NOVA SCHOOL OF
SCIENCE & TECHNOLOGY

DEPARTAMENT OF
Environmental Sciences and Engineering

A MULTI-METHOD APPROACH TO UNDERSTAND THE ROLE OF CIRCULARITY IN THE FASHION INDUSTRY

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"The way of success is the way of continuous pursuit of knowledge." (Napoleon Hill).

ABSTRACT

The Textile and Apparel (T&A) industry is considered one of the most critical merchandise industries of the globe, known for its vast supply chain. It is reputed as one of the most polluting sectors, accounting for almost 10% of the global emissions (Jia et al., 2020; Niinimäki et al., 2020). The circular economy concept has emerged as a solution to redefine growth while emphasizing societal benefits and reducing the depletion of natural resources (EMF, 2022).

In the present dissertation, a multimethod approach was applied, combining exploratory interviews, surveys, circular conceptual models, and testing the impact of different circular solutions in two case studies. This process allowed to capture experts, and multinational and small brands' perspectives regarding circular economy to understand the *status quo* knowledge of the concept. Additionally, it was aimed to identify and study the policies, strategies, actions, education, and awareness practices for circular economy throughout the value chain, and the impact strategies might have on emissions.

The complexity of the perceptions was addressed through the data collected through interviews and surveys and its relation with the literature review, culminating in the development of five conceptual models. Additionally, the data provided by the collaboration with Bezero Carbon company allowed a quantitative study of four strategies.

It was possible to verify the importance of the connection between all the developed conceptual models as tools for decision-making processes, being their application crucial for the achievement of the circular economy. From one conceptual model to another it was also observed that the relevance/presence of each value chain stage varies according to the models' type (strategies, actions, policies, education, and awareness).

With the present study, it was possible to understand the complexity of the circular system in the fashion industry, as well as the multiple parties that are involved and the numerous decision-making processes that are required to reach circularity. There are several paths to circularity that depend on multiple variants from the size of the value chain to the number of processes involved.

Keywords: Textile and apparel; Circular economy; Emissions; Sustainability; Policies; Strategies; Actions; Education

RESUMO

A indústria têxtil e de vestuário é considerada uma das mais críticas do globo, sendo conhecida pela sua vasta cadeia de valor. É também um dos sectores mais poluentes, representando quase 10% das emissões globais (Jia et al., 2020; Niinimäki et al., 2020). O conceito de economia circular surgiu como uma solução para redefinir o crescimento, enfatizando os benefícios sociais e reduzindo o esgotamento dos recursos naturais (EMF, 2022).

Na presente dissertação desenvolveu-se uma abordagem multi-metodológica combinando entrevistas exploratórias, inquéritos, modelos analíticos circulares e o teste do impacto de diferentes soluções circulares em dois casos de estudo. Este processo permitiu capturar as perceções de pequenas marcas e multinacionais no que respeita à economia circular com vista a entender o *status quo* do conhecimento deste conceito. Adicionalmente, procurou-se identificar e estudar as políticas, estratégias, ações e práticas de educação e sensibilização para a circularidade bem como o impacto que as estratégias podem ter ao nível de emissões.

A complexidade das perceções foi abordada através da recolha de dados através de entrevistas e inquéritos e a sua relação com a revisão da literatura, culminando no desenvolvimento de cinco modelos analíticos. Além disso, os dados fornecidos pela colaboração com a empresa Bezero Carbon permitiram uma análise quantitativa de quatro estratégias.

Foi possível verificar a importância da ligação entre todos os modelos analíticos desenvolvidos, sendo a sua aplicação crucial para a concretização de uma economia circular no setor. De um modelo analítico para outro observou-se que a relevância/presença de cada fase da cadeia de valor varia de acordo com o tipo de modelo (estratégias, ações, políticas, práticas de educação e sensibilização).

Através do presente estudo foi possível perceber a complexidade do sistema circular no setor da moda, bem como as várias entidades que estão envolvidas e os inúmeros processos de decisão que são necessários para atingir a circularidade. Existem diversos caminhos para a circularidade que dependem de múltiplas variantes desde o tamanho da cadeia de valor à quantidade de processos envolvidos.

Palavras-chave: Têxtil e vestuário; Economia circular; Emissões; Sustentabilidade; Políticas; Estratégias; Ações; Educação

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ACRONYMS

CE	Circular Economy
CS	Case Study
EEA	European Environment Agency
DIY	"Do it Yourself"
EMF	Ellen MacArthur Foundation.
EU	European Commission
HGV	Heavy Goods Vehicle
GHG	Global Greenhouse Gas
LC	Life Cycle
LCA	Life Cycle Assessment
PE	Participatory Evaluation
SCM	Supply Chain Management
SME	Medium Sized Enterprises
T&A	Textile & Apparel
USD	US Dollar
VAT	Value Added Tax

1 | INTRODUCTION

1.1 Topic Overview and motivations

In the late years, sustainability has been growing as a concerning topic. Practically all facets of our lives rely on natural resources. In 1987, the concept of sustainability was defined by the United Nations as "meeting the needs of the present without compromising the ability of future generations to meet their own" (United Nations, 2022).

In the book "Sustainability by design", J. Ehrenfeld mentions that the world's national history is characterized by a sequence of somewhat calm periods contrasted with severe social changes. Societies adjust to these changes rather rapidly as new generations take the place of those who have been defeated in violent transitions from one order to the next (Ehrenfeld, 2008).

However, the "World is different today", societies have created weapons so powerful that the human race cannot recover their numbers merely due to these periodic upheavals in history. The rapid proliferation of today's economies of technology and consumption - a threat of cultural, and possibly biological, mass destruction - is erasing what's left of cultures, that used to live in harmony with the planet and themselves (Ehrenfeld, 2008).

This current reality, mentioned by J. Ehrenfeld, links back to the concept of sustainability and the need to have concern for future generations. The necessity to care for the future of societies and tackle issues such as resource scarcity and pollution of resources constitute the driving force for many initiatives. These aim for the development and implementation of production-consumption innovations that dissociate economic growth from resource decrease and pollutant emissions. With this line of thought, emerged the concept of *circular economy* (CE), which constitutes one of the most preferred frameworks attempting to align economic activity and environmental welfare sustainably (Rankin, 2015).

Currently, there are numerous different definitions of the circular economy concept. According to the Ellen Macarthur Foundation (EMF), this concept is "a systemic approach to economic development designed to benefit businesses, society, and the environment". A circular economy expert (Metabolic) defines it as "a new economic model for addressing human needs and fairly distributing resources without undermining the functioning of the biosphere or crossing any planetary boundaries". Also, the definition presented by Geissdoerfer et al. 2016 is a "regenerative system in which resource input and waste, emission, and energy leakage are

minimized by slowing, closing, and narrowing material and energy loops" (Selvan & Ramakrishna, 2022; Geissdoerfer et al., 2017).

Considering this concept, it is important to underline the key principles it includes, mentioned in the book "An introduction to a circular economy": "design out waste"; "retain the highest value for the longest time" and "maximize renewables". For these to be achieved, it is crucial to rethink the present global economy as a framework to comprehend lifecycle impacts, material flows, and trade-offs, among others to follow up interventions that permit the circular shift (Selvan & Ramakrishna, 2022).

Slowing down resource loops results in the prolongation and intensification of the product's use and value retention over time while closing resource loops promotes upcycling to restore or generate new value from used materials. This requires eco-efficient ideas that decrease resource usage and environmental impacts per unit of product or service. However, with this emerges the question: How can these new ideas incentive closing loops and reduce emissions at the same time? Can these two goals be compatible? (Gallego-Schmid et al., 2020).

There are many challenges to achieving a CE model. For example, it has been implied that the world is only 9% "circular", approximately 8.4 Gt of materials are input in cycles, while 84.4 Gt are directly extracted as virgin resources. With this arises the paradigm of reducing the use of virgin resources while finding solutions that allow the input of used materials in cycles without augmenting GHG emissions (Gallego-Schmid et al., 2020; Circle Economy, 2020).

A concerning industry in the global economy that should be taken into account is the industry of Textile and apparel (T&A), which is considered one of the most critical merchandise industries, with a vast supply chain. It is reputed as one of the most polluting sectors. In particular, the garment manufacturing process demands large amounts of water and energy for fabric production. Pollution is seen as a concerning issue in the T&A industry (Jia et al., 2020).

The environmental problems are unanimous in the T&A supply chain across all stages, namely, design, sourcing, fiber and clothing manufacturing, storage and distribution, use, and waste processing. The input and output of the industry's value chains influence the environment, but it is important to underline the fact that these effects are astonishing since T&A values approximately 1.3 trillion USD. It is the third biggest manufacturing industry in the world, following the automotive and technology industries (Jia et al., 2020).

Furthermore, according to EMF (Ellen Macarthur Foundation) the greenhouse gas (GHG) emissions generated in the T&A industry surpass the combined emissions of international aviation and marine transport. If this emissions rhythm keeps ongoing it is predicted that the industry will contribute to a quarter of global carbon emissions by 2050. Besides, the yearly carbon footprint of this industry's product LC (Life Cycle) (3.3 billion tons of CO2) is very approximate to the EU's 28 countries ' carbon footprint (3.8 billion tons). This traduces the high level of hardship in adapting the industry to circularity via sustainable innovations (Jia et al., 2020).

Considering the previously mentioned it is important to define the concept of circular fashion which presents itself as a possible solution: *"Circular fashion can be defined as clothes, shoes or accessories that are designed, sourced, produced and provided to be used and circulate responsibly and effectively in society for as long as possible in their most valuable form, and hereafter return safely to the biosphere when no longer of human use"* (Muthu, 2019).

1.2 Research aim and questions

The present study focuses on the fashion industry, excluding footwear, to reduce the analysis scope. According to the Ellen Macarthur Foundation clothing is "Massively Underutilized", this is true in high-income countries, special in the United States where clothes are worn for approximately a quarter of the global average. The T&A industry is responsible for "an immense footprint", having a "catastrophic potential" for the environment (EMF, 2017).

The same source states that if this industry keeps this concerning path, by 2050 it might use around "26% of the carbon budget associated with a 2ºC global warning limit" (EMF, 2017).

Considering the previously mentioned issues, showing how this industry's resources have a lot of associated emissions, the present study aimed to deepen the understanding of the role of circular economy in fashion namely the relationship between circular economy and CO_2 emissions. Studying the potential impact of different CE models in the emissions of this sector.

The present dissertation was developed with the support of Bezero Carbon, which is an international rating agency for the voluntary carbon market, providing data and knowledge and facilitating the interaction with two case studies.

This dissertation has the following goals in the fashion industry:

1. Capturing multinational and small brands' perspectives regarding circular economy to understand the status quo knowledge of the concept by this sector;
2. Analysis of the perceptions and approaches of big (multinationals) vs. small brands for circularity
3. Identification of policies, strategies, actions, and education practices for circular economy through a participatory evaluation;
4. Understanding the role of the identified policies, strategies, actions, and education practices for circular economy within the different stages of the garments value chain and their relations;
5. Assess the impact of identified strategies for circularity in terms of emissions through case studies provided by Bezero Carbon Company

To achieve the mentioned goals, a multimethod approach was developed. This approach was focused on collecting brands and experts' perspectives, gathering and analyzing the collected data, and investigating the feasibility of the circular economy's strategies to reduce emissions.

The last mentioned stage of the methodological approach was made through the analysis of two of Bezero's Carbon clients, which were both T&A brands. The Life Cycle Assessments data of both companies was provided by Bezero Carbon.

The collection and assessment of the different stages' outcomes permitted the development of the conceptual models, which gather information on all the stages of the present dissertation.

1.3 Target Audience

This dissertation aimed to advance the state of the art of circular economy in the fashion industry research field, aiming at the same time contribute to companies and experts in the area. Having the contribution of real cases from "Bezero Carbon", allowed us to test concrete examples and reflect on the benefits of the proposed approach and outcomes.

"Bezero Carbon", is a company founded in 2020 with a mission to create "prosperity through climate action". One of their goals consists of scaling the voluntary carbon market using a universal risk language, ratings, and research across the market as well as through architecting information for ecosystem markets (Bezero Carbon, 2022). One of the products this company offers consists of Life Cycle Assessments of other companies' products, which were used as tools for the present study.

1.4 Thesis outline

The present study is divided into five main chapters, namely, the introduction, literature review, methods, results, discussion, and conclusions. A brief description of each chapter is outlined below:

Introduction- Poses the relevance of the topic**,** the current environmental issues of the T&A industry; the relationship between fashion and CE; the motivations and goals of the present study, and how it can contribute to future research.

Literature review- The characteristics of the fashion industry are vastly explored. This chapter studied the growth of fashion as well as its drivers, pressures, social and environmental features as well as the interconnections between them. The development of the garments industry impacts was analyzed in detail along with the adaptation of the industry to a circular economy as a solution for those impacts. Posteriorly, it was analyzed the relationship between emissions and the concept of circular economy as a possible dichotomy.

Methods- A multimethod approach was adopted for the present study to meet the main goals previously mentioned. The various methods adopted are described one by one, namely: Theoretical Underpinnings; Interviews; Surveys; Conptual model development, and Case Studies analysis.

Results and discussion- In this chapter, the results of all adopted methods were presented and discussed. This includes exploratory interviews with top management and experts; surveys answers and analysis; the developed conceptual models and relations between their elements; analysis of the impacts of four selected strategies on the case study's value chain emissions.

Conclusions- Main conclusions from the developed work as well as its limitations. Finally, proposals for future studies and improvements aspects.

2 | LITERATURE REVIEW

2.1 The Textile sector

The textile sector constitutes a very important part of the global economy since it represents a fundamental role in everyday life. Textiles, more specifically clothes, are worn by most people practically all the time, being for many a significant manifestation of individuality (Ellen MacArthur Foundation, 2017). This has been particularly relevant in recent years, with fast and ultra-fast fashion assuming a crucial role in the way people consume fashion, under the justification of fashion democratization. Fast fashion and, posteriorly ultra-fast fashion, have permitted consumers to get satisfaction with low-cost and on-trend garments that reproduce their fashionable influencers at low prices, hence nurturing hyper-consumption (Yoon et al., 2020).

2.1.1 Sector context and evolution

Over the last 30 years, the fashion apparel industry has grown significantly. The altering dynamics of this industry, such as the boost of fashion seasons and the structural changes of the supply chains have induced retailers to wish for lower costs of production, and more flexibility in delivery, quality, and speed to markets. Furthermore, other motives for competitiveness in the sector have emerged, such as marketing and capital investment (Bhardwaj & Fairhurst, 2010).

Analyzing the simple structure of the fashion industry as far as the end of the 1980s, the retailers of fashion apparel had the capacity of predicting the consumers' trends and demands before the actual period of consumption being, therefore, able to thrive in the market (Bhardwaj & Fairhurst, 2010).

According to Bhardwaj & Fairhurst 2010, "Until the mid-1980s, success in the fashion industry was based on low-cost mass production of standardized styles that did not change frequently due to the design restrictions of the factories, such as Levi's 501 jeans and a man's white shirt, although there were exceptional cases of rapid changing haute couture". Supposedly, during that period consumers were considered to prefer basic apparel (Bhardwaj & Fairhurst, 2010).

Fashion can be seen as a temporary cyclical occurrence enacted by consumers for a specific timeframe, therefore the life cycle of these types of products is relatively small. During the '80s a regular life cycle in the fashion industry would include four stages: the creation and endorsement by fashion leaders; the rise and development in acceptance by the aimed audience; mass compliance, and lastly the decay and aging of fashion. Moreover, during this period there was a relatively limited calendar with only two annual exhibitions, which included two patterns: Spring/Summer and Autumn/Winter (Bhardwaj & Fairhurst, 2010).

Nevertheless, with the approach of the 1990s, retailers began to broaden the range of their products and release new ones more often as a response to the demands of the actual fashion trends. With these approaches, emerged a new fashion calendar, including three to five mid-seasons imposing pressure for more delivery in smaller timeframes. These changes can be justified by the evolution of the consumer's lifestyle as well as the demand for answering the need for the existence of clothing for specific occasions (Bhardwaj & Fairhurst, 2010).

Since the year 2000, the number of clothing products has doubled, on a global scale, 14 years later there was an estimated production of 14 new articles per person per year worldwide (Manshoven et al., 2019).

Since then until now the textile industry has grown immensely. It currently employs over 300 million people across the value chain, on a global level. During these last 4 decades, the production of clothing has practically doubled, due to a continuously growing middle-class population around the world. As a result of the growth of this middle-class population, *per capita* sales have increased, being visible in the uprising of the "fast fashion" phenomenon. This phenomenon can be characterized by the fast appearance and change of new styles (EMF, 2017).

The intense competition within the sector has led manufacturers and retailers into a race never before seen for the lowest prices and, hence, to the lowest standards of production. The scattering of subcontracting other companies complicates the process of monitoring the working condition standards as well as the environmental issues of production (Muthu, 2015).

Consumers have been victims of the quality decline of garment products since the 1980s, before the beginning of outsourcing production and the times of mass manufacturing in developing countries and fast fashion (Piippo, Niinimäki, & Aakko, 2022).

Fast fashion is a phenomenon that depends on constant buying, most of the time, being seen as an impulsive action followed by the feeling of urgency installed when someone is consuming. This commerce model has been enormously effective, which can be seen by its constant growth and the development of online retail that outperforms the traditional models with its versatility and fast delivery of new products (Niinimäki et al., 2020).

By observing Figure 1it is possible to confirm the globality of the fashion industry. The garment's value chain includes multiple stages, many of which can be in different parts of the globe. This international market can often require more logistic phases between processes, according to economic decisions. These decisions, many times, rely on the fact that labor costs in low-income countries represent a competitive advantage. A good example is a Chinese market, which is an economic leader in this industry, exporting 109.9 billion USD (US dollars) value of textiles and 158.4 USD worth of garments annually (Niinimäki et al., 2020).

The fact that the textiles industry involves a worldwide scale has numerous environmental impacts associated, such as energy consumption, water use, chemical use, and waste production, among many others.

