast-paced delivery to market. The efforts made by numerous brands and individuals to move towards a more responsible future for fashion is often outweighed by increasing levels of consumption, with consumer spending predicted to rise from £70,456 million in 2019 to £77,637 million in 2024 (Mintel, 2019b). However, future predictions appear to be based on limitless supplies of finite resources, discarding planetary boundaries in favour of monetary profit at the cost of people and the planet. The global resource input needed in the production of fashion is immense with the annual water usage alone–more than 79 trillion tonnes. When this system input translates into an output, the waste totals 92 million tonnes created throughout the value chain. Again, this occurs at every stage of the lifecycle, ranging from poor quality seconds created in error during manufacture, to garments discarded by consumers to be worn only once to impress followers on Instagram. It can be clearly identified that a degrowth in fashion is desperately needed; however, a decline in consumption levels and thus production needs to be managed carefully to prevent damage to the social economy of the global supply chain (Niinimaki et al., 2020).

2.3 Challenging Sustainability

The boundaries of sustainability within a business context are heavily debated, with a lack of definition, parameters and regulation being often accountable for confusion and a hesitance to engage. This level of uncertainty is a cumulation of many factors, including language, terminology, limitations and the absence of unbiased governance. Further adding to the complexity of this situation is its voluntary status, with individual companies choosing whether to opt in, or opt out in the integration of sustainable values into the products they design, produce and sell to the mass market. Engagement with any level of responsible behaviour is largely subjective, relying on individual companies to develop their own response and effectively implement these strategies to fit their business.

The term *sustainability*, according to the Brundtland Report of 1987, refers to meeting the needs of the present, without compromising the ability of future generations meeting their own needs. This definition refers to not only a collective responsibility between current society and future generations of individuals, but it also

refers to sustainability as a long-term strategy for the future. When considering sustainability in the context of fashion, Rinaldi and Testa (2015) attempt to define and map common language, with the aim to show the relationship and distinction between the use of key terminology. Perceptions of *responsible fashion* indicates a series of actions that consider a breadth of stakeholders. *Sustainable fashion* is thought to focus on an individual's relationship with the environment and terms such as *ethical* referring to societal factors. Despite academic interpretation, the fashion industry has no discipline specific, definitive definition for sustainability, with thousands of interpretations rendering the term almost meaningless as it can be applied in a myriad of ways. As a result of laxed parameters, the term *sustainability* is often used interchangeably with many other phrases such as green, eco, conscious, responsible, ethical, and ecological to name but a few. When observing this confusion within an industry context, hazy understanding of terminology can often lead to misinterpretation or ineffective application of sustainable actions. Furthermore, sustainability in a business context can evoke the use of corporate vocabulary which further adds to the disengagement of individuals and complexity of dissemination to a general audience.

While the need for businesses to be responsible is not a new concept, the demand for more sustainable behaviour within a fashion context is becoming increasingly relevant, driven predominantly by the consumer. As knowledge and awareness of the environmental and social impact of fashion increases within society, so too is the pressure being placed on fashion brands and retailers to carry out their business in an ethical and *right* way. An increase in media exposure is largely responsible for heightening discussions around more sustainable ways of living, directing individuals to make sustainable choices in their everyday activities. Despite this increased awareness being generalised, fashion has come under particular scrutiny because of its historic association with the unethical treatment of people and the planet. Response to this growth in consumer demand relies on systemic change to the industry as a whole and faces many challenges in the assessment and implementation of such changes.

The rationale for engagement in responsible practices has on many occasions been questioned, often being proposed as a barrier to a meaningful response to sustainability from the fashion industry. Many companies feel like they must do *something* to keep up with their competitors, and while this may be perceived as a positive response, it can often lead to a token commitment used as a tick-box-exercise. This reluctancy to commit time, effort and financial contributions significantly impacts a company's level of engagement with responsible business values, with these actions being seen as an inconvenience. Over the past decade, many brands who have chosen to embrace positive sustainable change are beginning to see the financial and reputational benefits, including an increase in brand trust with their customers. However, until responsible business becomes conventional practice in the fashion industry, there remains many challenges and barriers to be overcome in embedding sustainability throughout global fashion supply chains.

2.3.1 Realising Sustainability

The garment lifecycle is a long and complex process, with many processes contributing heavily to the negative impact consequential of the fashion industry. From a business perspective, many companies are finding it challenging to become sustainable in all their practices across their supply chain, with materiality, production and transport inherently being heavily reliant on fossil fuel consumption. The growth in the use of man-made fibres, the volume of products being produced and the speed of delivery to market are all common issues in today's fashion industry making any level of responsibility difficult to achieve.