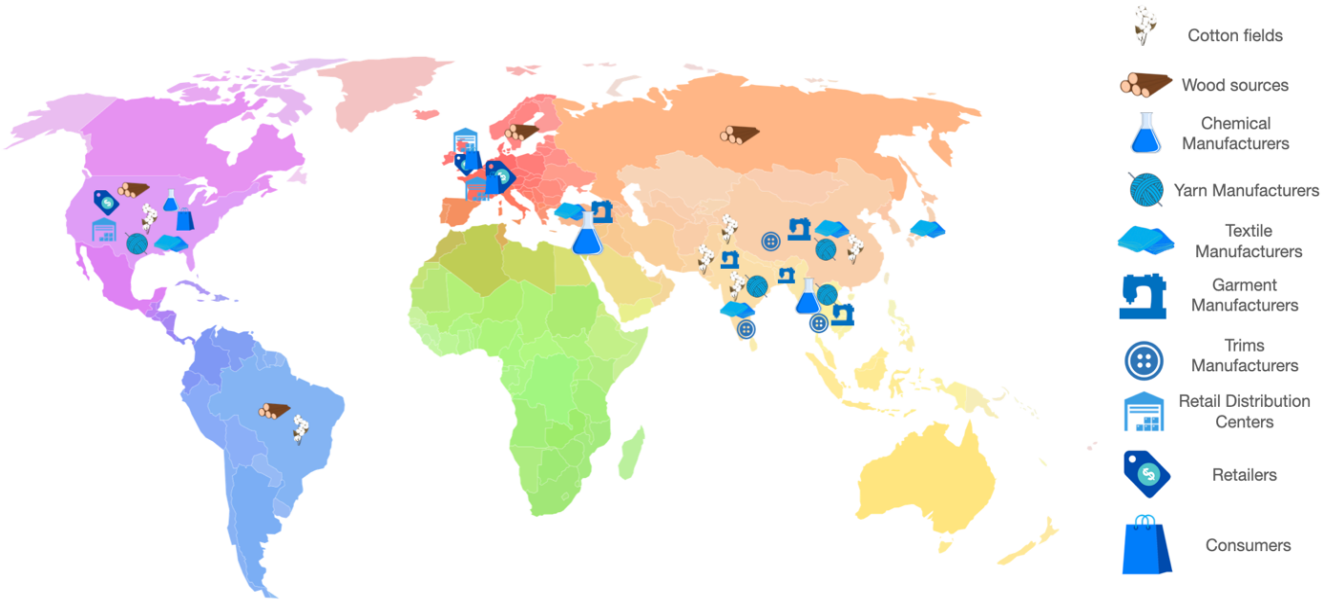
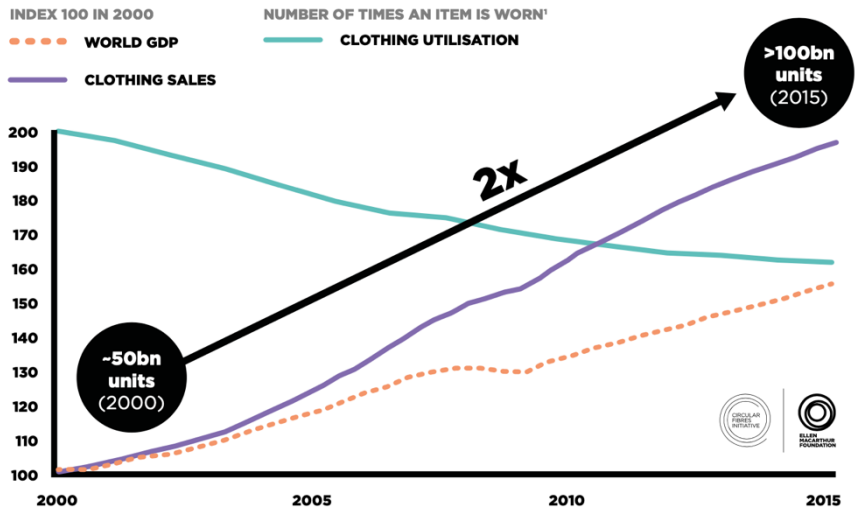


Figure 1- Garment supply chain in the world map (Adapted from: Niinimäki et al., 2020)

In Figure 1 it is visible that China and USA are the countries that include more stages of the garments value chain. Consequently, these countries are also at the top of the list when it comes to environmental impacts (Niinimäki et al., 2020).

2.1.2 Textiles wasteful ways of consumption and production

According to the Ellen MacArthur Foundation, clothing is "massively underutilized" globally. The same source states that the average number that a piece of clothing is worn before it stops being utilized has reduced by 36%. This comparison can be seen through the analysis of clothing sales and their utilization between 2000 and 2015 (Figure 2). Although several low-income countries have a reasonably high garment utilization rate, in many other countries worldwide the rates are much lower. In China, for example, garments use has decreased by 70% during the years between 2000-2015 (EMF,2017).



1 Average number of times a garment is worn before it ceases to be used

Figure 2- Increase of garments sales and degrowth of garments utilization (Retrieved from: EMF, 2017)

It's relevant to mention that consumption habits are only a part of all the wasteful phases within the sector. It is predicted that more than half of fast fashion products are disposed of in less than a year (EMF, 2017). The waste produced along the supply chain, including fibers to manufacture yarn, and throughout garments production was approximately 800 000 tonnes in 2016, of which 440 000 originated in India and China (Ribul et al., 2021).

It is estimated that in 2017, European households have had a consumption of 26 kilograms (kg) of textile goods per person. According to the European Environment Agency, this value has a certain degree of uncertainty since multiple studies conducted in various countries mention differing estimates varying between 9 and 27 kg per person (Manshoven et al., 2019).

It is also important to mention that only a small portion of 7,4 kg of textiles per person was manufactured within the European Union (EU). This value translates to a high dependence on imports to fulfill the consumer's purchases. On the other hand, Europe is also responsible for a considerable amount of exports, more specifically 11 kg per person. The motive behind the fact that EU exports surpass the EU's production is the re-export process which consists of the importation of textiles that are manufactured into determined products and re-exported again (Manshoven et al., 2019).

When analyzing this sector from a global scale perspective, approximately 60% of the textile fibers produced consist of synthetic polymers, while only 37% is cotton (Manshoven et al., 2019).

The waste during production is generated throughout the various manufacturing processes of textile and apparel products and it includes fibers, yarns, fabrics, and apparel (Table 1). The amount of waste can vary between 12% and 15% or, in some cases, between 25-30%. In the

yarn manufacturing phase, the treatment of cotton threads and the following spinning stage are the source processes of accumulation of short fibers around the machines and on the floor, being known as "cotton lint". In addition, degraded or low-quality yarn leftovers after production are assumed as waste from the spinning industry (Akter et al. , 2022).

Table 1-Material waste from textile-apparel production chain (Retrieved from Akter et al., 2022)

Industry	Raw Materials	Material Waste
Spinning	Cotton and other natural fibers, synthetic fibers	Cotton lint, damaged, yarn, unfinished cones
Knitting/weaving	Natural and synthetic yarn	Fly fiber, scrap yarn, greige/unfinished fabric
Wet processing	Greige/unfinished fabric	Rejected colored fabric, excess, finished fabric
Apparel	Finished Fabric	Fabric cut pieces (cutting waste), excess development samples, excess apparel

The weaving and knitting industries generate woven and knitted textiles, yarn, and cotton are some of the elements used as primary commodities in some countries, for example in Bangladesh. These processes produce waste such as unfinished fabrics or fly fiber (Akter et al., 2022).

Besides the previous industries mentioned, there is the wet processing industry which consists of dyeing and other stages, where the fabrics are colored and processed with chemicals to reach the quality desired for the finished product. With this process comes the excess fabrics and/or rejected ones owing to quality standards which become waste from the wet processing phase. The garment production processes generate multiple cut pieces and leftover textiles from the cutting stage (Akter et al., 2022).

2.2 The end of life of textile products

Practitioners of textile industries have often addressed, among other environmental issues, the high consumption of resources for production, waste generation, and wastewater problems (Roy et al., 2020). Currently, the materials recycled for the manufacturing of new clothes are less than 1%, symbolizing an annual loss of over 100 billion USD worth of materials. In addition to these value losses, the process of disposal is also linked to high expenses, such as landfilling clothing and household textiles (EMF, 2017).

According to the Ellen MacArthur Foundation, solely 13% of the materials that enter the system are somehow recycled after their use (Figure 3). A considerable part of this recycling is a cascade to other industries and use for other applications of lower value, such as mattress stuffing, wiping cloths, and insulation material among others. Most of these reused textiles used in these products turn out to be difficult to recapture, thus constituting a final use (EMF, 2017).

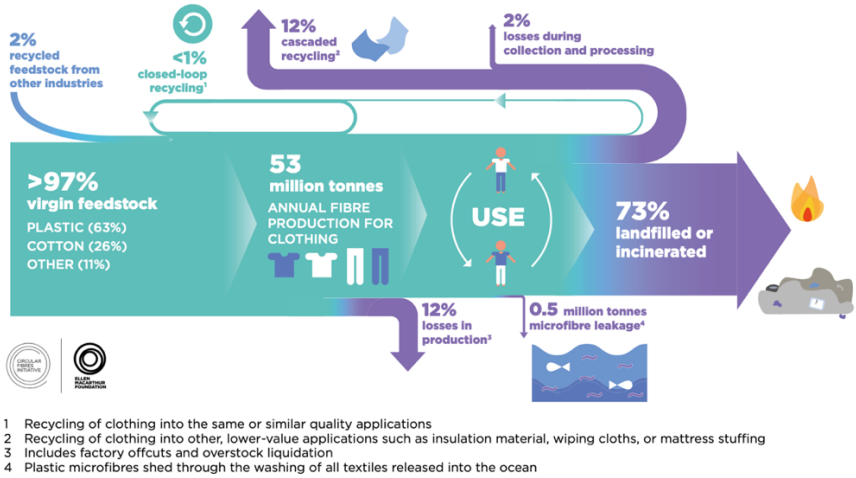


Figure 3-Worldwide material flow for clothing in 2015 (Retrieved from EMF, 2017)

The end of life of many textile products is mostly dependent on consumer behavior. In the EU, it is estimated that approximately 5.8 million tons of textiles are discarded by consumers annually, which can be translated to 11.3 kg per capita (Manshoven et al., 2019).

In Figure 4 it is possible to observe the consumption and separate collection ratios of seven different European countries, these vary from 11% in Italy to 70% in Germany. These differences can be explained by the divergence of infrastructures within each country, for example, the number of collection points or the frequency of collection initiatives by private or charity organizations.

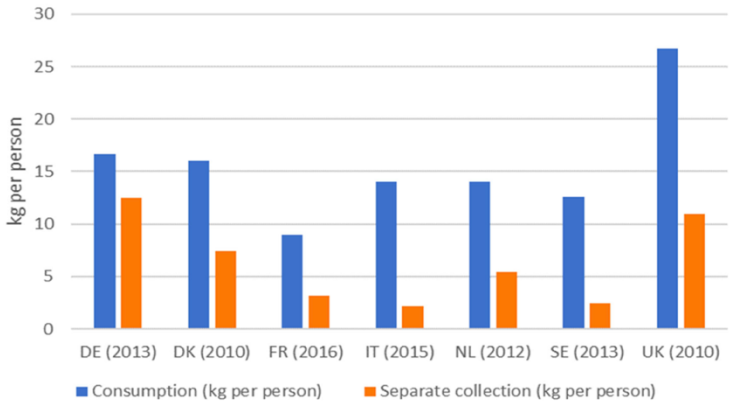


Figure 4-Estimated consumption and separate collection rates for apparel and household textiles in 7 EU countries (Retrieved from Manshoven et al., 2019)

Furthermore, the measures taken by the governments constitute a crucial role, such as the provision of subsidies and research and development (R&D), encouragements for new initiatives and processes throughout the value chain as well as the arrangement of public awareness campaigns for consumer behavior (Manshoven et al., 2019). With this is possible to extend the infrastructure differences around the globe since it is a transversal factor that influences, each country's capacity to evolve towards the reduction of disposal of these types of products.

Observing on a global scale, according to Akter et al., 2022 multiple studies have estimated that in 2014 the textiles industry generated approximately 92 million tons of waste, of which only a small percentage (as shown in Figure 4) is reused or recycled. Roughly 577 000 tons of litter is claimed to be produced from the apparel industry and fabric factories in Bangladesh, approximately half of this total is 100% recyclable cotton waste that has a worth value of nearly 100 million USD. In addition, it is estimated an increase of 60% in textiles waste globally from 2015 until 2030, producing more than 57 million tons of waste annually, combining a total of 148 million tons every year (Akter et al. , 2022).

By observing the graphic shown above it is possible to conclude that the UK is the country with the biggest disparity between consumption and separate collection, followed by Italy, even though the collected data is from different years.

It is also important to mention that more recent studies need to be made to have more accurate data regarding the different countries' consumption and separate collection since the ones above provided are seven years old or more.

It is visible that the end of life of textile products is mostly landfill, this problem can be associated with many factors depending not only on consumers' decisions and behaviors but also on the manufacturing companies.

2.2.1 Environmental impacts of garments end of life

The globe's ecology and its economy are on the verge of collision. The collision trajectory is largely related to a dichotomy in the misconceptions of unlimited resources and economic development, powering the linear economy paradigm (Siderius & Poldner, 2021).

Over the past years, the textile and apparel industry has been considered a perpetrator of numerous environmental and social issues. The recent pandemic associated with the virus Sars-COVID-19 has enlarged these issues owing to public awareness of social and environmental unfairness in the fashion sector(Sonnenberg et al. , 2022).

The pandemic caused universal operational disruptions in the fashion industry, however, it has had a low impact when it comes to slowing down megatrends that redesign the industry. As matter of fact, these have speeded up over the year 2021, with brands investing in the

digital market, prioritizing environmental and social aspects of the industry, and focusing on inclusion, equality, and diversity (Amed et al., 2022).

Besides, when it comes to the supply chain interruptions during the pandemic, the second most concerning issue in executive decision-making was the sustainability gap, mentioned by fifteen percent of executives as part of their top three concerns for 2022 (BoF-McKinsey survey) (Amed et al., 2022).

This subchapter will focus more specifically on the environmental impacts associated with apparel/clothing products' consumer care and end-of-life. The textile sector includes numerous industries namely: hi-tech synthetic yarns, bed linens, and industrial filters among many others… Considering the number of branches within the sector the analysis of the present study and, consequently, the subchapter had to be narrowed down to the apparel industry, excluding footwear.

Across the western world, the practices adopted by consumers for washing and dying clothes have been the most consuming regarding water and energy resources within the household. Indeed, for some products, home laundry and dry cleaning chores can be responsible for more environmental impacts than any other phase of the product's life cycle. Besides, it is estimated that up to 80% of the clothing product's carbon footprint occurs during the stage of consumer care. For this reason, it is advised that garments designers and manufacturers focus on finding solutions to lower the impacts derived from the washing and drying processes (Muthu, 2015).

The environmental impacts linked to clothing care can differ according to the raw materials used and consumer habits. Fiber content can be contributing factor to the environmental consequences of clothing care. For example, cotton fiber requires more water for the washing process (absorbs a greater degree of water) than polyester and other artificial fibers (Muthu, 2015).

The fact that every person has their individual laundry habits influences the number of water needs of the household. Besides, these habits are associated with behaviors including a tendency to use a dryer, water temperatures, and dimension of washing loads. All of these have varying environmental consequences. Thus, it is clear that clothing care requires the consumption of water and energy generating water and air pollution, constituting an environmental threat (Muthu, 2015).

As garments get closer to their end of life, the input of environmental impacts continues through the generation of solid waste. However, the textile industry can be very effective in reusing pre-consumer textile and fiber wastes, created during industrial processes. It is estimated 75% of these wastes are recycled into other materials, such as mattresses, paper, home furnishings, and car seats among others (Muthu, 2015).

In general, every second there is one garbage truck of textiles heading to landfills or incineration establishments. Additionally, the disposal of clothing involves high costs. New York City is a good example, this city alone spends over 20 million USD annually disposing of textiles,

more specifically landfilling and incinerating. A considerable part of these textiles consists of clothing (EMF, 2017).

According to the EMF (visible in Figure 3), 73% of the material flow for clothing ends up in landfills or incineration (EMF, 2017). The organic materials decomposition process generates methane as an off-gas. Currently, as a GHG this gas is the second biggest contributor to climate change. In comparison to carbon dioxide, methane can be 20 times worse regarding environmental impacts. For this reason, the presence of this gas should not be undervalued. In addition, landfills are also nests of other atmospheric pollutants and toxins, plenty of which contain carcinogens (Muthu, 2015).

In Figure 5 it is possible to observe the worldwide pollution "hotspots". It is visible that Asia and the North American continents (more specifically the USA) are responsible for the biggest variety of environmental impacts. As seen in Figure 1 these two are also the ones that include the highest amount of different stages of the garments value chain.

The fact that the fashion industry involves a global scale has occasioned an unequal distribution of environmental impacts, with low-income countries (who mainly produce this industry's products) bearing the burden of developed countries (who are largely responsible for the consumption of this type of products). Hence, western economies import the impacts (e.g CO_2 emissions associated with polyester production) when purchasing garments. Yet, the greater globalization and segregation of garment manufacturing made the assessment of environmental impacts more difficult, for example, owing to the unclear sourcing of raw material and its processing (Niinimäki et al., 2020).

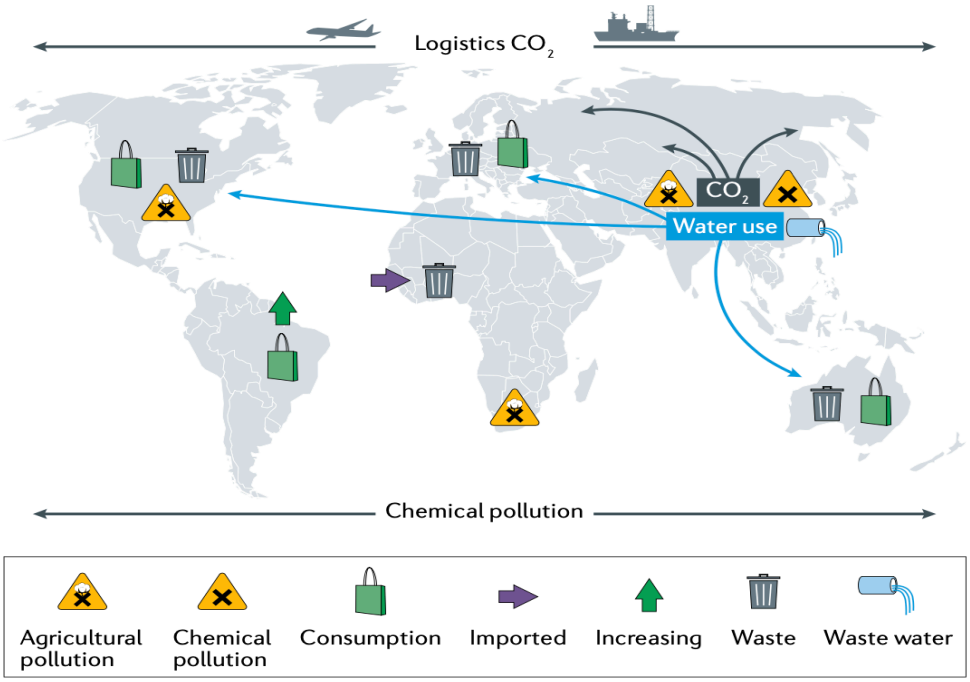


Figure 5-Critical locations in textile and fashion manufacturing industries (Retrieved from: Niinimäki et al., 2020)

2.3 The circular economy approach within the textile sector

Besides the fact that the globalization of the fashion industry is responsible for a considerable amount of environmental impacts, its nature also inflicts environmental burdens. With this said, fashion enterprises can be divided into two major categories. The first category consists of enterprises that hold out sustainability practices and seek to survive in an extremely demanding environment. The second category consists of the enterprises that seek to embrace and develop sustainable strategies and practices throughout their value chains by resorting to tools such as management systems, communities of practice, environmental audits, eco-labeling, fair trading, and alternative transportation modes among others (Turker & Altuntas, 2014)…

Nevertheless, it is essential to consider the global perspective of this industry's impacts and the need for recognition of the second category strategies. The uptake of strategic actions will require that retailers adopt different practices and share them through published sustainability reports. A very frequently mentioned example is the global retailer H&M which states that they have been implementing exhaustive sustainability practices in their sourcing, stakeholder management, and environmental processes (Turker & Altuntas, 2014).