A common approach in today's fashion market, is for brands to select certain areas of their business to focus on in terms of sustainability, improving smaller areas, in preference to a systemic overhaul, which could be argued is the most effective method to meaningful change. These small, isolated changes come in many forms, again varying from company to company, but can range from a shift to the use of organic cotton to providing basic education to workers within their supply chain. Efforts again come in many different guises and can encompass both environmental and social aspects of sustainability, with no parameters to determine what or who is targeted in a company's efforts to operate in a better way. These voluntary pockets of activity on the part of individual companies begin to build a narrative of responsibility across the fashion industry. However, it is the parity of engagement from brand to brand which poses many future, long-term challenges going froward. Reliance cannot be on those companies which are actively engaged in making their business more sustainable, but rather a collective leverage needs to be established, with every company playing their role in a much bigger picture. It is to be acknowledged that companies, regardless of market sector, need to be profitable to operate and to ensure the future sustainability of their business. It could be argued that only once this has been achieved can a company begin to consider their actions in terms of impact to people and the planet. These activities cannot be based on philanthropy alone, especially when companies are entrenched in both a society and a market sector which relies heavily on a capitalist economic model.

The varying stages of the supply chain offer many opportunity for a business to target specific areas where they want to focus their efforts in becoming more responsible. For companies who are transitioning away from more traditional production processes, these adaptations may be small yet considered. This can range from a shift to packaging that can be recycled or using deadstock fabric in future collections to larger, more logistical changes in the supply chain such as working conditions in garment factories and the transportation method from factory to shop floor. The size of the company and the volume of their operation will distinguish the ease in which these transitions can be made, with smaller brands obviously being able to adjust their processes with more ease. However, on the contrary, it is the larger fashion brands, with longer, more complex supply chains that can make small modifications but create the biggest positive impact due to the volume of product they sell. It is these same organisations who often have the most financial means and department capacity to also action these changes efficiently. Regardless however of the

size and make-up of the company, it is the willingness to change which is paramount to implementing sustainable business practices. The value in making these changes also needs to be acknowledged by senior management with collective buy-in from workers, suppliers and contractors.

2.3.2 Responsible Fashion Practices

It was once believed that shopping sustainably was only for the elite, those who could afford to pay extra for the privilege of their products being made responsibly. The accessibility to ethical and sustainable fashion used to be perceived as one of the largest barriers to change, with mass-market consumers not having the luxury of choice when it comes to responsible values. However, this is no longer the case, increasingly so within the fashion market, with numerous high street fashion brands now committing their time and energy to create a more responsible approach to their business practices. These commitments are broad and diverse, ranging from the use of recycled plastic in their carrier bags to clothing take-back schemes, and the use of waterless dyes to producing in carbon neutral factories. In addition to the type of responsible commitment, the level of engagement from companies also varies wildly, creating further complication due to the lack of industry standards and regulations. Despite these efforts being demonstrated, many believe that lower priced retailers especially, cannot possibly be sustainable as they actively encourage negative behaviour such as over consumption and premature disposal. Again, these contrasting perspectives interpret their responsible actions to be disingenuous, perceived only as a tick box exercise. Fast fashion and ultra-fast fashion brands have come under heavy scrutiny in their pursuits to be more environmentally friendly, leading their efforts to be questioned and often accused of *greenwashing.* Defined as the use of sustainability for financial or reputational gain, false or exaggerated responsible action is seen as a form of lying or being untruthful about the activities that are being taken. It is difficult to see how some items with exceptionally low-price tags could ever have been made with low-impact materials, manufactured under good social working conditions, and still have the fashion brand make a profit. In addition to the value-end of the market being scrutinised, so too is the high-end, luxury market, with little evidence for a positive correlation between price and sustainability. When comparing the manufacturing practices of low and high-end brands, there is surprisingly little difference with many of the same operations occurring, meaning the only distinct difference is product mark-up and consequently profit. The assumption of a premium price meaning greater responsibility is beginning to be challenged by consumers, with alternative consumption models such as buying second-hand, or leasing clothing now perceived as a more sustainable option.

Despite many mass market retailers now engaging in some level of responsibility, consumer knowledge of the key sustainable issues facing fashion remains largely unknown. This confusion also extends to purchasing, with 79% of consumers stating that they find it difficult to know which fashion brands are sustainable, with a fifth of these participants believing that price is a good indicator (Mintel,

2019a). This perception not only provides evidence that consumer knowledge and awareness remains a key challenge when it comes to sustainable engagement, but it also questions the accessibility of sustainable goods to customers. Furthermore, the efficiency of a brand's sustainable communication also plays a role here, with fashion retailers needing to find a balance between greenwashing and informing their target market. Effective communication of a company's sustainable commitments (often referred to as corporate social responsibility) has been evidenced to provide a range of business benefits, with effective CSR engagement not only facilitating financial gain but also an increase in brand trust. In a recent consumer survey, Marks & Spencer is said to the most trusted high street brand by far, with 63% of participants favouring the British heritage company.

With little standardisation across the fashion market, the shape and direction that responsible business should take is entirely debatable. Terminology alone remains a challenge with again a lack of regulation, leaving the interpretation of complex concepts such as sustainability and ethics, open to individual interpretation. The scope of these challenges in a fashion context, have been widely discussed. However, the practical implementation of these values within the sourcing, production and consumption of fashion remains to be seen. The onerous appears to remain with the company themselves and their personal drive to implement sustainable practices within their business, while remaining profitable and competitive in the market. Business cannot be based on philanthropy and to enable change to be created, a move away from the outdated linear model currently shaping the fashion industry, companies primarily need to make enough money to operate effectively and to create profit for future business aspirations. Many companies are beginning to interpret what responsibility can mean for their business; however, just as with the long, complex and highly individual supply chains, sustainability does not come in a one-size-fits-all approach. It is now down to the individual brands to shape their future and begin to action sustainable change, with the most successful examples beginning to embed these principles throughout the full scope of their unique value chain.

2.3.3 Building a Resilient Future

As a reflection of the very nature of fashion, the industry is continuously changing and shifting to remain desirable and responsive to the needs of consumers. Changes in retail, manufacturing methods and design trends pose frequent challenges, where brands must adapt and adjust their practices to maintain their competitive edge. The rise in awareness and demand for more responsible principles in the fashion industry is yet another challenge for existing brands, where their response is crucial in working towards a more sustainable system. However, the fashion lifecycle is a complex series of mechanisms and processes, with no element working in isolation, meaning that meaningful change will need to be systemic as opposed to isolated instances of behaviour. The brands who are leading the way in this level of innovation are beginning to really set themselves apart from the crowd, setting a standard for industry competitors to work towards.

In March 2020, the fashion industry was posed an almost insurmountable challenge with the outbreak of COVID-19, the global pandemic which closed all non-essential stores and reduced fashion retail sales by up to 80% (The Business of Fashion, 2020). The industry had to respond in numerous ways to facilitate some level of business-as-normal in the continuation of the global fashion supply chain. As discussed throughout this chapter, the fashion lifecycle is a fragmented and fragile system relying on an undisclosed number of factors for it to function. These recent challenges have only highlighted further the delicate state of the global supply chain which is reliant on social and environmental input. A significant decrease in fashion sales brought the supply chain to a standstill, meaning garment workers were out of work, suppliers were not paid and seasonal excess stock, worth approximately £18bn was building up in warehouses (Szajna-Hopgood, 2020). As is common practice in the fashion industry, suppliers are expected to pay up front for garments costs, with payment for finished products being made by retailers after the shipment has been delivered. In anticipation of slow sales, retailers cancelled orders with their suppliers, withholding payment of $2.8bn, leaving many of the 4.1 million garment workers who for western brands with no work or wages (Roberts-Islam, 2020). Brands such as Primark, Arcadia and Urban outfitters cancelled orders with their suppliers (Szajna-Hopgood, 2020), with retailers such as New Look suspending payment to suppliers indefinitely and asking for rent holidays for their stores (Jahshan, 2020).

A report issued in response to the Coronavirus by The Business of Fashion and Mckinsey and Company states that it is the responsibility of big fashion players to set an example for the rest of the industry in their rethinking of the fashion cycle, enabling real change using new digital formats. Positioned in the context of the lifecycle, they presented a model to demonstrate several ways innovation within the supply chain has been evidenced in response to the limitations created during unprecedented times. Examples include, 3D design, video signoffs, virtual shows and social consumer selling. In addition to innovation evidenced in the existing lifecycle, alternative consumption models, leaning towards a greater sense of responsibility, are also set to grow in popularity, with resale, upcycling and recycling facilitating a shift in current levels of excess stock. While these changes have been initially actioned in response to specific circumstances, they have the potential to change the fashion industry in a more long-term sense, with new and revised ways of working becoming the new normal. While there are numerous negative connotations with change, many have deemed it as *a chance to rewrite fashion*, addressing many of the systems, process and practices that are no longer suitable for contemporary society. Trend forecaster, Li Edelkoort reiterates the need for change going forward: ‘the virus I think is like our conscience, it brings light on what is so terribly wrong with society and the everyday becomes clearer, it teaches us to slow down and to change our ways’ (The Business of Fashion, 2020).

For decades now, it has been recognised that the traditional fashion model is not operating in a sustainable manner, with business decisions, profits and consumer greed determining the level and rate of fashion consumption. In addition to the period of lockdown as a chance for the industry and its consumers to reflect on their

core values, it has also offered the opportunity for innovation and a new way of thinking for the fashion industry. A renewed reliance on technology has enabled methods such as virtual sampling and AI supported planning to be utilised in remote or isolated working, empowering key roles in the supply chain such as designers and merchandisers. The use of technology has been extended to the use of digital showrooms for trade shows and fashion weeks, preventing the production of millions of sample garments and travelling many thousands of miles by attendees. This provides further examples of how innovation has been born out of necessity, all of which has had a very positive impact through the reduction in energy use and waste production during sampling and a significant cut in carbon emissions from national and international travel. Furthermore, the global pandemic was said to be responsible for a recent preference to bringing production methods closer to home, often referred to as 'nearshoring' (The Business of Fashion, 2020). Whether from necessity or not, this move again has a positive potential reduction in environmental impact, with a reduction in carbon emissions created during the transportation of goods and materials in the supply chain.