2.3.1 Garments Linear Value chain

The resulting environmental impacts from the manufacturing and consumption of garments reflect the great sophistication and linearity of their life cycle. The variety of impacts relies on the multitude of existent textile fibers alongside the environmental and socio-economic settings throughout the production, distribution, usage, and end-of-life stages. Some examples of the impacts that stand out along the value chain consist of: a decrease in material resources, land use, and water, as well as the toxicity of the used chemicals (Manshoven et al., 2019).

It is important to reinforce the fact that the garments industry operates practically in a linear way, as visible in Figure 6. Therefore, the amounts of non-renewable resources extracted for the manufacturing of these products are frequently used for a short period, after which the resources end up in landfills or are incinerated. The adoption of this linear process can leave numerous economic advantages unexploited, but increases the pressure on resources, pollutes natural landscapes and their corresponding biodiversity as well as damages local, regional, and global societies on a social level (EMF, 2017).

It is estimated that 500 billion USD worth of clothing is lost annually due to the lack of material recycling and underutilization (EMF, 2017).

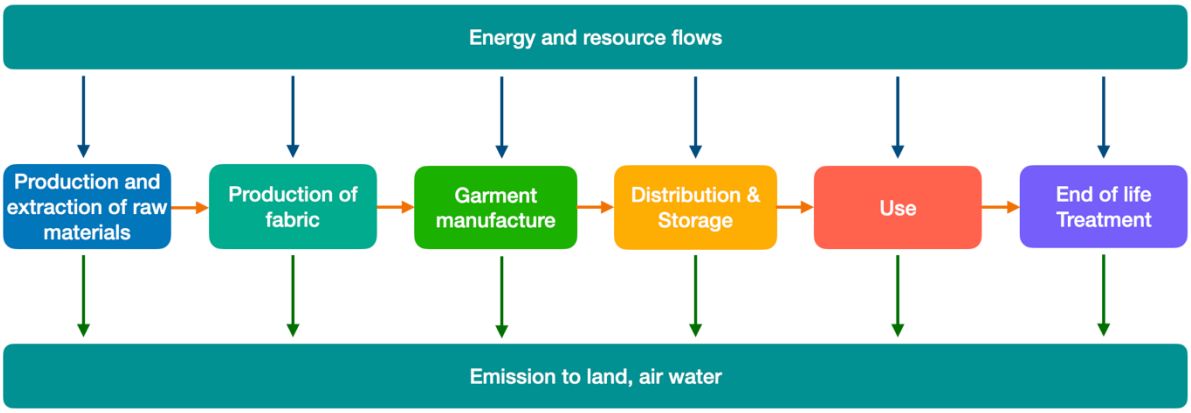


Figure 6- Typical linear value chain of a garment. The horizontal arrows represent the stages transitions and the vertical arrows represent the flows from each stage (Adapted from: Braun et. al., 2021; Ellen MacArthur Foundation, 2017)

It is also worth mentioning that many of the substances used to produce garments can be hazardous for the health of both workers and consumers of clothes, being also possible the release these substances into the environment. In addition, some garments, while being washed, can discharge microfibers. Approximately 1.5 million tons of these microfibers are released annually into the oceans, corresponding to 16 times more than the micropollutants from cosmetics. Late estimations indicate that these damaging impacts will grow relentlessly, with probable catastrophic consequences in the future. Therefore it is evident that this linear model is set for disruption (EMF, 2017).

2.3.2 The concept of circular economy

Currently, the concept of circular economy has increased its popularity substantially, since it also is a recent topic. This economic model aims to generate value by reducing the environmental impacts of manufacturing through the reduction of resource usage, the re-purpose of products, and recycling materials. This model prevents the overproduction of waste and promotes the full value of products (Braun et al., 2021; Shirvanimoghaddam et al., 2020).

It is also worth mentioning that a circular economy is based on three main fundaments, which are (EMF, 2022):

1. The elimination of waste and pollution;
2. Circulation of products and materials (optimizing their value);
3. Regeneration of nature;

The aforementioned principles are key for the adoption of a circular economy in any context. The first principle consists of the adoption of upstream strategies that aim to eliminate waste, starting with product design. The second principle focuses on the long usage of materials, keeping them in continuous interconnected loops. Hence, the waste production is nearly none or none at all, since the waste starts being an intrinsic value of products. In this second

fundament, there can be considered two main circular cycles: technological and biological (visible in Figure 7) (EMF, 2022).

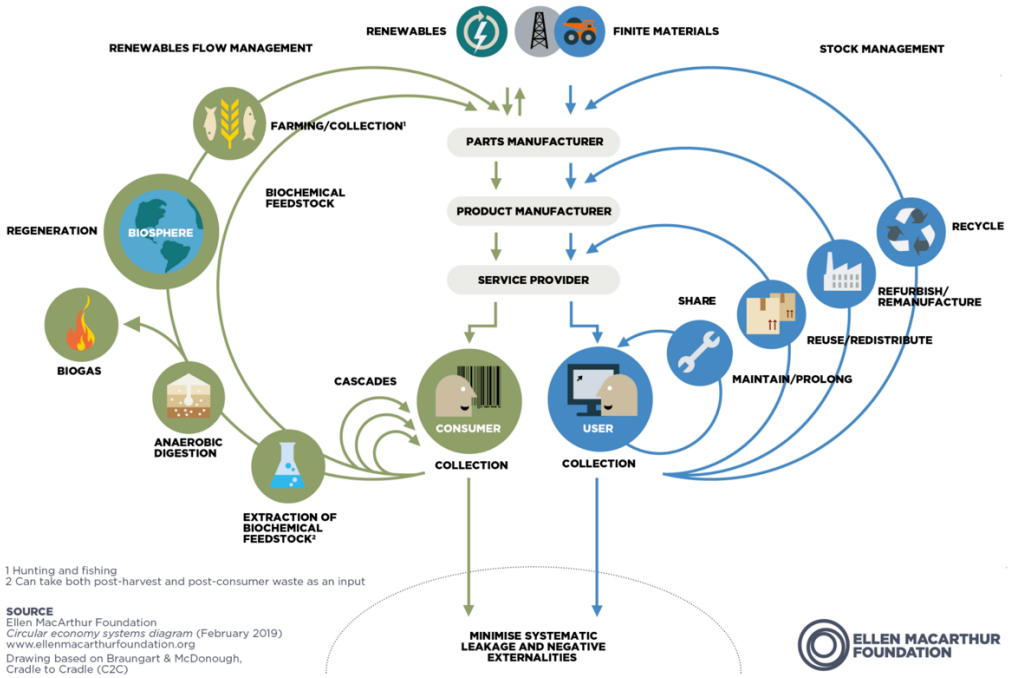


Figure 7- Technological and Biological circular cycles (Retrieved from: Ellen MacArthur Foundation, 2022)

The technological cycle was developed to preserve the tech products as a whole, facilitating their preservation as much as possible. This comprises business models based on sharing, so consumers can access a product rather than purchase it, promoting its usage by more people over time. Besides, this cycle englobes other strategies that can encourage the cooperation of different business strategies such as sale; repair; refurbishment, or, even maintenance (EMF, 2022).

The biological cycle focuses on biodegradable and renewable materials/products. Although it is impossible to reuse biodegradable materials, by digesting anaerobically or composting organic components, it is possible to obtain useful nutrients, including nitrogen, potassium, phosphorous, and micronutrients. These can later be used for soil regeneration and, consequently, for the growth of renewable matters such as cotton or wood (EMF, 2022).

It is important to mention that elements like cotton can circulate through both cycles, technological and biological. Therefore, it is possible to maintain, reuse, repair, and, even recycle these types of products. However, their life period reaches an end, which means at some point in time they can be returned to nature. This latest process can be done, as previously mentioned, by composting or anaerobically digesting these materials (EMF, 2022).

The adoption of a circular economy strategy within the fashion industry can be driven by many factors such as competitor pressure, governments' incentives and legislation, customer consciousness and social pressure, executive leadership, and commitment (Jia et al., 2020).

On the other hand, there are also barriers companies might face when adopting this type of model. The absence of information and technology systems, as well as poor stakeholder engagement (e.g outsourcing entities such as retailers or distributors), the absence of financial support, and the deficiency of policies and enforcement laws, are some examples of the mentioned barriers (Jia et al., 2020).

2.3.2.1 Defining Strategies, Actions, and Principles

The circular economy model within the textile and apparel sector includes multiple terms/concepts that need to be clearly defined to facilitate the understanding of the present study. In Table 2 are presented the most important concepts as well as their source, to clarify their definitions and main differences.

Table 2- Concepts associated with circular economy and their source

Concept	Retrieved from	Definition
Policy	Cambridge Dictionary, 2022; McDowall et al., 2017	By definition and according to the Cambridge Dictionary, a **policy** is " a set of ideas or a plan of what to do in particular situations that have been agreed officially by a group of people, a business organization, a government or a political party" in this context a policy for circular economy consist on action plans and ideas in order to attain successfully CE (e.g EU New Circular Economy Action Plan 2020)
Principle	Adapted from Cambridge Dictionary, 2022; Ellen Mc Arthur Foundation, 2022	By definition, according to the Cambridge Dictionary, a principle is "a theory or rule about how something happens or works". Circular economy has three main principles: "Eliminate waste and pollution"; "Circulate products and materials at their highest value" and "Regenerate nature". Therefore each of these consist on the definition of a **principle** within the context of circular economy.
Strategy	Adapted from Cambridge Dictionary, 2022; Spreafico, 2022	According to the Cambridge Dictionary, a **strategy** is "a detailed plan for achieving success in situations such as business or industry", in this case circular economy strategies consist of plans or business models that aim to circularity within the value chain**.** CE strategies presented by Spreafico 2022, for example, are: "Design for recycling" and "Design for reuse".
Action	Cambridge Dictionary, 2022; EU 2020	According to the Cambridge Dictionary an **action** is "the process of doing something, especially when dealing with a problem or difficulty". In the context of circular economy in the textile and apparel industry. An example of an action proposed by the EU in the "New Circular Economy Action Plan" is: "boosting the sorting, re-use and recycling of textiles, including through innovation, encouraging industrial applications and regulatory measures such as extended producer responsibility". An action can be seen as the mean to accomplish a strategy.

A shift in the direction of a more sustainable and circular textile sector demands a deep systematic change additionally to small-scale actions and individual success cases. The adoption of a circular economy asks for new production methods, innovative business models, more sustainable behaviors, and supportive actions across the value chain (Manshoven et al., 2019).

In Figure 8 is represented a scheme that includes multiple business options, policies, and education & behavioral changes that can be adopted along the textiles value chain to achieve a circular economy. Many of these require collaboration between multiple entities when aiming for success.

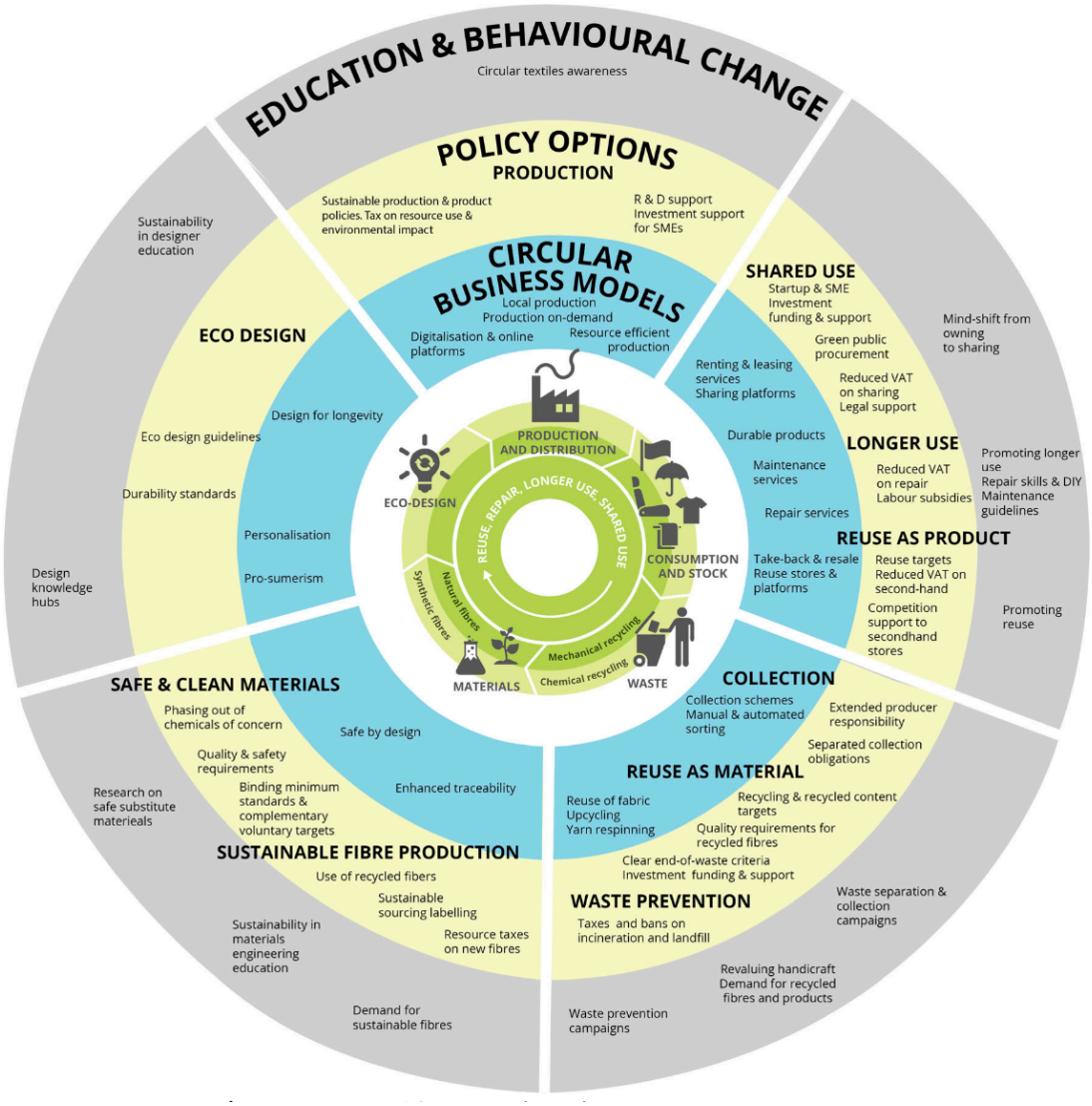


Figure 8- Business models, policy options, and education & behavioral change options for a circular economy (Retrieved from Mashoven et al., 2019)

2.4 Approaches for circularity in the fashion industry

Nowadays, fast fashion is associated with designs that express quick responses to ongoing trends or styles moving with hastiness from runways to stores increasing the value and demand for products for fast-changing fashion items. Fast fashion merchants strive to respond quickly to the wide range of consumer requirements and reduce lead times in supply chain management (SCM). The standard lead period from runways to consumers is roughly six months in the current system. In contrast, multinational fast fashion retailers including ZARA, H&M, MANGO, and Topshop stand out with their fast cycles and weekly product releases to entice fashion buyers (Yoon et al., 2020).

However, recent research projects have been conducted to improve manufacturing processes by enhancing production processes centered on several crucial objectives. These objectives incentive circularity within the industry, including lowering shedding rates in textiles (H&M), decreasing the generation of fabric waste by using 3D printing technologies (H&M), using advanced dyeing techniques (OVC, Gap), chemical safety along the value chain (Inditex), and treatment of microplastics throughout manufacturing (H&M) (Dragomir & Dumitru, 2022).

Some of the above-mentioned companies have used multiple indicators to measure circularity in manufacturing proceedings: the fraction of facilities using water-efficient technology (H&M), the portion of production water being reused (H&M), the volume of water that is conserved or collected (Inditex, Gap, VFC), and prohibited substances that shouldn't be used in finished items (PVH, Gap). Yet, research has shown that water savings are associated to cost reductions rather than environmental concerns (Dragomir & Dumitru, 2022).

A rise in awareness among textile producers has generated restricted usage or complete elimination of hazardous chemicals in the production of textile items. There are multiple targets considered key to tracking circularity in the manufacturing stage, such as, eliminating single-use plastics or reducing the proportion of water usage compared to a baseline (H&M) (Dragomir & Dumitru, 2022).

Additionally, brands such as C&A already enhance certified circular programs. An example of these initiatives is the "cradle to cradle" products program that incentives customers to return used items. The "sustainable" labeling is also a strategy adopted by some brands, like the Inditex group and Brownie Spain, with "Join Life" and "Re|Love" labels aiming to generate awareness for consumers' decision-making when purchasing (C&A 2022; Zara 2022; Brownie 2022).

It is important to underline the fact that most of the improvements and goals presented by the mentioned companies are linked with the following two principles for the circular economy: "Elimination of pollution" and "Circulation of products and materials". Being the third principle ("Regeneration of not nature") less considered.

2.5 The dichotomy "Emissions vs. Circular Economy"

The textile and aluminum industries are responsible for the highest amount of emissions per unit of material. According to the Intergovernmental Panel on Climate Change (IPCC), the textile industry is accountable for approximately 10% of the global GHG emissions, however, the scope and method of this calculation are uncertain (Niinimäki et al., 2020). This percentage is higher than all international flights and maritime shipping combined (EU, 2022).

More cautious estimations have been conducted showing that the fashion industry emitted around 4.0 gigatons (Gt) of CO_2 equivalent in 2016, corresponding to 8.1% of global CO_2 equivalent emissions. Roughly one-fifth of these emissions were from the footwear industry alone, while the rest was from apparel (3.3 Gt CO_2 equivalent). Besides, it is also worth mentioning these estimations do not include the additional emissions of the transport from retail environments and laundering (Niinimäki et al., 2020).

From 2016 until 2020 there was a rise in GHG emissions by 2%. According to a 2020 McKinsey report with no additional mitigation measures beyond those already in place, there will be an increase of around 2.7 billion tonnes by 2030, considering a relatively quick economic recovery following COVID-19 and subsequent growth. In Figure 9 it is possible to observe the GHG emissions along the Footwear and apparel value chain in the year 2018 (McKinsey & Company, 2020).