Many of these chances for innovation can be interpreted as a way of futureproofing the fashion industry for any potential threats which may come in the near or distant future. Companies are now encouraged to identify, prioritise and scale-up any successful innovative methods implemented during recent periods of difficulty to be responsive in periods of flux that require speed and flexibility to survive (The Business of Fashion, 2020). The need for harmonisation within the fashion industry has been called upon, with a balance between pre and post pandemic states needing to be found.

3 Reshoring Garment Production

Despite the offshoring of garment production from the UK in the 1980s, making good business sense at the time, considerations around the return of manufacture have begun to gain momentum, with many motivational drivers being identified. Just as with many aspects of sustainability, terminology remains inconsistent, thus the practical response to such debate is often subjective and misguided. Terminologies interspersed within these debates include *backshoring* ['Re-concentration of parts of production from own foreign locations as well as from foreign suppliers to the domestic production site of the company' (Kinkel & Maloca, 2009); 'The geographic relocation of a functional, value creating operation from a location abroad back to the domestic country of the company' (Holz, 2009)], *reshoring* ['Moving manufacturing back to the country of its parent company' (Ellram, 2013)], *backsourcing* ['Production return relocation from an[…] external entity' (Holz, 2009)], *de-internationalisation* ['Any voluntary or forced action that reduces a company's engagement in or exposure to current cross border activities' (Benito & Welch, 1997)], and *international divestment* ['A reduction of ownership percentage in an

active direct foreign investment on either a voluntary or involuntary basis' (Boddewyn & Torneden, 1973)].

However, two terms that better reflect the needs of the garment industry are *new shoring* and *next shoring*, encompassing the expectations around the ability to scale at speed, while working within resource limitations of new locations. Unlike other terms, these embrace the innovation behind the approaches, adopting systemic change and true technology disruption in areas such as advanced robotics, digitalised manufacture and the optimisation of additive manufacture. Through these new ways of working there are many opportunities to considerably reduce the traditional steps required in the production of garments and as such time, cost and resource use. While onshoring challenges can be seen by some as limitations to commercial entry, these can be re-framed as innovation opportunities born out of a systemic change in use of technology and process. Although it could be argued that there are only subtle definition differences with these terms, they do focus on the step change needed from purely producing in a new country or location, to that of commercially producing to meet a consumer need within a new country or location. Furthermore, through discussions of the practical implementation of these concepts, it should be noted that 100% shift in production may not always be appropriate, with a segmented move allowing developing areas of the supply chain time to mature and scale. An example of this could be that raw materials critical to the end-product are shipped in from overseas, while textile and garment manufacture are carried out at scale within the UK. The potential these approaches provide to the design and development of clothing is significant and should be seen as a design opportunity for future fashion.

3.1 Motivations for Reshoring Production

The scale of negative environmental impact created by linear production and consumption methods within fashion is widely acknowledged. However, the relationship between reshoring production and environmental sustainability has been previously questioned with debates suggesting that this alone cannot be the rationale for such logistical upheaval (Orzes & Sarkis, 2019). Motivations to instigate reshoring of production within the context of fashion are varied and go beyond sustainability. However, the consequences of many key drivers reduce or negate social and environmental impact. The breadth of motivational factors is diverse and can often offer multiple benefits where the division between the benefits is not always clear (i.e. the introduction of a new innovation/technology, could support the boost in national economy while also offering considerable sustainability advantages).

In an extensive literature analysis conducted by Di Mauro et al. (2018), a total of 42 key motional drivers were identified for both offshoring and backshoring resulting in the development of a theoretical framework. Additionally, this considered internal and external factors within the context of perceived customer value and cost

efficiency. Key findings conclude that offshoring is often highly motivated by reducing costs, in comparison to backshoring which is said to be based more on a strategic approach (Bals et al., 2016; Mugurusi & de Boer, 2014). This is due to the facilitated collaboration between production and development functions and therefore, despite increased manufacturing costs, can be perceived as a sensible location response to the changed competitive strategy (Di Mauro et al., 2018).

Figure 1 illustrates the authors interpretation of the key motivations for reshoring production, adopting an industry stakeholder perspective. Furthermore, it seeks to propose practical solutions for implementation through clustering in four key areas:

Industry Leadership The UK can again regain its position and reputation in textile innovation and leadership within garment production, reflecting on the prosperity for manufacturing prior to offshoring in the 1980s.

– Reshoring production also boosts the national economy, increases jobs and industry revenue contribution to GDP.

Sustainability First Working through the framework of Newshoring/Nextshoring a sustainability first approach can be applied to new innovation and technology developments.

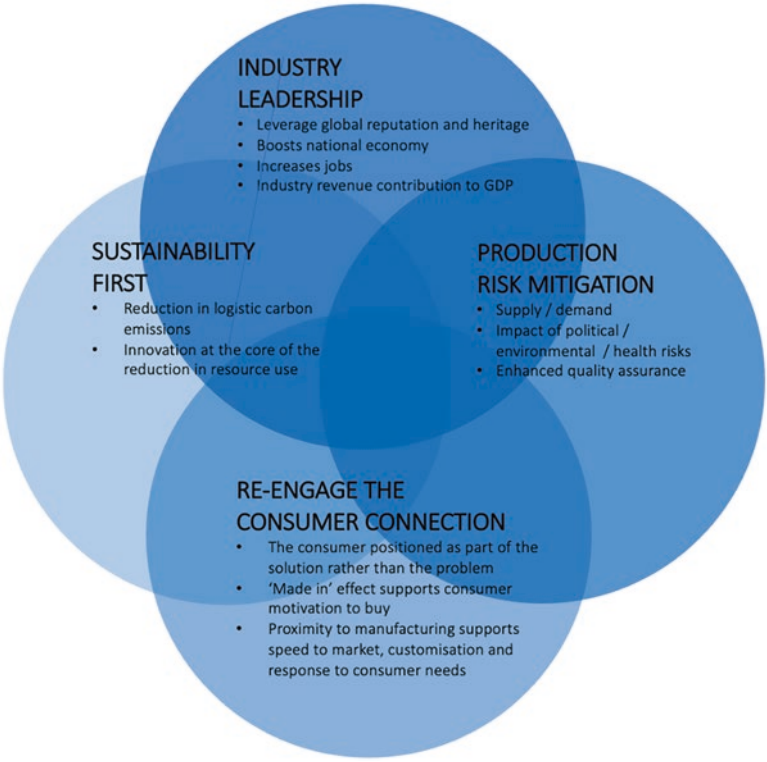

Fig. 1 Motivations for reshoring fashion and textile production. (Authors own)

– A reduction in logistical reliance can be expected as a result of a direct and significant decrease in transportation needed of goods and materials from the production location to the point of sale. Consequently, this will result in a reduction in carbon emissions from sea and/or air freight and reducing the environmental impact of the supply chain processes.
– As production embraces low resource use technologies (i.e. CO_2 Dyeing where zero water and 50% less energy is required) production facilities will be able to measure resource savings in areas such as energy, water and raw materials.

Re-engage the Consumer Connection A closer consumer connection to manufacturing can be developed, empowering the consumer to become part of the solution rather than accelerating the problem.

– The positive impact of what has been labelled as the 'made in' effect can aid in the consumer motivation to buy into a specific brand or label, providing instant insight into the origins of the product. Additionally, this could overcome the knowledge, connectivity and empathy gap identified between consumers and the supply chain (James & Montgomery, 2017).
– Enhanced trust can be built between companies and their customers facilitated by a transparent supply chain narrative.
– Consumer customisation opportunities are opened up through a new approach in manufacturing that is smaller, embraces new technologies and is closer to the market. With this closer consumer engagement, a sense of 'made by me' is imparted to clothing supporting greater longevity for garments within the system.

Production Risk Mitigation With manufacturing being closer to the company headquarters, a greater sense of control can be gleamed over the manufacture of products including the quality of the garments being made, the sustainability processes embraced and greater confidence over supply and demand.

– Resource constraints could be overcome by utilising localised supply and production which have been experienced recently through periods of conflict and the global pandemic. Furthermore, this would enable resource and manufacturing self-sufficiency contributing to a regenerative localised model of production and consumption.
– Furthermore, this will facilitate a more controlled level of social compliance with auditing practices executed with ease and business operating under UK governance and legislation. Gao et al. (2018) believe that the environmental sustainability of a supply chain could be enhanced due to such events as greener operations of developed country firms.

In accordance with the climate targets set out in The Paris Agreement and in response to the call to action set out by The United Nations to address the climate emergency, reshoring production can contribute in multiple ways towards achieving the Sustainable Development Goals. To work within the resource boundaries of the UK, low or zero water manufacturing solutions will need to be implemented

especially within colouration and dying of textiles (No. 6 – Clean Water and Sanitation). This approach will not only utilise far less water than current methods but also create less water waste and polluted water from production processes. Furthermore, the integration of advanced technology will aid in the development of clean manufacturing methods, utilising renewable power sources and creating less emissions (No. 13 – Climate Action). This relates closely with the use of industry infrastructure and boosting the UK's innovative textile and garment manufacturing globally (No. 9 – Industry innovation and infrastructure). With the key in-country motivations for reshoring, the development of the national economy in the creation of jobs and industry revenue begins to protect self-reliance and supply of necessary resources (No. 8 – Decent Work and Economic Growth). When considering the supply chain narrative in building product-consumer value through customisation, Responsible Production and Consumption (No. 12) becomes the focus. However, just as intended with the SDG's, these factors cannot work in isolation and rely heavily on the success of other areas of growth and development (No. 17 – Partnerships of the Goals).