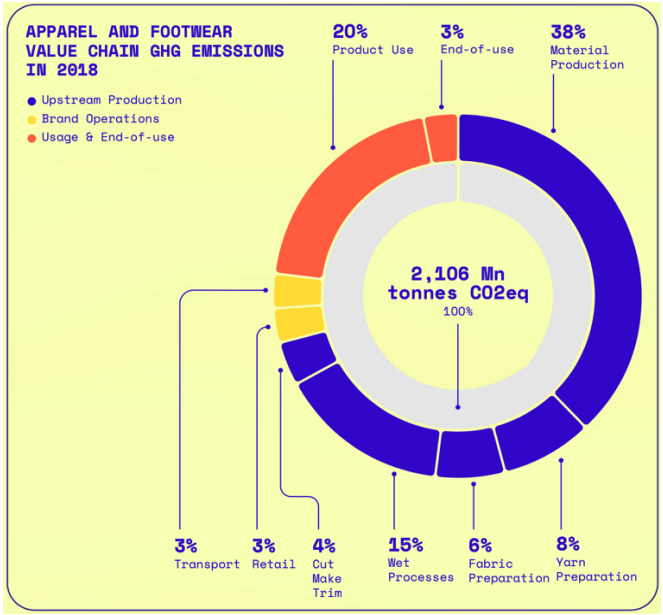


Figure 9- GHG Emissions along the apparel and footwear value chain in 2018 (Retrieved from: McKinsey & Company, 2020)

According to Figure 9, the end of life of the apparel and footwear industry only accounts for 3% of the total amount. The source does not specify the meaning of this value which, from a broad perspective, might not be accurate. Has stated before, 73% of the material flow ends up in landfills or incineration. Besides the direct emissions associated with the incinerating processes, the indirect emissions linked to landfilling should also be accounted for. This corroborates the fact that the end-of-life emissions value might not be certain.

It is also worth mentioning that the COVID-19 Pandemic might have affected the numbers previously mentioned since it had a significant effect on the fashion industry. During this period many of the world's retail establishments closed, creating a new perspective on health, safety, and environmental-related issues (McKinsey & Company, 2020).

The fashion industry's significant carbon footprint can be justified by the high energy used and its source. In China, for example, many existent textile factories rely on coal-based energy, therefore China has a 40% higher carbon footprint than the textile industries in Turkey or Europe (Niinimäki et al., 2020).

High energy requirements and CO_2 emissions are linked not only with textile manufacturing but also with consumer use (e.g laundry) and shipping, especially when it involves air transport. Nevertheless, when analyzing the complete value chain of a garment it is possible to verify that the initial fiber extraction consists of the stage that has the highest energy consumption and, consequently, a high quantity of CO_2 emissions, approximately 38% as visible in Figure 9 (Niinimäki et al., 2020).

According to Braun et al. 2021, a recent report has proved that CE strategies have the capacity (if properly implemented) of lowering GHG emissions over a third while reducing demand for resources by more than a quarter.

According to the European Environment Agency 2020, "GHG emissions can be reduced by making material flows more efficient and maintaining the utility and value of materials and products for as long as possible" (European Environment Agency, 2020).

However, when countries and companies are facing decisions regarding circular economy actions to prioritize and include in climate-oriented measures or policies, a comparison is needed to compare the relative benefits and emission reductions of the particular circular economy actions (European Environment Agency, 2020). With this said, it is visible that there might exist a dichotomy between circular economy actions and associated emissions, since, in some cases, a strategy might be effective from a circular perspective but induce an increase in GHG emissions and vice-versa.

According to Sandin & Peters, 2018, for example, the reuse phase that requires transport might generate an environmental impact that exceeds the benefits of avoided manufacturing, unless this stage is extended enough.

A recent study showed that the carbon footprint of virgin polyester textiles manufacturing was 119.59 $kgCO_2/100kg$ while the carbon footprint of the waste polyester recycling process

was 1154.15 kgCO_2/100 kg. This last value represents approximately ten times the first one (Qian et al., 2021). With this, it is possible to conclude that some of the options that can be considered "more circular" by some companies can be even more pollutant than the original methods.

Despite the considerable amount of available information related to the environmental impacts and circularity of the fashion industry, there was a visible gap in the literature when it comes to linking circularity with GHG emissions.

In some cases, the industry is engaging circular approaches, as seen in the previous subchapter. However, there is no evidence of the effect some strategies might have on emissions.

Besides, another identified gap was the lack of relations within strategies, actions, policies, awareness, and education practices liking the importance of their holistic application in the fashion industry. In order other words, the understanding of the relations between policies, strategies, actions, education, and awareness facilitates the process of their implementation in the industry.

Considering the previously stated, it is possible to affirm that the relation between circular strategies-emissions remains little studied, being this one of the principal aims of the present dissertation. The information available in this chapter and the articles in it cited were used as methodological tools for the following stages of the study.

3 | METHODS

In this section, the process and the methods used are presented.

3.1 Theoretical Underpinnings

The "Scopus" database was used as the starting point for the literature review development. Three principal keywords —"Circular economy," "Emissions," and "Textiles"—were added with the conjunction "and." These were inserted both in pairs and all at once.

In “Scopus” the number of findings consisted of 34 articles. The article selection was based not only on a relationship with the current theme but also on their public access and specificity. Therefore, the number of extracted articles was significantly small (12 articles). In addition, none of the found articles mentioned the relationship between determining circular strategies and associated emissions in the fashion industry. This highlighted the novelty of the topic.

Therefore, to provide detailed and accurate information for the theoretical stage of the presented study other methods of research were used, such as the browser “Google Scholar” which is connected to multiple different databases. In this browser, the same keywords and more were used. The additional keywords/expressions were: “Fashion industry”; “Circularity” and “Textile waste”.

Additionally, the Ellen McArthur Foundation, the European Environmental Agency, and the United Nations were three important organizations for attaining reliable data. The bibliographic references of the reports from the mentioned organizations were also a resource for some of the cited articles.

Bezero’s Carbon support not only allowed contact with companies of the sector, understanding their approaches and operations, but also the analysis of the theoretical basis of the present dissertation in two case studies. These case studies consist of two of Bezero’s Carbon clients, which are two companies in the fashion industry.

Given the fact that this company is based in London (UK) all the interactions with its representatives were made online, more specifically, through video calls. Part of the provided data and its treatment was done in contact with one of Bezero’s Carbon research associates.

The contact with Bezero Carbon brought advantages such as the opportunity to have direct contact with brands of the industry and to get an insight into these companies' operations. The

accounting of Bezero's Carbon client's emissions enabled the study of the viability of strategies for circularity when it comes to reducing emissions.

3.2 Methodological Tools

The present dissertation provides an innovative methodological approach to studying the role of the circular economy in the fashion industry. The proposed methodology aimed at the importance to fill the identified gaps in the literature and understanding the impact of circular economy on GHG emissions. The noted gaps show the importance to combine different methods to support a study on this topic, namely participatory methods (interviews and surveys).

Most of the articles scoped to date scarcely used combined methods to analyze the role of circular economy in the fashion industry. However, a study named "Closing the loop on the take, make, waste: Investigating circular economy practices in the Swedish fashion industry" (Brydges, 2021) is an example of an exploratory study that recurred to interviews for comprehensive, exploratory work. Another example within this context is the study "Life Cycle Assessment to Ensure Sustainability of Circular Business Models in Manufacturing" (Bjørnbet & Vildåsen, 2021) where besides the LCA analysis of a case study other approaches were adopted, such as email communication, LCA's workshops, field trips, among others… With this is possible to highlight the importance of combing methods to obtain an accurate and holistic analysis to reach the goal of a study, reasoning the development of the innovative methodology of the present dissertation.

To understand the impact of circular on GHG emissions, specifically, it was important to apply an LCA approach. With the basis of ISO, the overall LCA method involves defining the purpose and scope, analyzing the life cycle inventory, determining the life cycle effect, and interpreting the life cycle (Balanay & Halog, 2018).

3.3 A multi-method approach

To understand the role of circularity in the fashion industry nowadays, various stages and sources of information were needed. A multimethod approach was adopted, being possible to acquire data from a wider range of sources.

In Figure 10 it is possible to observe a resumed scheme of the process used for the present study.

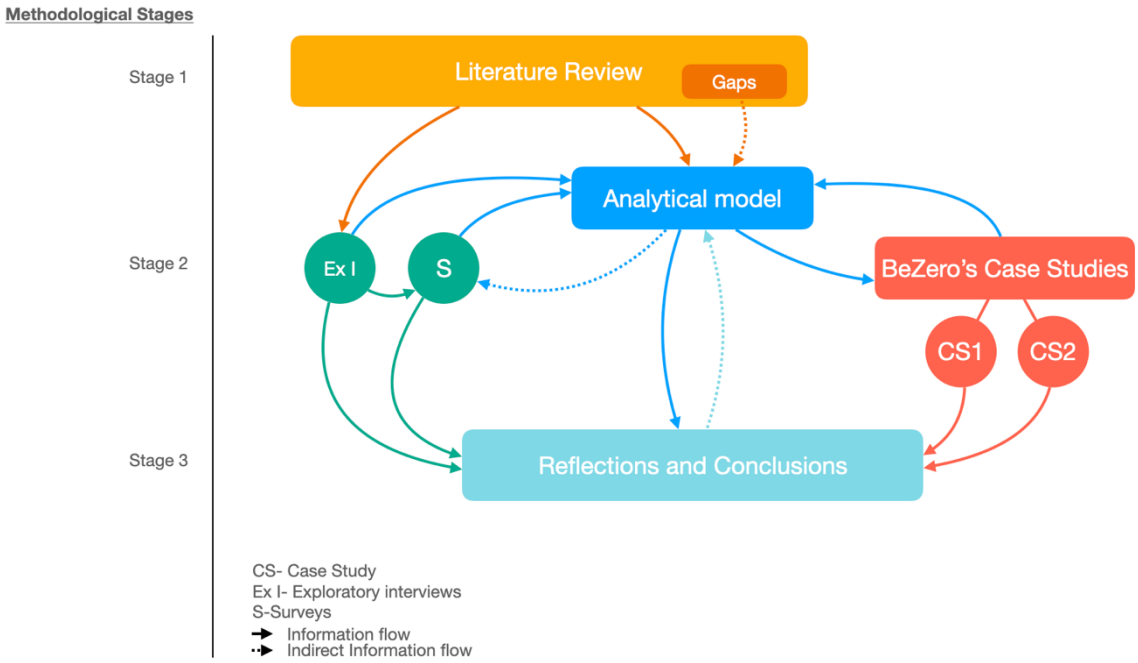


Figure 10- Scheme of the used methodology

The literature review was the basis of the whole process. This first stage was characterized by gathering information regarding circular economy in the textile sector, more concretely, in the apparel industry. This specific phase had a special focus on the current issues within the industry and on the strategies/actions/principles and policies that could or are being adopted in fashion (Table 2).

During the research phase, the found gaps in the literature were considered, namely the lack of information available regarding the relationship between circular strategies and emissions, as well as tools to support how this relationship can be studied. These gaps were used to understand the aspects that needed more focus in this study and the issues that need to be addressed.

With the aim of reaching both small and big international enterprises in the participatory evaluation, two different interview stages were adopted: Interviews and surveys. The first interviewing process was with brands' top management and experts. The contact with these entities had the goal of understanding their vision of the functioning systems of garments value chain and respective levels of circularity.

On the other hand, since some of the fast fashion multinational brands didn't reply via email (e.g H&M), another participatory approach was adopted. Intending to understand multinational brands' approaches to circularity, surveys of employees in stores were conducted.

All of the gathered information from each methodological stage was used to support the final reflections and conclusions, which, consequently, supported further improvements of the

conceptual models. These models were aimed at gathering strategies, actions, policies, education, and awareness practices in visual frameworks that would link these concepts with their respective value chain stage(s). These frameworks also included the type of relation the model's elements have with each other, facilitating the analysis of their viability and possible application in the future.

It is important to underline the fact that the main goal of the frameworks' development was to fill the gaps in the literature with the obtained data from the interviews and surveys and, posteriorly, the other methodological stages. Gaps, such as the absence of the concepts presented in table Table 2 and their application in the vision of the circular fashion industry.

Summarizing, the model was based on various sources: Literature review; Interviews; Surveys, and Bezero's Carbon case studies. These case studies consist in two companies in the fashion industry that are Bezero's Carbon clients. This means, both companies contacted/hired Bezero Carbon to provide them with Life Cycle Assessments of their products, to get the full scope of their emissions.

The information provided in the models was used for the data analysis of the case studies. Subsequently, the results obtained from the case studies were key to understanding the feasibility of some circular strategies when it comes to their relationship with emissions reduction.

In Figure 10 it is also visible that there's a relationship between the conceptual model and the surveys. This relationship exists since to create questions for the surveys it was important to know which strategies could already be applied by some brands, so it would be clearer for employees to answer the questions asked.

With this methodology, it was not only possible to develop an innovative conceptual model that includes the fashion brands' perspectives on this topic, but also some of the strategies that can be put into practice and contribute to progress. This progress can be both in terms of awareness towards circular economy and reduction of emissions.

All of the different stages were valuable for each other and culminated in conclusions and reflections. These not only had the goal to inform and generate awareness among brands and garments consumers but also supported further scientific studies within this field. Finally, the reflections and conclusions were also used to improve the conceptual model, meaning that the all methodological process was, in a way, cyclical.

3.3.1 Interviews & Surveys

3.3.1.1 Exploratory Interviews - Top management & Experts' perceptions

The exploratory interviews aimed to contact the brand's top management or anyone within the company's management that would be informed about the company's sustainable practices in detail. Therefore, forty-two entities were contacted including two of Bezero's Carbon clients (case studies). The selection of the contacted brands was mostly based on the contacts

provided in their platforms and the type of products sold, which had to be specifically garments (footwear companies were not included). The choice of this type of product was to specify the fashion branch in the analysis.

The companies' contacts were obtained through multiple ways including Contacts available on their websites; Linkedin keywords research and the Snowball effect. Considering the fact that most for most brands of the available contacts were exclusively customer care related, those were the used ones.

The Linkedin search was made by seeking the brands' sustainability representatives on their official pages. However, most of these representatives were unreachable, since they had premium accounts that only allowed premium users to contact them personally.

Regarding the snowball effect, a considerable part of the brands contacted was mentioned by interviewees. Additionally, 4 of the interviews were conducted in an event called "Zero City" in Lisbon. This event occurred for 3 days (8th,7th, and 9th of July 2022) and included lectures, workshops, and a market with multiple brands that put social and environmental sustainability among their priorities. However, the interviews were performed on only one of the days. This event was an opportunity to contact small brands that somehow had some consciousness towards sustainability.

Besides regular retailers, it was attempted to contact companies that consisted of part of the textile value chain, more concretely, companies that were part of the stages mentioned in Table 1. Besides, other entities were interviewed such as a retailer of Portuguese brands and a Portuguese fashion activist.

Out of all 42 contacted entities 4 refused to be interviewed, 28 didn't reply and 10 were interviewed. In Table 3 are presented chronologically the interviewed entities and their respective contact source. Except for the last 4 and the first, all of the interviews were made through online video calls. The first interview was conducted through phone call and posteriorly finished via email.

This interviewing process started on the 10th of May 2022 and finished on the 8th of July 2022. The interviewees had a minimum duration of 30 minutes and a maximum duration of 1 hour and 30 minutes.

Table 3- Interviewed entities

	Entity type	**Interviewee role**	**Headquarters Country/Country of Origin**	**Contact Source**
Interview 1	Textiles printing company	Sales support responsible;	Netherlands	Company's website

	Entity type	Interviewee role	Headquarters Country/Country of Origin	Contact Source
Interview 2	Yarning company	Quality and Assurance director	Portugal	Company's website
Interview 3	Fashion activist	Researcher	Portugal	Cense Researcher
Interview 4	Portuguese online clothing retailer	Company's creators and representatives	Portugal	Company's website
Interview 5 (Case Study 1)	Textile accessories company (e.g tote bags; socks; pouches etc…)	Operations Lead; Production & development manager	USA	Bezero Carbon
Interview 6 (Case study 2)	Women's Designer Fashion & luxury clothing brand	Head of sustainability	UK	Bezero Carbon
Interview 7	Garments and accessories brand	Brand creator and main representative	Portugal	"Zero City" event
Interview 8	Women's swimwear brand	Brand creator and main representative	Portugal	"Zero City" event
Interview 9	Women's clothing brand	Brand creator and main representatives	Portugal	"Zero City" event
Interview 10	Clothing brand	Brand representative	Portugal	"Zero City" event

It is also important to underline that it was attempted to have an international sample of the top management perceptions instead of restricting to the Portuguese context.

All of the interviews of the first stage were conducted following a script. This script was developed considering the need to understand the different brand's perspectives of the sector,

their current and future environmental goals, and how they prioritize the principles presented by the Ellen MacArthur Foundation.

After a brief presentation the interviewees were asked the following questions:

1. What is the **(brand's name)** current vision of the sector? Is it sustainable? Is sustainability at the core of the company or is it a concern that emerged later on? How does your company look at sustainability?
2. Which are the **(brand's name)** current environmental approaches and goals? Do you have sustainability reports? If yes, what's the frequency of their release? Does the company monitor the impacts throughout the value chain frequently?
3. The diagram (Figure 11) here presented consists of a typical value chain of a textile product, with five stages. Which changes does your company think could be made and in which stages and why? Does your company have any control over what happens in these stages?

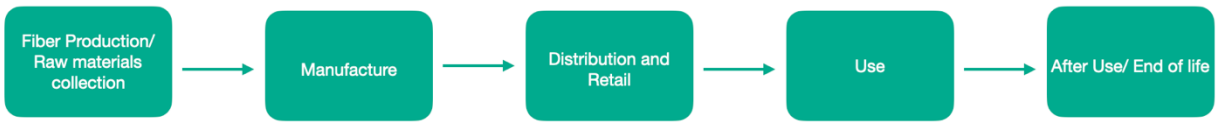


Figure 11- Linear value chain presented the interviewees during the interviews

4. Is there any environmental goal or strategy your company is aiming to achieve?
5. Here you have four principles (Figure 12) that promote the circular economy model within the sector, these principles were presented by the Ellen Macarthur Foundation. How would you/your company rank them from the least important to the most important? Is there any specific aspect you would add to any strategy proposed here?