3.1.1 Current UK Manufacture

As discussed earlier in the chapter, current practice does not align the UK with garment and textile production; however, there remains several established brands who have either re-shored their production in-country or who have built their business on the foundation of a Made in UK approach. Several examples of best practice can be highlighted within a UK context, where brands have already started to relocate some of their production closer to their business location. These brands currently work within the true sense of onshoring or backshoring, with further consideration needed to produce commercially at scale to embrace new-shoring or next-shoring approaches.

- Community Clothing owned by Patrick Grant adopts a Made in UK model, covering the full supply chain, established with a simple goal in mind; 'to sell quality affordable clothing and by doing so, sustain and create great jobs in the UK's textile making regions. Each product comes from one of their 28 partner factories (most of which are family owned) including spinners, weavers, knitter, dyers and finishers across Lancashire, the East Midlands, Scotland and South Wales. Furthermore, they position their manufacturing in some of the UK's most deprived areas, creating economic prosperity and jobs within the local area. As a company, they pride themselves on quality, sustainable products that are made to last a lifetime.
- Hiut Denim Co. have embraced their heritage, where for three decades they produced 35,000 pairs of jeans per week; however just like much of the production within the UK, this was relocated overseas in the 1980s, leaving 400 people unemployed. However, Hiut Denim Co. have re-shored their production back to Cardigan in Wales to where the knowhow and skill have remained. This is an

example of how the DNA of an industry has been retained within a community, despite the skilled workforce spanning generations of families.
- British luxury brand Burberry retain some manufacturing within the UK, especially with heritage products synonymous with the Burberry brand. For example, they weave gabardine fabric invented by Thomas Burberry in Keighley and their traditional trench coat products are made in Castleford, both within Yorkshire. This example links the British manufacturing heritage and iconic textile production with the UK as a manufacturing location.
- British apparel brand Finisterre made a commitment back in 2005 to position Marino wool as a key fibre component in their collections, due to its heritage properties and sustainable credentials. However, sourcing became an issue as there were only 28 Bowmont Marino sheep within the UK which could not supply the quantity of product needed. Working in close collaboration with the flock owner for nearly a decade and the future of the breed has been established with almost 300 Bowmont Marino sheep not residing in the UK, building a 100% British supply chain from scratch.

3.1.2 Feasibility of Reshoring Garment Manufacture

When considering the feasibility of reshoring textile and garment manufacturing to the UK, it is also to be acknowledged the geographical lack of resources available, thus leading through sustainability practices could begin to set the UK apart from alternative production regions. Access to land, natural resources such as water and manufacturing infrastructure is scarce, thus, alternative, responsible methods can begin to build a bottom-up approach in volume-led global manufacturing regions. Consequently, this approach will operate within global and environmental boundaries from necessity rather than subjective and voluntary action.

Further considerations within the value chain are also necessary when considering feasibility of reshoring garment manufacture including resource efficiency, infrastructure, and technology capabilities. Water usage for example is a key consideration, integral to the production of textiles and fashion products; however, within a UK context, the high cost of fresh water and wastewater processing will need to be addressed through the integration of low water technologies within the dying and processing phases. A critical argument opposing the implementation of UK manufacturing is the limited existing worker infrastructure and the comparative high cost of labour. A prevalent skills gap exists since the offshoring of production in the 1980s, with the aging workforce retiring and a lack of apprenticeships and training to replenish staff. The use of advanced robotic automation could aid in addressing this core challenge (as already evidenced in agriculture and automotive industries in the UK); however, unlike industries commercially adopting automation today, further considerations specific to the clothing industry around the handling of lightweight fabrics through robotics and accuracy of manufacture is needed.

Restrictions around geographical location present further challenges in the relocation of production. In comparison to manufacturing localities in Asia, the UK has

restrictions on space and available land which could be used for factory sites. Rethinking factory footprints will be integral, alongside the streamlining and simplification of the long manufacturing process currently utilised in global supply chains. For example, Stenter machines are critical to the core of textile production to dry and set materials but require space as a minimum of 60 meters. However, these challenges have been overcome in other industries, such as farming which has moved towards a vertical farming method to reduce space, while still performing at full capacity. By taking systems change approach, this could be challenged and ultimately removed as a process requirement, for example if wet textile processing was eliminated or replaced with other processing methodologies. Considering unused, non-traditional spaces within the UK may also provide answers, such as redundant retail space. With cleaner manufacturing from newer and more closely regulated processes, clothing manufacture can be bought into city centres that have large spaces and accessible transportation networks as well as closer access to the consumers. Furthermore, cleaner manufacturing will be paramount due to high energy costs and restrictions on industrial emissions. The textile industry is an energy intensive industry and new thinking will be imperative, the UK has an opportunity to lead through example to high volume manufacturing countries within Southeast Asia, where coal is still used as fuel within textiles. Additionally, positioning the consumer at the core of the drive towards sustainability can aid in fast tracking progress, with this approach previously adopted within the food industry, where ethical and sustainable supply chains remain an expectation.

3.2 Technology Driven Innovation

As detailed, the supply chain is a long, complex process and a knee-jerk reaction to relocation could be counterintuitive and potentially catastrophic for existing global supply chains. A phased, modular approach would facilitate staged change but ensure correct measures have been taken to not jeopardise supply while maximising the UK's potential to onshore production.

Adopting a small scale, yet high value approach to the development of ranges could maximise the potential of UK heritage and the craftmanship narrative within the supply chain. Referring to Community Clothing as an example, they embrace the slow manufacture of their products, with their unique selling point being around the supply of Made in UK products at a reasonable price and supplied in manageable quantities. Embedding this approach within the brand story goes beyond creating disposable clothing but develop value and emotional connection at a consumer level. Moreover, the brand examples already discussed create a connection between the product and the maker, with Hiut Denim Co. assigning each individually crafted product to a particular member of their work force, with the machinist signing the label for each piece they make. Additionally, UK brand Harris Tweed have emphasised their heritage narrative through collaboration with mass market brands such as Nike, Vans, Topman and Adidas.

To increase possibilities of UK manufacturing, the adoption of technology driven innovation is crucial to overcome some of the core challenges highlighted and discussed throughout this chapter. As framed within the context of the garment value chain, the following areas of advanced innovation could be explored:

Dyeing and Printing

- Super critical CO_2 dyeing – currently being utilised in Taiwan, Thailand and Vietnam, this process utilises no water resources and likewise, produces no polluted wastewater as with traditional dying processes. 50% less energy is used (due to the reduced need to heat water, dry fabrics, etc.) and 50% less chemistry (using pure pigments, reducing the need for a lot of the auxiliary chemicals needed in more traditional dyes). Additionally, the CO_2 used in the process is recycled and the factory footprint is greatly reduced. This technology would enable brands to ship greige knitted fabric to the UK in one scenario and dye smaller lots, closer to market and the consumer. Currently, this process is only being utilised in a commercial context with the colouration of polyester but has opportunities to be rolled out for other fibre types to impart performance to a fabric through the application of performance chemistry, replacing traditional wet processes.
- Dope dye (spun or solution) – while this is not a new technology it has been experiencing a resurgence since the focus on lower energy and lower water technologies have come under scrutiny. The process utilises 80% less water and consequently lower energy. Pigment (colour) is added at the polymer stage at the start of the process, rather than using water, energy and space intensive processing later on in the manufacturing stages. While increasing dope dye production within the UK at this stage may not be a solution, by purchasing pre-dyed, dope dyed polymer or yarn, later textile production steps (undertaken in the UK) can be much reduced as there is no subsequent need for fabric dyeing (i.e. backshoring).
- Zonal printing – applies colouration to fabric only where needed through high-speed digital printing (i.e. garment panel are first printed then constructed). In 2019, new digital printing technology emerged that printed fabric at up to 90 metres per minute, presenting great commercial opportunity for UK manufacturing. Furthermore, water and energy usage are significantly reduced. From a practical implementation perspective, this technology enables retailers or designers to send an order to a local print house, also known as a *fulfiller,* where designs are printed directly onto the fabric and garments produced in just a few minutes. The system eliminates the need for long lead times and helps retailers to minimise waste instead of having to make large orders months in advance, they can quickly and flexibly respond to demand.

Knit technologies: A design led approach to knitting technologies can considerably reduce the process from raw material to finished garment, thus making it an attractive opportunity for UK manufacturing. Yarn is knitted directly into a garment bypassing the need for complex lengthy cut, make and trim (CMT) processes utilising minimal stitching.

– Weft Knit seamless – again while this is not a new technology, onshoring the application of this technology to the UK would integrate traditional craft processes with advanced technology methods. Weft knitted seamless garments, traditionally focused to lingerie and sportwear, are knitted in tubular form and therefore can be designed to require very minimal CMT. This makes it a favourable technology for global regions where labour is expensive or in short supply (i.e. The UK). The expertise is held within the application of technology and design, which again makes it a very favourable approach for UK onshoring. Due to the reduction in processes, lead times can also be reduced.
– Warp knit seamless – This technology is less used across the industry due to the larger footprint machines, slow production speeds, reduction in production flexibility but does empower the role of the designer. Edges can be easily raw cut and elements of customisation can be incorporated. Although the machines themselves are large, it does cut out the need for many additional CMT processes, thus shortening the complexities within UK manufacturing.