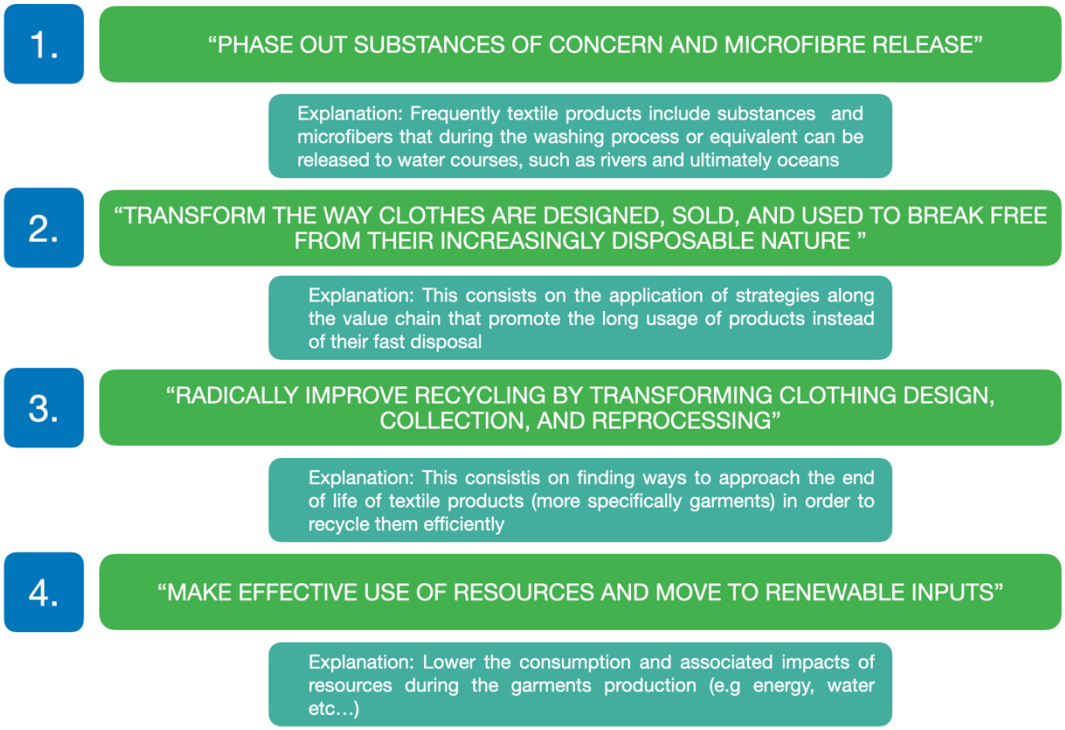


Figure 12- Principles to be ranked by the interviewees

6. What's your company's environmental vision for the future?
7. Is there any other information within this topic about your company you would like to share for the sake of this research project?
8. Do you recommend any other brand to interview?

It is worth mentioning that some of the questions weren't asked or had to be adapted according to the entities being interviewed (e.g fashion activists).

The first group of questions asked had the purpose of understanding the brands' current vision of the sector and how it is progressing (positively or negatively). The answers obtained from this question were used not only for comparison between the interviewed brands but also to understand what was the proximity of their vision with the reality obtained throughout the literature review.

The second group of questions was focused on the sustainability approaches the different brands/entities were already adopting and how they were monitoring their progress (e.g reports). The frequency of the reports was also included to understand if the practices that were being adopted were punctual or regular.

The third group of questions of the interview script had a graphical component (Figure 11) which was a visual aid to the question itself. The image presented was based on Figure 7 of the literature review, but presented with more simplicity to facilitate the interviewees'

analysis. This topic intended to analyze the different entities' vision of the value chain stages and which, according to them, needed to be somehow intervened or changed, from the current linear perspective.

The control over the value chain was also an important aspect of this question since to improve circularity having control over the different stages of the value chain is key. Figure 7 explains the importance of the relationship between the different phases of the value chain. The fourth question was direct, having the purpose of obtaining the goals the different entities aimed to achieve in the future.

The fifth stage of the interviews (like the third) had also a visual aid. In this case, the figure presented to the interviewees had the goal of acquiring interviewees' categorization/prioritization of the principles proposed by EMF in the fashion industry. The given rankings were posteriorly analyzed aiming to understand if there was unanimity or disparity in the entities' perspectives.

The sixth question was related to the fourth, nevertheless, it aimed for a broader answer. This is, it was related to the provision of the future of the sector and not just the brand's future when it comes to circularity. The seventh question had the goal of obtaining any further information the interviewees considered important to add to the present dissertation. The last question is related to the "snowball effect" aiming to contact more brands.

All of the exploratory interviews were recorded (with the interviewees' consent), to guarantee that no answer would be left out when they were put in the transcript. Posteriorly, the answers were all processed in an excel file where they were analyzed one by one and as a whole.

It is also important to mention that there wasn't a "correct" answer for the scripted questions, the goal was to evaluate the entities' perspectives when facing the questions asked. Another important note is that none of the questions asked mentioned specifically circularity since this concept is still relatively recent and might not be clear to some of the interviewees. Besides, if the concept was explained it could influence the answers in some of the interview stages, namely the third and fourth stages. Therefore, the relation of the answers with the studied topic was made throughout the data analysis.

3.3.1.2 Surveys - Collaborators' Perceptions

The surveys aimed to reach brands of bigger dimensions that are present on an international level in hundreds of shopping malls around the world.

Throughout the process of trying to contact some of these brands through their websites, it was possible to conclude that they were unreachable on a management level. An example of this was Patagonia, a multinational clothing brand that is known for its sustainable practices. They rejected to be interviewed giving the following justification: "(…) Due to the high volume of incoming inquiries, we are very sorry that we cannot respond to each of them. However, we have a lot of information posted on our website and blog (…)".

A lot of the multinational brands that were attempted to contact for the exploratory interviews didn't have any available contact on their website besides customer care. Linkedin was also used as a contact source but these brands' responsible entities were mostly unreachable.

For this reason, it was attempted to get an insight into international brands by surveying in-store employees. These surveys were conducted in the "Oeiras Park" shopping mall in the municipality of Oeiras, Lisbon district, Portugal. The selection of this establishment was due to its easy access and relatively low affluence of customers (in August).

After evaluating the obtained sample from "Oeiras Park" it was possible to conclude that the inquiries were a niche of the multinational fast fashion brands considering the average prices of their products. Consequently, more surveys were conducted. This time the chosen local was "Colombo Shopping Center" which is the shopping center with the highest number of stores in the Lisbon district, with over 340 stores (Colombo, 2022). In short, the main criteria for the brand selection was that they had to be multinational having the particular condition of the employees' availability and willingness to answer the surveys.

The employees were approached in stores during working hours, more specifically during the morning period which usually is less crowded. The interviewer started by presenting herself and giving, posteriorly, the choice of employees to answer the survey (or not). Therefore, only stores with less customer movement were easily accessible for the interviews. The surveys had an average duration of 5 minutes.

With this, 6 surveys were conducted to the following brands: "Levis"; "Adolfo Dominguez"; "Lacoste"; Ralph Lauren"; "Bimba Y Lola"; "Brownie Spain".

With the aim of inquiring multinational fast fashion brands in Colombo, 7 more interviews were conducted in the following stores: H&M; Springfield; Massimo Dutti; Bershka (Inditex Group); Oysho (Inditex Group); C&A and Brandy Melville. Out of the 7 surveyed brands 3 were from the same company (Inditex) intending to understand if the answers and sustainability approaches were similar between brands that belonged to the same group. Additionally, it is important to emphasize that, as well as the surveys in "Oeiras Park", were all in stores with a similar average price of products.

It is also worth mentioning that the importance of this approach is not only related to the analysis and evaluation of brands' sustainability, but also to the fact that employees are the entities that have direct contact with consumers. Consumers are practically the main ones responsible for the product's end of life and, therefore, they should be well informed on how to treat their products to guarantee circularity in the industry.

The survey's questions were adapted not only accordingly to the interviewees' possible insight into the brand's sustainable approaches, but also according to their available time. For this reason, the questions asked were mostly "yes" or "no" questions.

The questions asked in the store were the following:

1. Does the company have any sustainability strategy or policy or sustainability campaign on going? (e.g take-back of products; renting services, etc...)? (yes or no)
2. When there's a sustainability campaign do you usually inform the customers? (yes or no)
3. Is there any type of training (punctual or regular) related to circular economy-related aspects? (yes or no)
4. When a client buys a garment do you usually inform him/her/them about its specifications? (e.g How many times it can be washed) (yes or no)
5. If a customer tries to give back a damaged or defaulted product does the brand offer the repair? (yes or no)
6. Do you have any knowledge about what happens to the "Deadstock"? (yes or no)
7. Is there any approach related to a circular economy and the brand you consider important to mention? (yes or no)

The first question of the inquiry, like in the first approach, aimed to understand if the brands already had any ongoing strategy/policy or campaign related to sustainability and if the company's employees were informed about these strategies.

The second question was in sequence with the first one and had the goal of understanding the employees' ongoing circular campaigns (if existent) to consumers. With this question, it was also possible to analyze if there was an effort made by brands toward customers to have circular practices.

The third question had the purpose of understanding if the top management passed any information regarding their circular strategies to collaborators in stores. This way, if there was any transmitted information, they could pass it on to customers. However, it is important to underline that the concept of the circular economy had to be briefly explained by the interviewer to get an accurate answer.

Question four was related to one of the strategies obtained from the literature review and exploratory interviews, namely the customer care of products. In other words, this question had the goal of analyzing if brands had any procedure to inform their customers on how to make the garments last longer.

The fifth question had the specific objective of understanding if brands made an effort to maintain the products within the life cycle by repairing them, or if they would change to a new product every time there is a visible flaw. The sixth question targeted the waste management of the brands, aiming to understand if the collaborators had any knowledge of what happens to the "dead stock", and if there was any nitid circularity strategy/policy or action adopted regarding this issue.

The last question was only to obtain further information the interviewees considered important to share for the sake of the present study. After the interviews, the written answers were all inserted in an excel document where they were posteriorly analyzed and compared.

3.3.2 Conceptual models development

The conceptual models were based on the literature review, interviews, and surveys supported by the case studies analysis. With this, it was possible to gather all the obtained information in an excel document where a table (see appendix) was developed. In this table, the information was classified according to the definitions presented in Table 2 and according to their source.

As mentioned in the previous chapter, the conceptual models were developed based on the need to fill the gaps in the literature. These gaps include the concepts in Table 2 as well as the lack of available information regarding the link of these concepts with the garments' value chain stages. The frameworks created aimed to include both the holistic and detailed vision of the role of circular economy in the studied industry.

In Figure 13 is presented an extract of the excel document used to develop the different frameworks.

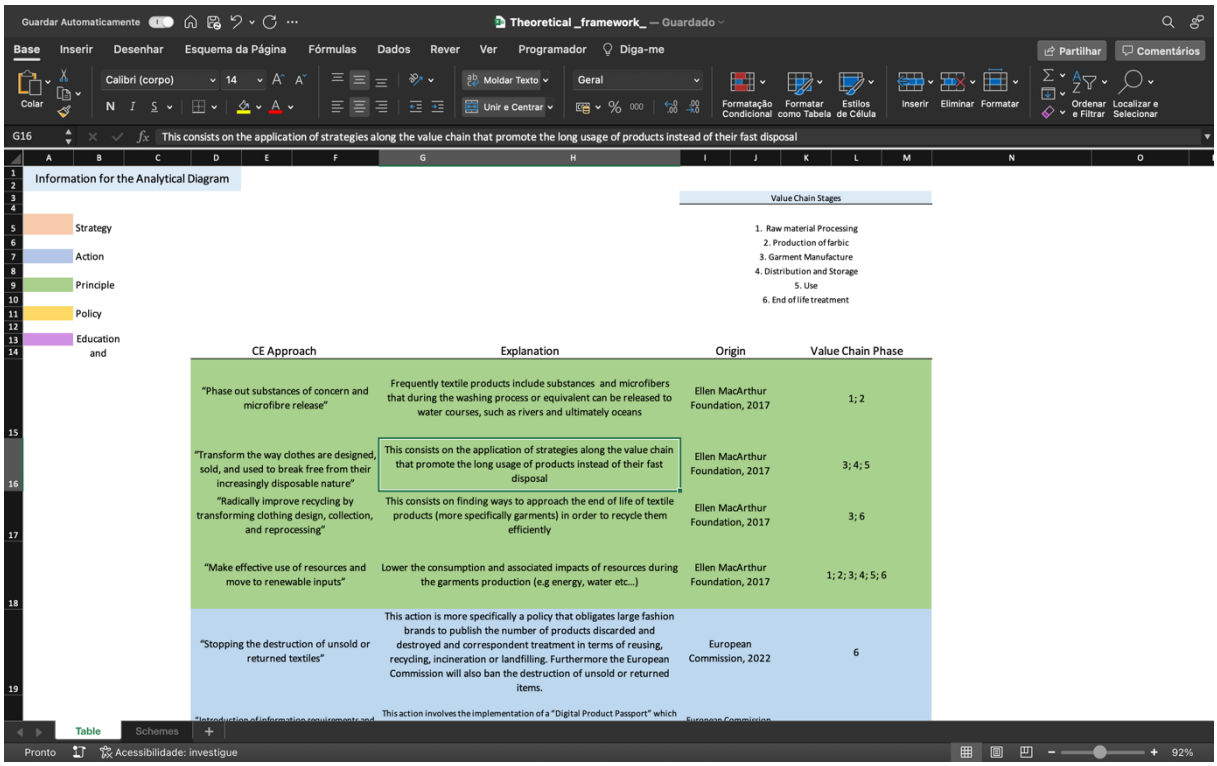


Figure 13- Excel data treatment

Posteriorly to all the data being classified in strategies, actions, policies, education, and awareness practices each element was associated with the value chain stage(s) it belonged to.

After building the models it was possible to analyze the interrelations between the elements within them. These interrelations were a way to analyze the influence the concepts within the models could have on each other.

Besides the content itself, this model had the aesthetic challenge of maintaining the idea of circularity, which explains why the different elements were put within a circle.

3.3.3 Case Studies

The collaboration with Bezero Carbon permitted the narrowing of the study to a quantitative analysis of circular strategies. Bezero Carbon is an international rating agency for the voluntary carbon market, having LCA focused on emissions accounting as one of their products. A life cycle assessment is a comprehensive method to examine a product's environmental impact across its full life cycle (Vries & Boer, 2010).

The connection with Bezero Carbon was made to get a detailed vision and analysis of companies within the fashion industry. The goal of analyzing the case studies specifically was to evaluate in a quantifiable perspective some of the strategies presented in the conceptual model and how beneficial they could be emissions-wise, in real scenarios.

The data provided by the company consisted of the complete LCA documents for both cases. These data were presented in excel documents with the calculations divided by value chain stages, this is, each calculus sheet corresponded to the calculus of the emissions of a determined value chain phase (e.g Manufacturing stage) (see Figure 14).

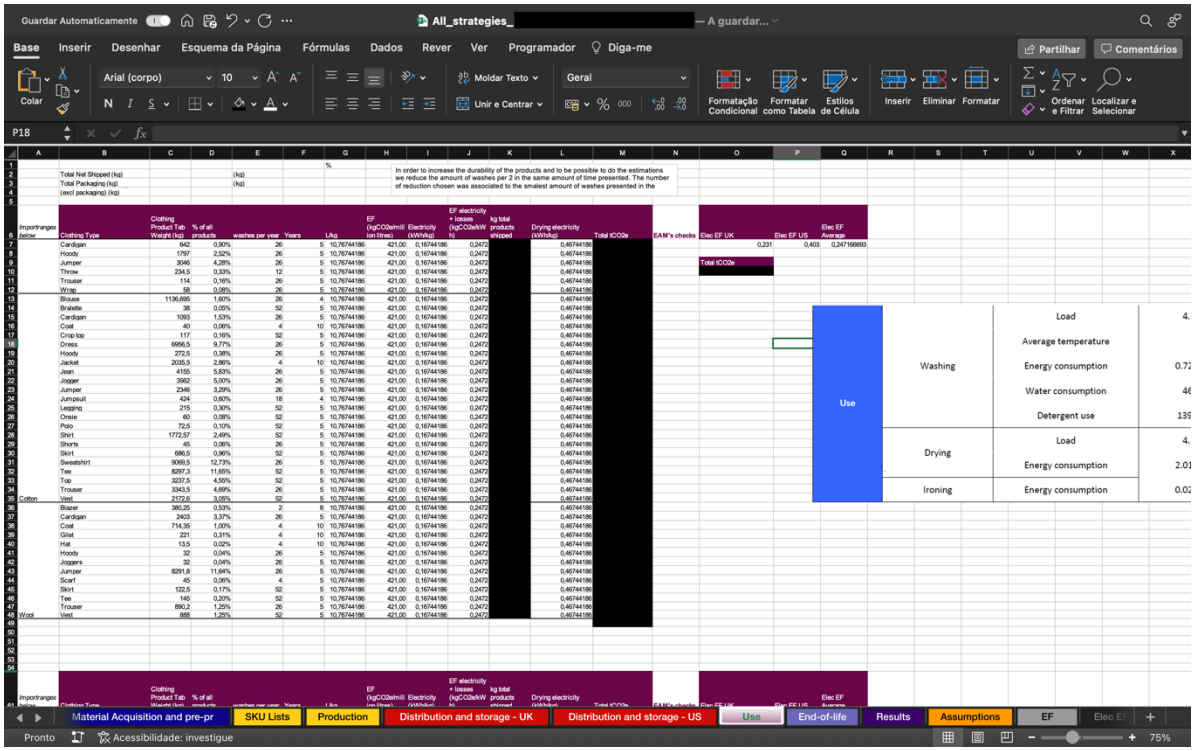


Figure 14- Extract of Bezero's provided LCA data

After interviewing each case study it was attempted to analyze how they could improve their LCA's and how would that reduce their emissions. The answers given in the interviews and the results from the data analysis were posteriorly compared in order to understand the relationship between the strategy's performance.

To simulate the reduction of emissions when determining circular strategies were applied, four quantifiable strategies from the conceptual model were selected:

1. Reuse of fabric/upcycling/ yarn respinning (Recycled fibers)
2. Local Production
3. Resource efficient production
4. Long-lasting products (use phase)

Considering the difficulty of applying these strategies in the LCA's some of these strategies had to be adapted according to the results found, as will be further explained in the results and discussion chapter.

The data treatment and processing were done directly in excel documents provided by Bezero Carbon. These documents contained the complete LCAs of each case study, with all the emissions calculations and results. To study the reduction of emissions when applying each strategy, the emission factors were substituted in Bezero's Carbon provided LCA's, being possible to obtain new results.

For the calculus of the first strategy, the emission factors of recycled fibers were provided by Bezero Carbon. The emission factors used are presented in Table 4.

Table 4- Fiber types and respective emission factors (source: Bezero Carbon calculations and ecoinvent database)

Fiber type	EF (kgCO2e/kg)
Recycled Cotton	0,214
Recycled Nylon	1,77
Recycled Polyester	6,59
Recycled Elastane	5,41

Regarding the second strategy, "Local production" it was possible to observe in the second case study data that the emissions associated with HGVs (Heavy Goods Vehicle) were higher than the ones that required sea transportation and HGVs posteriorly.

Given this fact, the calculus of the "Local Production" strategy would be senseless if the calculations only considered HGVs, since the emissions would be inevitably higher. Therefore, another estimation was made considering that the transportation was made with different types of vehicles, namely: Battery Electric Trucks (BETs) and Catenary Electric Trucks (CETs). Both these models were recently studied, however, they are not yet being used. This means that this is only an estimation for the future if these types of trucks start being used. For this reason, the EF's (Emission Factor) were estimations for 2030.

The BETs consist of trucks whose batteries replace the area of a combustion engine. Additional batteries are inserted into the chassis frame. Currently, truck producers are longing to modify the nowadays models and turn them into electric propulsion systems. The EF used in the case studies analysis was obtained out of an LCA study based on assumptions related to the battery's capacity and the execution of the electric powertrain. The energy consumption for the LCA of a BET was set at 130kWh/100km (Seemungal et al., 2021).

The CETs analysis was based on a study conducted in Germany, being CETs one of the proposed solutions focused on decarbonizing road transport. The CET was also designated as an "eHighway or Electric Road System" (ERS). In Figure 15 is presented a CET prototype (Seemungal et al., 2021).

Figure 15- Current CET prototype (Retrieved from: Seemungal et al., 2021)

The CETs are, therefore, presented as an alternative to HDVs (Heavy Duty Vehicles). Opposed to BETs, the CETs offer the advantage of overhead catenary lines, which solve the need for board battery storage. With this, the trucks have a smaller battery that besides weighing less, it costs less. This battery would be used only in circumstances when there were gaps in the infrastructure, for example, when transitioning from the depot to an eHighway. The main obstacle to this truck model is the infrastructure, which requires investment to install and maintain the catenary lines (Seemungal et al., 2021).

The choice of calculating these vehicles' potential was based on the fact that if the truck transport had less associated emissions, the process of local production could become less pollutant and possibly reduce the need for overseas outsourcing. This change would also promote the strategy of "collaboration between brands" longing to make transport more efficient and less pollutant by switching to electric modes.

Besides, this analysis also aligns with the issue of the third strategy since it isn't directly related to circular economy, having an indirect relation but still impactful when It comes to the environment. The EFs are presented in Table 5, these values were calculated using the WTW Besides, this analysis also aligns with the issue of the third strategy since it isn't directly related to a circular economy, having an indirect relation but still impactful when It comes to the environment. The EFs are presented in Table 5 these values were calculated using the WTW (Well to Wheel) approach which includes the generated impacts by the used energy in the vehicle (Seemungal et al., 2021; Osorio-Tejada et al., 2018).

Table 5- Electric trucks WTW EF (Retrieved from Seemungal et al., 2021)

Vehicle Type	EF (kg CO_2e/tkm)
BET (rigid 6x2)	0,0909
CET (rigid 6x2)	0,0843

Additionally, and to support the studies on local production evaluation, another analysis method was adopted. In this approach, all of the distances that covered the transportation of manufacturing materials/products were reduced. This reduction was between an interval of 5 000-10 000 km for sea transport and 100-300 km for land transport. All the trajectories that had fewer kilometers than the lowest value of the intervals were not altered. It is important to note that both case studies have an international value chain obtaining their resources from a multitude of countries. The storage and distribution are also on a worldwide scale, however, this analysis was made only on the stage to obtain raw materials for manufacturing. This was due to the configuration of the provided LCA's since for both cases the calculus of storage and distribution was done with specific software only used by Bezero's Carbon employees.

The "Resource-efficient production" strategy, from a circular perspective, is mostly related to saving materials (waste avoidance) along the value chain. However, as can be observed in the conceptual model, it is related to the first strategy. For this reason, the strategy was adapted to an energy-efficient production instead. Being related to one of the circular economy principles. When analyzing the concept's purpose, it aims to reduce environmental impacts in the industry and therefore a resource-efficient production in all variants possible.

Given the above-mentioned, for "resource emission production" the electricity EF was changed to zero since it was considered that electricity came from renewable sources during the manufacturing process.

For the last strategy used for the case studies, the EF for drying electricity was changed to zero. Additionally, it was studied the reduction in the number of washes per piece of clothing and the reduction of emissions if some products were hand-washed. However, these last two options were only used for the second case study, since the first didn't have the data of the use stage organized per piece, but the per type of fabric. After finishing all of the calculations of both cases, the results were gathered in one excel document to facilitate the analysis process and comparisons.

4 | RESULTS AND DISCUSSION

4.1 Interviews - Top Management and Experts' Perceptions

With a view of a detailed analysis of the results, the interview questions were all analyzed one by one.

4.1.1 Interviewees' vision on sustainability

Even though most brands have a similar vision of the sector, the disparity of perceptions and answers to some questions shows that to be seen as progress in terms of circularity there should be a common vision of sustainability in the first place. This may suggest that there is a need for corporate awareness to understand the internal benefits of a circular vision.

Table 6- First set of questions of the interview's script and respective answers

1. What is the Brand's current vision of the sector? Is it sustainable? Is sustainability in the core of the company or is it a concern that emerged later on? How does your company look at sustainability?	
Interview 1	"For HouseofU sustainability is very important. From the beginning sustainability has been a concern (…) in the future the brand will try to have more sustainable fabrics along with the transition to slow fashion"
Interview 2	They consider that within the industry of yarning, collection and separation of waste is very difficult. They always look for improvement
Interview 3	She considers that a reduction in consumption is crucial in order to see good improvements regarding sustainability. "There should be a disintegration of materials from companies or organizations to provide them again for production". She doesn't consider the sector sustainable
Interview 4	Don't consider the sector currently sustainable
Interview 5 (Case study 1)	"It's a vision and a sector that is always aiming for profit. Not sure about the progressions of the sector"; "There's not that much information available regarding this topic"

Interview 6 (Case study 2)	"Ultimately is clear that the sector is not sustainable and that responsible bodies should take more action"; "In (Brand's name) sustainability emerged later"
Interview 7	"There's a lot of progress to be done"; "There should be a shift in the mentality of consumers and brands"; "There should be more transparency within the industry"; The creation of the brand had in its core sustainability, since it was inspired by the owner's grandparents
Interview 8	"Barely sustainable"; "The small brands are niches"; Sustainability was always in the core since they started in a small atelier
Interview 9	"The industry is not sustainable"; "They longed for sustainability since the beginning"
Interview 10	"The sector needs transparency"; "In Portugal the sector is still not adapted to sustainability"" "This is an activist and social brand"

In general, 6 of the 10 interviewed entities considered that the industry is not sustainable. Both interviewees number 5 and number 10 mention that the industry needs more transparency.

Part of the brands (Brand 4 and Case Study 1) didn't respond directly to some of the questions asked, more concretely", " Is sustainability at the core of the company, or is it a concern that emerged later on? How does your company look at sustainability?". However, brands 1, 5, 6, and 7 confirmed that have been trying to be sustainable since the beginning.

It was also mentioned, in two interviews (3 and 5), that the industry needs progress in terms of sustainability and consumerism mentality.

Since most brands don't consider the industry sustainable, it is a visible need for progress. With this, it is also possible to conclude that there is a common perception of the unsustainability of the industry, which can be seen as the first step toward change.

The question "how does your company look at sustainability?" wasn't directly answered by any of the interviewees, which could imply that they either didn't have a well-structured perspective of sustainability or that they were facing sustainability from multiple perspectives and therefore there might not be one simple answer.

It is worth mentioning that the majority of the small brands interviewed had sustainability as a concern from the beginning.

According to the interviewees of Case Study 1 "There's not that much information available regarding this topic". This could be interpreted in two distinct ways: there isn't, indeed, enough information available, or the available information doesn't cover enough platforms to reach fashion brands. The second alternative can be concerning since knowledge is key for good progress towards sustainability and circularity.

4.1.2 Brands' environmental strategy and reporting

It is visible that most brands are already longing to make progress or have products that have some degree of sustainability, such as biodegradable fibers. All brands had considerably different answers to the same questions. In general, it is also important to consider the fact most brands didn't have sustainability reports, especially the smaller ones. This can be an aspect to improve.

Table 7 presents questions from the interview script and the respective given answers.

Table 7-Second set of questions of the interview's script and respective answers

2. Which are the Brand's current environmental approaches and goals? Do you have sustainability reports? If yes, what's the frequency of their release? Does the company monitor the impacts throughout the value chain frequently?	
Interview 1	They do have sustainability reports; They also have innumerous ecolines (Didn't have the answer for the other questions)
Interview 2	They want to start doing LCA'S for their products; when it comes to energetic consumption they will try to install photovoltaic panels; They already have plenty of biodegradable fibers
Interview 3	This question doesn't apply since she's not a brand owner
Interview 4	"Maintain the criteria they already have with the brands they have partnerships with"; "Help brands to reduce their waste"; "Consumer education"; "Networking between brands and synergies"
Interview 5 (Case study 1)	Right now they are studying how to lower emissions; They still haven't aligned on this yet, they are still in the "gathering information stage"
Interview 6 (Case study 2)	They have a SEDEX (first audit partnership) partnership and audits SMETA; They also have internal monthly reports; They have been monitoring their emissions with BeZero Carbon
Interview 7	They want to work on the concept of "How to take care of" and introduce more this concept among costumers; They do not have 100% control over the value chain of the different products; They don't have reports or certificates
Interview 8	"Slow fashion brand"; On demand products; they didn't have reports or certifications; Sometimes they are not able to attend the demand for being slow fashion and also because the products are personalized; They use the deadstock for other purposes such as tote bags
Interview 9	Having profit for R&D; Improve transportations methods; Transition for renewable energies
Interview 10	Inclusive brand; "Garments for everyone"; They are not able to have complete control over the value chain; They give workshops to their collaborators on how to work with different fabrics

Out of hall of the brands interviewed only one (Interview 1) had effective sustainability reports and none of them could have 100% control over their value chain. These questions didn't apply exactly to two of the interviewees since one was a fashion activist (Interview 3) and the other was a retail brand (Interview 4).

It was possible to see the disparity of approaches of the different interviewed brands. In the first interview, it is visible that the company already accompanies the impacts with their reports. The fact that they have eco lines shows that they worry about the source of the sold products even though it has not been clear what the “eco line” consists of exactly.

The second interviewed brand had the goal of having LCA's for their products which allows them to have more control over their value chains. They also considered energetic consumption as a sustainability aspect being, therefore, capable of reducing emissions during the manufacturing process.

Regarding the biodegradable fiber, from an end-of-life perspective, it is visible that in this stage the impact can be reduced since the product biodegrades easily. However, it is still unclear if the process of manufacturing this type of fiber is effectively less pollutant than the conventional ones. It is also worth mentioning that, when it comes to circularity, is preferable to maintain the different materials in the loop of the product's life cycle than creating waste even if it is biodegradable.

In the fourth interview, the interviewee's perspective was distinctive since they don’t manufacture the products that are sold on their platform. Nevertheless, they admitted to having special criteria for the brands they have partnerships with and want to help them reduce their waste by improving the communication between the brands that are part of the platform. This can be seen as a useful strategy to promote collaborations for circularity.

The fifth brand interviewed had an educational goal for the future, being focused on the "use" stage.

The sixth brand already had the slow fashion concept based from the beginning, delivering on demand. This branding model can be an option for the future since the aim, according to the owner, is to maintain the “on-demand” model, being worried about their impacts which, considering the brand's size, could be easily quantified.

The seventh interviewee considered the research in the field important, mentioning that R&D investments are needed. This point of view, besides being distinctive, is crucial to maintain the existence of innovation in the industry and also to promote a shift towards circularity.

The eighth interviewee had an answer more focused on the social aspects of the brand than on the environmental ones. Even though this is an important variant for the industry, it does not concern directly the present study.

Concerning the case studies interviews, it was visible that case study 1 was behind when compared to case study 2. Case study 1 is still gathering information to improve in terms of sustainability while case study 2 already had reports and concerns.

4.1.3 Interviewees and inputs of garments linear value chain

Analyzing from a broad scope it is possible to conclude that even though many brands mentioned the same stages they all had different visions of solutions for improvement (e.g vouchers to promote circularity vs. pick-up systems).

Table 8 is presented the third set of questions and respective answers to the exploratory interviews.

Table 8-Third set of questions of the interview's script and respective answers

3. The diagram here presented consists on a typical value chain of a textile product, with five stages. Which changes does your company think that could be made? In which stages and why? Does your company have any control over what happens in these stages?	
Interview 1	"We order our fabrics with a supplier that is as sustainable as can be. We will also develop our sustainability in the next few years. We mostly order by boat, to be more sustainable. In our production, we try to use as less water and energy as can be. We also use sustainable certified inks and fabrics. In the stages of distribution, retail, use and end use, we do not have control over this"
Interview 2	There should be improvements regarding transportation and water usage. When yarning, it is important to reuse the waste. The coloring products can also be an issue since they subcontract to do blended fibers. They also have contracting requirements
Interview 3	The changes should be made previously, that is in the mentality of production and consumption; The design thinking is really important; The products should reused as a hole
Interview 4	The stage that needs more intervention is "After use/End of life". The products durability is dwindling, therefore it is important to tackle this issue. Improve donation and resale systems
Interview 5 (Case study 1)	Use/after use stages; Improvement in the repair management of products
Interview 6 (Case study 2)	More sustainable material usage; Distribution and retail was also considered important due to transportation; In terms of "End of life "they consider important the concept of "Passing on" awareness and charity
Interview 7	In terms of raw materials it is important to be transparent; Regarding the use stage the labels are important
Interview 8	In terms of raw materials extraction it is important to consider the chosen materials (e.g polyester can only be recycled once); Less outsourcing and more local production; All of their fabrics are certified
Interview 9	End of life of the products should be tackled with pick up systems; A more sustainable production is also important

Interview 10	There should be a voucher to promote the "take back" of products or the support of institutions (social support)

The first interviewees didn't answer directly the questions asked, however, they long to have control over most of the value chain stages. In the second interview, the answer was also regarding transportation, with an additional mention of water and waste management, showing care beyond the simplicity of the stages by mentioning the raw materials used.

The fashion activist had a different perspective from both of the previous ones mentioning that there should be a change upstream when it comes to the whole industry. According to Salomé (the fashion activist), there should be a shift in society's mentalities to reduce consumption and, therefore, production. She also considers design thinking important, since it is associated with durability (products should be in trend for more than a season). Additionally, she mentions the reuse of materials as a whole.

In the fourth interview, they considered the "after use/end of life" stage as the most important one, mentioning the need to improve donation and resale businesses/systems.

The first case study, like the previous interviewees, supported the need for a change in the "end of life/after use" stage mentioning the repair management of products.

The second case study interviewee referred to more than one value chain stage, more concretely, the "Fiber production/raw materials extraction", "Distribution and Retail" and "After Use/End of life" showing concern for each one.

The fifth interviewed brand mentioned both the "Fiber production/Raw material extraction" and "Use" stages indicating the need for transparency and the importance of labels for consumers.

The sixth interviewee, like the previous two, addressed the first stage of the value chain. However, she also referred to a stage that had only been mentioned once before: "Manufacturing", considering the need for more local production and less outsourcing.

The last two brands also mentioned the "After Use/End of life" stage referring not only to the necessity of development of the "Pick up"/ "Take back" systems.

This question had the goal of understanding the different companies' views on a typical linear value chain and how they prioritize the stages that need change the most towards circularity.

Considering all the given answers it is visible that the perspectives regarding changes in the value chain differ. However, 6 of the 10 interviewed brands mentioned somehow the last stage of the presented diagram (Figure 11). This can be interpreted as a good start towards closing the loops since more than half of the contracted brands had the indirect notion of the need for circularity.

4.1.4 Brand's environmental goals

The fact that most brands have given diverging answers to the same questions shows that the knowledge on sustainability topics is also divergent. All interviewees long for improvement, however, the concept of circular economy is still unclear or unprioritized for most of them. Nevertheless, the prospects of the interviewees are, in general, positive.

is presented the fourth answer to the interview's script and respective answers.

Table 9- Fourth question of the interview's script and respective answers

4. Is there an environmental goal or strategy your company is aiming to achieve?	
Interview 1	In the future they aim to make more ecofabrics; Installation of solar panels in their establishments
Interview 2	As answered in question 2 their working on LAC's; Implementation of solar panels on production sites
Interview 3	Doesn't apply
Interview 4	Answered in question 2; Keep the criteria of contracts of sustainable brands
Interview 5 (Case study 1)	Gather data and understand the company's position regarding sustainability
Interview 6 (Case study 2)	Gather information with BeZero and understand their emissions
Interview 7	Answered in question 2; keep on educating their clients and improve the share of knowledge
Interview 8	Have a more sustainable Glitter which is also a best seller
Interview 9	Answered in question 2; Have more profit for donations for R&D; renewable energies
Interview 10	Keep on making fashion inclusive

This question had the goal of understanding the company's vision in the long term to progress toward circularity.

observing the answers to this question it is possible to conclude that it is redundant with the second set of questions since most brands mentioned their current approaches and the ones they are longing to achieve. It is also visible that most answers are aligned with the ones given

in "question 2", that is, most brands want to keep on working on the goals they are already aiming to achieve.

The interviewees have different perspectives regarding sustainability, for example, while the second interviewee is aiming to start having Life Cycle Assessments (LCA's) for their products, the seventh interviewee would like to have enough profit to donate for R&D and invest in renewable energies

4.1.5 Interviewees' ranking of EMF's principles for circularity

This topic of the interviews was aimed to understand how brands would compare and rate the principles presented by EMF for the T&A sector. These principles are: "Phase out substances of concern and microfiber release"; "Transform the way clothes are redesigned, sold, and used to break free from their increasingly disposable nature"; "Radically improve recycling by transforming clothing design and collection, and repossessing"; "Make effective of resources and move to renewable inputs" (Figure 12). The interviewees' answers are presented in Table 10.

In general, the answers stood out the disparity of perspectives once more, regarding the circular economy and how different brands/entities face the challenge of adopting these principles in their businesses. With this is clear that does not exist a unanimous point of view, is evident that the adapting process is different according to multiple factors such as the company size, the products sold, and the economic status, among others.

Table 10-Fifth set of questions of the interview's script and respective answers

5. Here you have four principles that promote the circular economy model within the sector, these principles where presented by the Ellen Macarthur Foundation. Would you/your company rank them from the least important to most important? Is there any specific aspect you would add to any strategy proposed here?	
Interview 1	1<2<3<4
Interview 2	3<1<2<4
Interview 3	4<3<1<2
Interview 4	1<4<2<3
Interview 5 (Case study 1)	2<3<1<4
Interview 6 (Case study 2)	3<2<1<4

Interview 7	1<3<2<4
Interview 8	4<3<1<2
Interview 9	1<3<4<2
Interview 10	1<4<3<2

This was an important question of the interview's script since it aimed to get the interviewees' vision of the circular economy principles and how they prioritize them. This prioritization was done by the interviewees according to their perception of their importance and ease of implementation, this shows the importance feasibility has for the brands. The implementation of the principles in the different businesses was also a variant considered by interviewees.