Manufacture

– Polymer to product – Turning the linear production process on its head, direct polymer to product manufacture bypasses the many additional processes used in textile and garment manufacture such as fibre extrusion, yarn spinning, textile manufacture (knit or woven) and CMT into a garment. This has huge potential not only at a sustainability level (through a reduction in workforce, resources, time and space requirements) but also from a customisation point of view. Exploration to date, although mainly at the concept level, has taken place in garments, textiles and accessories (i.e. footwear/eyewear, etc.) in areas such as:

    • Additive manufacture /3D printing – a collaboration between Loughborough University and the Yeh Group created fully flexible 3D textile uppers for footwear in a vision to be able to 100% manufacture 3D printed footwear and apparel which is completely customisable to each individual customer. Commercial examples can be found already in fashion accessories, although moving into more flexible forms (i.e. fashion fabrics and textiles has limitations). Examples of existing commercial use includes brand such as The Sole Theory and Adidas Futurecraft. While Design ideas currently supersede technology and material readiness, it provides opportunities to 3D print products at the site of the machinery.
    • *Non-wovens/Spray-on clothing* – Fabrican Spray-on fabric creates an instant sprayable non-woven fabric directly onto the human body, thus bypassing the need for lengthy processing. Developed from sustainability concerns within the fashion industry, this new technology, showcased during the Paris Haute Couture Fashion Week (2022), embraces a circular approach, enabling total recyclability at end of use when it can be dissolved and resprayed into a new garment.

– Industry 4.0 – Many experts consider Industry 4.0 to be the production method of the future. The aim is to combine the latest digital technology with the automation possibilities of big data and new production methods. Smaller, decentral-

ised and highly automated production facilities right where the consumer is located. The goal is a whole network of new sites that use intelligent robot technology will exchange data with each other.

- Speed factories – the highly innovative concept of the Speed Factory is based on the idea of Industry 4.0 previously used by Adidas, but challenges in the process arose when labour costs were overlooked due to an increased staged approach that garment manufacture needed.
- *Robotics* – the adoption of automation remains slow within garment manufacture as compared to other industries as fluid, light weight fabric and stretch properties are difficult to work with effectively from a machinery perspective. While workers can adapt to a fabric's stretchiness or tendency to fold, machines may not properly move or handle fabric, causing them to make mistakes or damage raw materials. However, the development of Robotextil begins to address this, with this technology designed to pick up each fabric layer and set it down again safely and smoothly at the desired position for sewing and surging operations.

Performance finishes: Traditionally, garment performance finishes (such as water repellence, moisture management, stain resistance, etc.) are applied in the textile form during manufacture which requires additional wet processes on the fabric after the textile has been coloured. This adds time, and additional processes that have the associated water, energy, and chemical impact. To support the infrastructure of manufacturing with the UK, the factory footprint, and complexity of application needs to be reduced while upholding the performance that the garment requires.

– *Cold plasma treatment* – is used in various industries to impart a surface treatment and or a performance function onto a material. Initially adopted more broadly within electronics and high value/small part industries, it can perform various performance finishes with lower chemical use and more zonal application requiring a smaller factory footprint.

4 Conclusions

This chapter has primarily analysed the traditional methods and processes undertaken within the textile and garment value chain, highlighting challenges and areas for opportunity for both more established reshoring, or onshoring, but also more commercially framed new-shoring or next-shoring, manufacturing technologies to the UK. While the feasibility of relocating large scale garment manufacture has been challenged, this text approaches this from the perspective of identifying ways to make reshoring and new-shoring work to fulfil a current and contemporary industry need. As previously discussed, these debates go beyond the primary driver being sustainability or responsible practices, but within the practical implementation of

production methods and processes in a UK context, advanced technology is critical which often encompasses reduced resource and energy applications.

It is to be acknowledged, that a business-as-usual approach to relocating production will not be possible, with the UK needing to carve out its unique approach to manufacture while embracing advancements in technology to overcome geographical and social challenges. Feasibility will require bold action and cross industry collaboration to create leverage across the value chain, while additionally empowering consumers to co-design commercial possibilities from a participatory design perspective. Companies within critical operational positions in the UK industry need to draw on the textile heritage and historical positioning where possible, embracing previous knowledge and practice within the existing DNA of textile and garment production regions. Maximisation of a modular, gradual shift towards relocating production will futureproof supply chains and ensure a consistency in supply.

Governmental support will be crucial in the success of expanding the industry, with environmental and fiscal modelling needed to determine scalability and economic prosperity within degrowth parameters of the fashion industry. Primary funding will also be required to develop pilot and concept testing, enabling an elementary approach to support technology landscapes to evolve and grow. Obviously within the current period of financial instability and economic downturn within the UK, a financial reliant model is paramount to the success of initial activity.

Many of the proposed opportunities to embrace innovative, technological advancements adopt responsible manufacturing practices and will significantly reduce resource and energy use, emissions and waste within the supply chain. Additionally, the social implications of relocating operations to in-country locations are extensive, with the creation of secure jobs, upskilling and training opportunities and the further development of existing skilled worker communities. Furthermore, the consideration of locating some manufacturing to non-traditional spaces such as disused retail spaces could begin to integrate garment and textile production within the infrastructure of cities the length and breadth of the country. While reshoring, onshoring, new-shoring and next-shoring of production is not a quick-fix to many of the financial and sustainability issues currently facing the country, it does explore the medium to longer-term opportunities to reposition the UK as a global leader within textile and garment manufacture.

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