When analyzing the answers, it is possible to conclude that only two interviewees gave the same answer (interviewees 3 and 7). The fact that most of the answers were different shows the difficulty of prioritizing the presented principles. However, it is also important to stand out that the two principles considered the most important by most interviewees were: "Make effective use of resources and move to renewable inputs" and "Transform the way clothes are designed, sold, and used to break free from their increasingly disposable nature".

Another noted aspect is that both case studies chose the same first two principles, showing concern for the principles that are related to impacts along the value chain.

4.1.6 Interviewees' vision of the future of the industry

Considering the brand's projections for themselves, the vision is mostly of sustainable growth, this means that they want to maintain their production and selling rates, but in the most sustainable way possible. Yet, to exist in a circular economy within the fashion industry it is important to consider the fact the rate of production has to be aligned with the recycled waste or, preferably, the reused materials/products. Given this fact, it is essential that brands are aware of their waste generation and impacts to achieve a circular economy successfully.

Table 11- What's your company's environmental vision for the future?

6. What's your company's environmental vision for the future?	
Interview 1	The answer was from the brand's perspective: They aim to produce more sustainable products
Interview 2	The vision of the sector is of growth in the perspective that clothes will be more durable and sustainable

Interview 3	She hopes there will be a systematic change for progress in the industry even though there will still exist a lot of issues regarding sustainability
Interview 4	The world cannot support this consumption rhythm and the second hand retail has to grow
Interview 5 (Case study 1)	Answered briefly in question 1 the vision is of constant profit
Interview 6 (Case study 2)	The answer was from the brand's perspective: They are not going to stop producing collections but are willing to find ways to make it more sustainable
Interview 7	The answer was from the brand's perspective: Maintain the concept "made to last"; maintain the emotional aspect of the brand and the fact that the emotional connection with a product starts having a story
Interview 8	The answer was from the brand's perspective: they wish to change to a bigger atelier but not a factory so they can assure the slow fashion model
Interview 9	The answer was from the brand's perspective: Vision of growth and more physical stores
Interview 10	Vision of commitment with sustainability

Just like the fourth question, the sixth ended up being redundant in some interviews, namely the first case study's. In general, most of the answers were positive. However, the interpretation of the question was not the same, diverging between what the owners want for the future of the brands and the future of the industry itself. In this case, the goal of the question was to understand the interviewees' projections of the future of the fashion industry. Therefore, the use of this question wasn't effective considering the answers given.

When it comes to the sector's future projections most interviewees showed hope and desire for improvement. Nevertheless, it is important to underline the answer of interviewee four who mentions the need for a change in the consumption rhythm.

4.1.7 Additional information

This last question was with the view of obtaining any information that the interviewees considered important for the sake of the present study.

Some of the answers given above were posteriorly used not only for the conceptual model but also for the surveys, namely the "Deadstock management should be seen as a circular measure". It is also clear that most of the given answers are related to a circular economy addressing

the waste management issue in the industry. Nonetheless, the first two interviewees' answers were more on a logistical level of transport, being both exceptions.

Table 12-Seventh question of the interview's script and respective answers

7. Is there any other information within this topic about your company you would like to share for the sake of this research project?	
Interview 1	Fast delivery, that is automated production; The costumer can choose the delivery process
Interview 2	Quality control of the products; Product tracking
Interview 3	"Dead stock management should be seen as circular measure"
Interview 4	Shared knowledge between brands; Costumer education regarding the reason for higher prices (price background)
Interview 5 (Case study 1)	A proposed circular economy action was the comparison between companies
Interview 6 (Case study 2)	Without results of their own projects they still cannot give information regarding this topic
Interview 7	Reduce the number of fashion seasons; Brands evaluation
Interview 8	Recycling; The whole process should suffer a change
Interview 9	No answer
Interview 10	No answer

When analyzing all of the given answers in this interviewing process it is noted that the visions and perceptions of the brands are convergent on a sustainability level but divergent at the level of priorities. This means, the logics behind the answers is similar and there is a visible willingness for improvement, but, simultaneously, there is a difference in priorities when brands are faced with the same (or a similar) set of principles (e.g Table 10).

An example of the convergent vision is in the first question. In this phase of the interviews, more than half of the interviewees considered the sector currently unsustainable.

4.2 Experts and top management value chain knowledge

Considering the given answers and the perceptions of the interviewer, a comparison of the knowledge over the value chain was made. The study of the company's size was done according to the information available on the respective LinkedIn pages. In the case of the smaller

brands of the "Zero City" event, this information was given in the interviewing process. In Figure 16 it is possible to analyze this comparison.

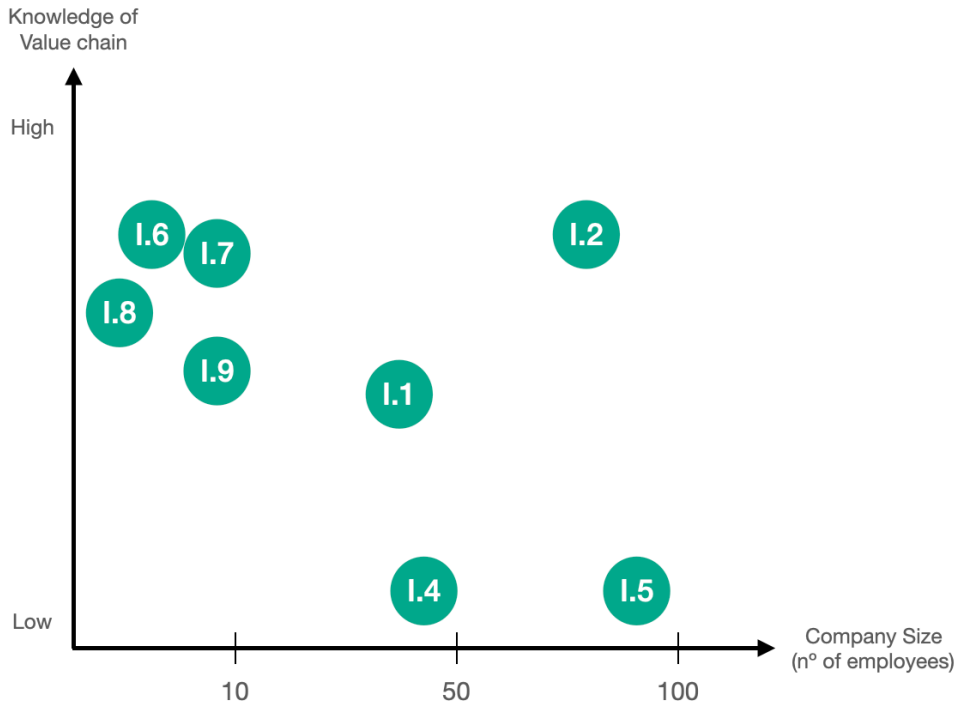


Figure 16- Comparison between the interviewed companies' size and the control over the value chain (I.1= Interview 1)

The figure above shows that the company size doesn't necessarily influence the control it has over the value chain, even though size can be an influencing factor. It is also worth outlining the fact that the brands with a bigger size that have more control over the value chain are both parts of the value chain of textile products (I1 is a printing company and I2 is a yarning company). This means they could have fewer phases associated with their manufacturing processes.

Nevertheless, all of the brands had some knowledge of their value chains. It is also possible to conclude that this knowledge is related to the brands' willingness and concern for improvement regarding the circular economy.

An additional influencing factor on the knowledge variant is the size of the value chain and the fact that the more international it is, the more difficult it can be to control the different stages.

A perception of this interviewing process is that the companies with a relatively bigger size of production keep on aiming to produce at the same or higher rates. This means that the goal is mostly to produce more sustainably instead of reducing their rates and controlling their waste generation.

4.3 Level of Knowledge on Circular Economy

Besides the evaluation presented in Figure 16, it was also possible to rank the accuracy of the perceptions regarding the concept of circular economy according to the type of interviewee (Figure 17). With this, it was possible to understand the difference in perceptions according to the type of interviewee.

In this case, it was visible that the fashion activist had a great insight into the concept, being able to answer elaborately the questions. On the other hand, the case studies were still searching for a better understanding of the concept, probably since their focus was on counting emissions and, therefore circularity was not a priority. Another possible reason for this fact might be the choice of emissions counting as a starting point to address sustainability in the company. In other words, the case studies might have seen the emissions counting as a good beginning to improve their value chain.

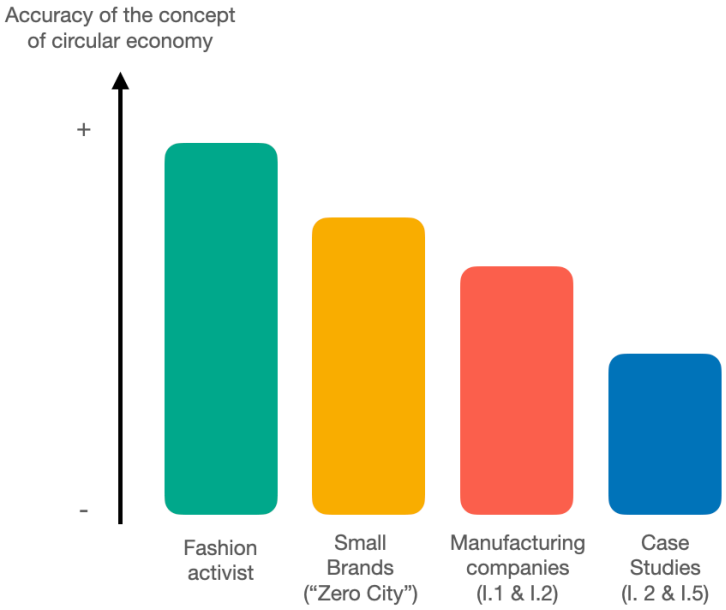


Figure 17- Ranking of perceptions of circular economy

This stage of the methodology was crucial for the following development of the present study since it was possible to get useful information for all of the other phases.

4.4 Surveys - Collaborators' Perceptions

As has been previously mentioned the collaborators' perceptions survey was an alternative approach to getting information associated with fast fashion multinational brands' approaches to a circular economy. Since they were hard to reach through email and linked in, it was attempted to get a bottom-up understanding of multinational brands' circularity approaches.

4.4.1 Brands' ongoing sustainability approaches

In Figure 18 it is possible to observe the answers to the first question ("Does the company have any sustainability strategy or policy or sustainability campaign ongoing" (e.g take-back of products; renting services, etc...)?") of the survey. Most of the interviewees replied positively.

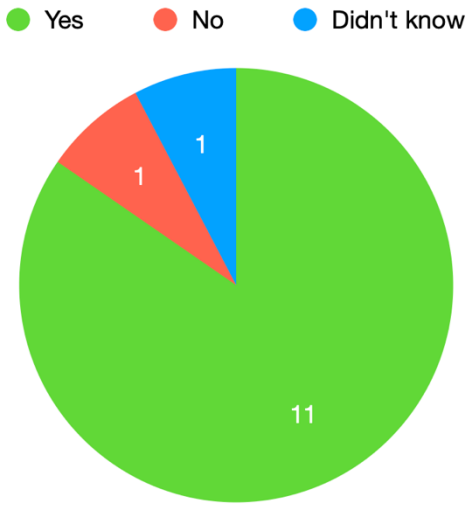


Figure 18- Graphic with the answers to the question: "Does the company have any sustainability strategy or policy or sustainability campaign ongoing (e.g take-back of products; renting services, etc...)?"

The answers visible in Figure 18 shows that most of the surveyed brands had strategies/policies or campaigns, and the collaborators were aware of them. However, there still were two brands that either didn't have any of the asked approaches or the employees weren't informed. To specify these brands were: Ralph Lauren ("Didn't know") and Brandy Melville ("No").

4.4.2 Customer Awareness

In Figure 19 are presented the answers to the second question (“When there's a sustainability campaign do you usually inform customers”) of the survey. Unlike the previous question, the answers were more distributed between “yes” and “no”. Yet, the number of “yes” responses was still higher.

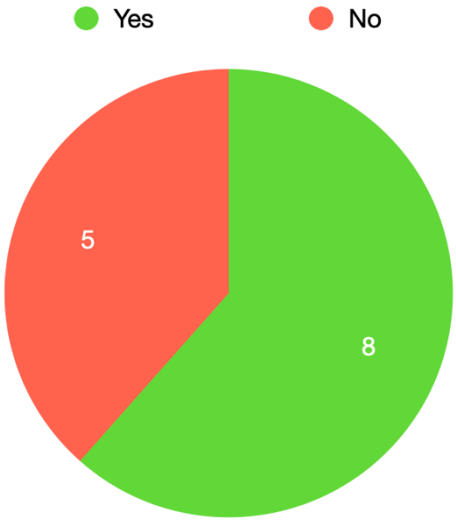


Figure 19- Graphic with the answers to the question: “When there's a sustainability campaign do you usually inform customers?”

It is important to emphasize that many factors could influence the fact that collaborators do not inform the customers about sustainability campaigns, such as the lack of campaigns; the lack of knowledge collaborators have regarding the existence of these campaigns; the Personality of the collaborators; Lack of availability to inform; the collaborators could also assume that the brand already gives enough information regarding these campaigns through marketing.

Nevertheless, it is still relevant to mention that the majority of the surveyed collaborators are concerned to inform customers about this type of strategy their company adopts. The brands that responded negatively were: Levis; Adolfo Dominguez; Ralph Lauren; Bimba y Lola and Brandy Melville.

4.4.3 Brands’ top-down information flow

In Figure 20 are presented the answers given to the third question (“Is there any type of training (punctual or regular) related to circular economy related aspects?") of the survey. The answers to this question were the same as the ones given in the previous one. The fact that the majority of the collaborators have training related to sustainability is a very positive observation. This means, that the top management is concerned to inform the entities that have direct contact with customers about their approach and the importance of sustainability for the brands.

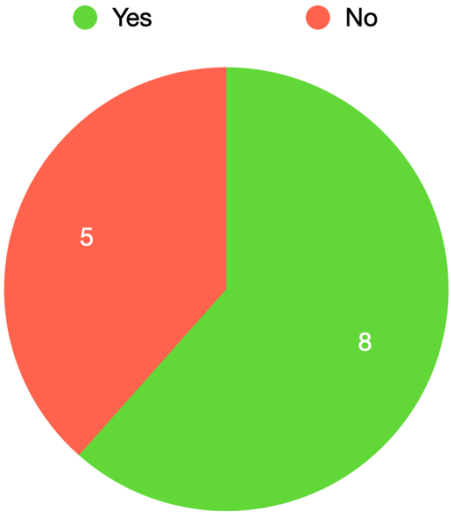


Figure 20- Graphic with the answers to the question: "Is there any type of training (punctual or regular) related with circular economy related aspects?"

It is still unclear if the trains given to collaborators' circular economy are mentioned. The brands that responded negatively were: Levis; Ralph Lauren; Bimba Y Lola; Brownie Spain and Brandy Melville.

4.4.4 Product care

In Figure 21 are visible the results of the fourth question ("When a client buys a garment do you usually inform him/her/them about its specifications (e.g How many times it can be washed)?") of the survey. The majority of inquiries stated that they inform the customers about the care they should have with the product they are buying. However, some of the inquiries also mentioned that this information also depends on the type of garment (e.g if it is synthetic fiber or cotton).

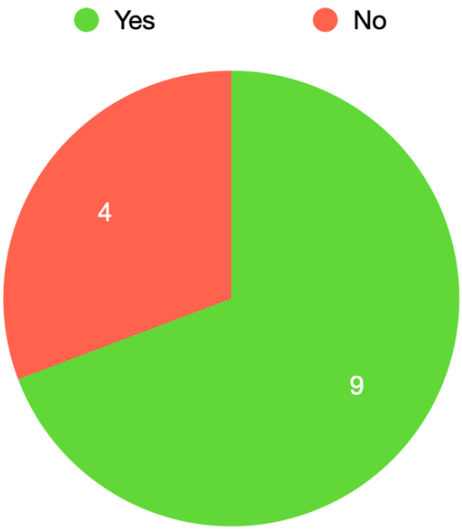


Figure 21- Graphic with the answers to: "When a client buys a garment do you usually inform him/her/them about its specifications (e.g How many times it can be washed)?"

The inquiries that replied negatively to the above-presented question were: Ralph Lauren; H&M; C&A and Brandy Melville.

4.4.5 Products' value

In Figure 22 are visible the answers to the fifth question ("If a customer tries to give back a damaged or defaulted product does the brand offer the repair?") of the survey. In this particular question, most of the inquiries replied negatively meaning that most brands do not try to repair the damaged products, giving the customers the same value of the damaged piece or a new one. The relevance of this question was associated with the goal of understanding if brands, when confronted with a damaged product avoid waste generation.

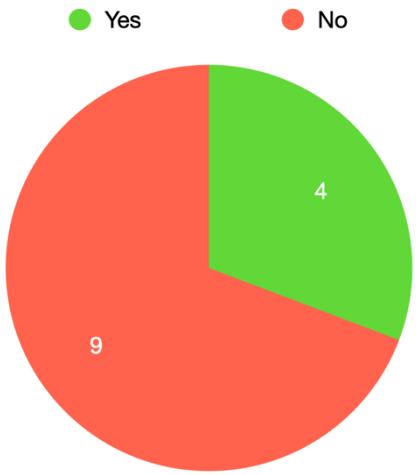


Figure 22- Graphic with the answers to the question: "If a customer tries to give back a damaged or defaulted product does the brand offer the repair?"

In this case, the only four brands that replied positively were: Levis; Adolfo Dominguez; Ralph Lauren, and Bimba Y Lola. Unlike most of these brands' answers in the previous questions, in this case, they were the only ones that replied positively. This result could be explained by the fact the common aspect they have is the average price of their products, which could justify each piece's value. This means, since their products are, in general, more valuable there could be a higher concern when it comes to giving new ones to customers.

4.4.6 "Deadstock"

The answers to the sixth question ("Do you have any knowledge about what happens to the "Deadstock") of the survey are presented in Figure 23. Most of the inquired collaborators responded "yes", however only part of those knew more precisely what happened after the outlet. Most of these brands after sending their "Dead Stock" to outlets keep them in storage for future seasons. Yet, the majority of inquiries said didn't know what would happen to the unsold garments.

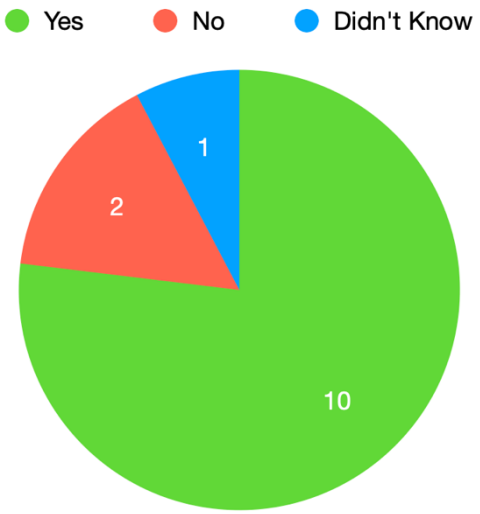


Figure 23- Graphic with the answers to the question: "Do you have any knowledge about what happens to the "Dead stock"?"

The last question of the survey, just like in the interviews, was for additional information. The answers were gathered in Table 13.

Table 13- Last question of the survey and respective answers

Is there any approach related to circular economy and the brand you consider important mentioning?	
Levis	No
Adolfo Dominguez	"No, only the fact that the brand try to improve as much as they can"
Lacoste	No
Ralph Lauren	No
Bimba y Lola	No
Brownie Spain	"Every year the brand tries to find ways to reduce waste (e.g no staples policy)"
H&M	"Yes, The way sustainability is dealt in fast fashion in constant progress"

Sipringfield	No
Massimu Dutti (Inditex Group)	"The stores shouldn't be open until midnight it facilitates consumption until late hours"
Bershka (Inditex Group)	"The usage of iPods, and the fact that sustainability is in the core of the company"
Oysho (Inditex Group)	"Sustainability has been a growing concern"
C&A	No
Brandy Melville	No

This last question was useful to obtain a further vision/opinion of collaborators regarding the circular economy. There is one particular answer that is worth underlining, which is from Massimo Dutti's store responsible: "The stores shouldn't be open until midnight it facilitates consumption until late hours". This wasn't mentioned by any other interviewee, which made it stand out. The reduction of the open hours of the selling establishments could be an influencing factor in the industry. This fact can also be linked with the fashion activist's answer to the third question of the interview ("The diagram here presented consists of a typical value chain of a textile product, with five stages. Which changes does your company think could be made? In which stages and why? Does your company have any control over what happens in these stages? "). According to her, to reach circularity there's a need to reduce consumption and consequently production.

It is also worth emphasizing the fact that the brands that replied "No" the most were Ralph Lauren and Brandy Melville. However, Ralph Lauren was also one of the few brands that offered to repair the damaged pieces that customers could complain about.

In general, the majority of the interviewed multinational brands according to their collaborator's perceptions had some level of concern towards sustainability. Yet, when compared with the interviews with top management and experts it is clear that there's a difference in the level of insight into the brand's approaches.

Additionally, during the inquiry process, it was possible to notice that most brand approaches were done "upstream", for example, the Inditex group collaborators showed the "Join Life" label of recycled fabrics. This was tagged in a considerable amount of the group's products. This label is a standard developed by the Inditex group and it includes an "environmental attribute" that must respect at least one of the following requirements: "Care for fiber" (products manufactured with TENCEL, Lyocell, organic cotton or recycled fabrics); "Care for Water" (this includes products that at least in one of the production stages incorporated technologies that reduced water usage) and "Care for Planet" (Products that were manufactured with renewable energy in one of the value chain stages) (Zara, 2020). With this, emerges the following question: Why doesn't the label comply with all of the requirements at once instead of being "at least" one of the requirements mentioned?

A possible answer to the above-presented question could be the difficulty of its implementation considering the high dimensions of manufacturing the group includes. Nonetheless, it still is a question to be posed and studied with the Inditex group, since it wasn't possible to have contact with the top management of the company.

According to the same source, in 2017 there were 68,953 Massimo Dutti garments under the Join Life Label and 4.9 million Oysho garments under the same label (Zara, 2020). However, the number of produced garments is extremely high which is a concern considering the probable lack of circularity of the generated waste of the massive production systems.

Another interesting fact mentioned by the Springfield collaborator was the "UV Lazer" technology to wash jeans, this technology besides not needing water it also helps to preserve this type of garment. This technology could also be studied/used by other brands.

A relevant conclusion from these surveys was that out of the 13 interviewed brands 8, had collaborators' training related to sustainability. A good example was given by Springfield and Inditex where they have a common platform for employees that gives access to knowledge related to sustainability and the respective company's strategies/actions/policies.

With the gathered answers it was possible to make a comparison between the average price of the brand's garments and their sustainability approaches (Figure 24). To calculate the average price of the different interviewed brands, a piece of garment was chosen and the prices were compared according to the information on the respective websites. The chosen piece of garment consisted of a pair of jeans since almost all brands had this type of garment for sale. However, Oysho is a brand that sells mostly sportswear, therefore the chosen garment for comparison was leggings. The vertical scale was evaluated according to the number of affirmative answers.

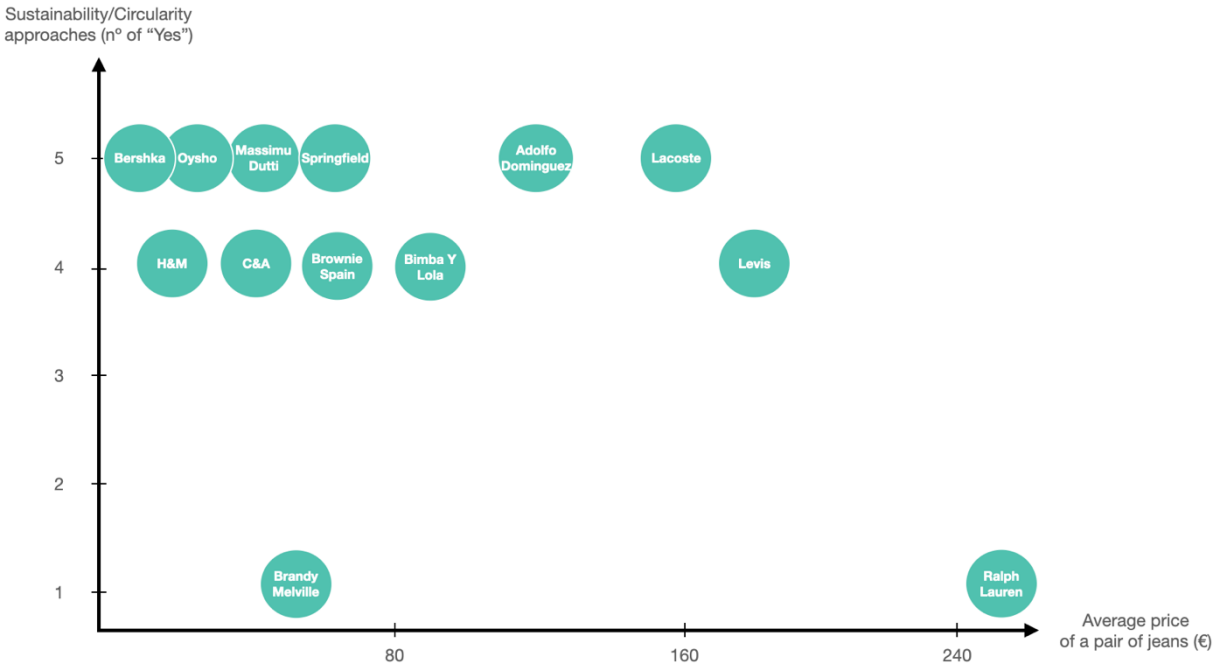


Figure 24-Comparison between the average price of the companies' pairs of regular denim jeans and their sustainability approaches

When analyzing Figure 24 it is possible to conclude that the existence or amount of sustainability approaches seems independent of the average price of products. A good example of this is the visible distance between Springfield and Ralph Lauren. Even though Ralph Lauren's garments are, on average, more expensive they responded negatively to most of the questions posed in the survey, unlike Springfield.

Another aspect to emphasize is that although the 3 brands that belong to Inditex have different price ranges they all adopt the same sustainability/circularity strategies.

It is also noticeable that the brands with more sustainability approaches, according to their collaborators are: Bershka, Oysho, Massimo Dutti, Springfield, Aldolfo Dominguez, and Lacoste. These brands have different price ranges, however, all of them have shown care for the knowledge and adoption of sustainability approaches.

4.5 Conceptual Models

The conduction of exploratory interviews and brand surveys, allowed us to identify the importance of gathering the obtained data and organizing it into multiple frameworks that could support decision-making processes. Given this line of thought different conceptual models were developed, considering policies, strategies, actions, education, and awareness.

In other words, these models consisted in a way to systematize information that can be considered new and complex to provide not only information for future studies but help the decision-making process when attempting to implement a circular economy across the sector of different entities in their value chains.

The developed models include the relationship between the different concepts and the identification of the associated value chain stages. This combination of value chain stages and the relationship between the multiple elements allows an integrated vision in the decision-making process as well as the identification of the priority stages when starting to implement circular economy models in this sector.

4.5.1 Circular Policies conceptual model

In Figure 25 is presented the "Circular Policies conceptual model tailored for fashion". This model describes the interrelations between the different circular economy policies, meaning which polos are increasing and supporting others and/or are dependent. Considering the content of this model it is important to highlight that the target audience that would benefit from this model are the entities that participate in policy design and development.

This circular model is based on the possible effects these policies have on each other according to the literature review, interviews, and surveys. When it comes to the link of the policies presented in this model with the literature review, some are presented in Figure 8 and others were based on the "EU Strategy for Sustainable and Circular Textiles", where some of these policies are explained in detail.

Regarding the basis of this model in the interviews process, on the last question (" Is there any other information within this topic about your company you would like to share for the sake of this research project?") some interviewees gave input regarding policies, for example, "Quality control of the products" and "Recycling". These answers' interrelation is presented in the model in the link between "Quality requirements for recycled fabrics" and "use of recycled fabrics".

Besides, the first question of the surveys ("Does the company have any sustainability strategy or policy or sustainability campaign going (e.g take-back of products; renting services, etc...)?") also provided input for the model in question, since many employees mentioned that the brands they work to have durability standards. The previously mentioned UV cleaning system used in Springfield is an example related to the policy "Supporting research, innovation and investments" which, in the model, has an interrelation with "Durability standards". Through a holistic analysis, it is possible to identify synergies and opportunities to scale up different policies.

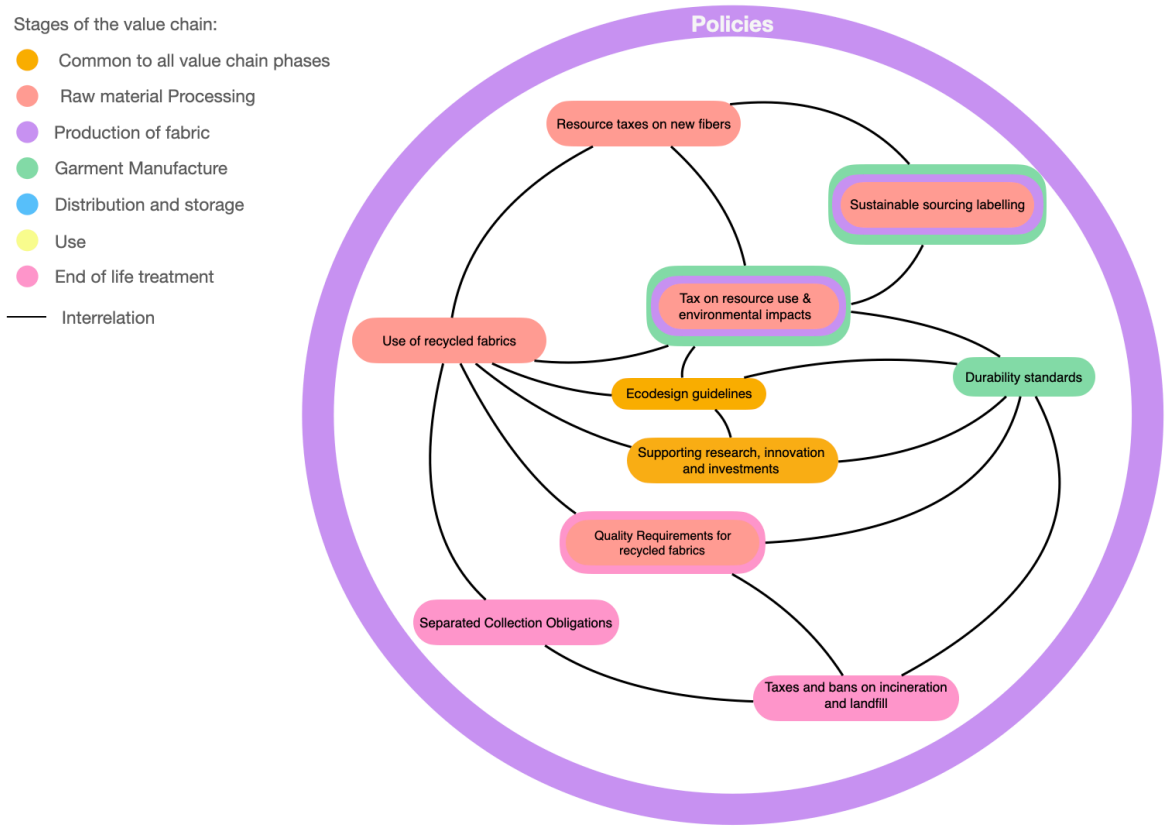


Figure 25- Circular Policies conceptual model tailored for fashion

An example to explain these interrelations is the "durability standards" and "eco-design guidelines" policies. The first can support the second in a way that helps understand which are the best standards for eco-design guidelines. On the other hand, it also works the other way around, this is, ecodesign guidelines can influence the development of durability standards.

An example that translates the interrelations, an example is the "Taxes and bans on incineration and landfilling" and "Separated collection obligations". These two are correlated to the extent that "Taxes and bans on incineration" inflict the need to apply "Separated collection obligations" and vice-versa. The "Separated collection obligations" can also demand "Taxes and bans on incineration and landfilling" as a way to avoid the use of alternative processes.

In general, it is visible that the majority of the presented policies are associated with the first stage of the value chain (Raw material processing). This observation is since in the recurred sources nearly none was associated with other value chain phases (e.g use or distribution and storage). An example, of policies that weren't found/mentioned in the research process or interviews and surveys, were shared transport policies, for this reason, there wasn't enough evidence to support the input of these types of policies in the circular model. Even though these policies weren't mentioned doesn't imply the lack of their existence. On the other hand, this could suggest that this stage is the one with the most relevance for the implementation of these policies, being followed by the "end-of-life treatment" stage.

Another valuable aspect to mention is that the "Use of recycled fabrics" policy is the one with the highest number of interrelations. It is worth highlighting the fact that this policy, is grounded in the idea of mandatory use of recycled fabrics or at least a mandatory recycled percentage. Additionally, these recycled fabrics, to guarantee the circularity of the value chain, should come from other garments or textile pieces. The fact that it has the highest number of interrelations could mean that the implementation of this policy might be a driving force to implement other policies, such as, "Quality requirements for recycled fabrics".

The policy of "quality requirements for recycled fabrics" is the only one that doesn't involve two adjacent stages of the value chain. However, this particular fact shows the connection between the first and the last stages of the value chain, closing the loop.

4.5.2 Circular strategies conceptual model

The Circular Strategies conceptual model's target audience consists mostly in fashion brands that are trying to apply the concept of circular economy in their value chains. This model intends to support the decision-making process of choosing the most suitable strategies to implement by different organizations and to help in prioritizing the different possible strategies.

Figure 26 presents the Circular Strategies conceptual model, describing the interrelations between the different circular economy strategies.

In this model, the most present stage of the value chain is "Garment Manufacture". This could mean that this stage is key for the implementation of circular strategies.

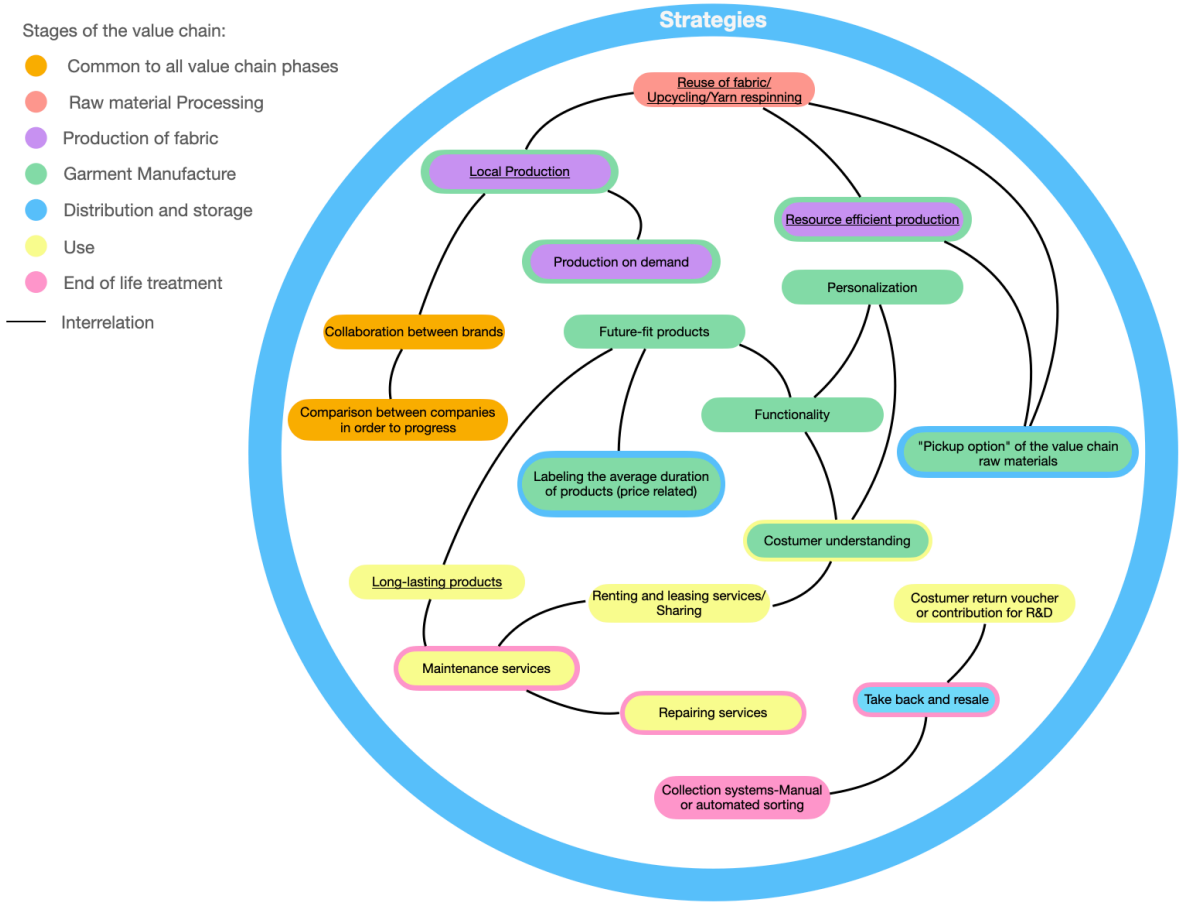


Figure 26- Circular Strategies conceptual model tailored for the fashion industry

The strategies with the highest number of interrelations in this model are "Future-fit products" and "Reuse of fabric/upcycling/yarn respinning". This is a particularly important fact due to their connection with design. Design is one of the principles for circularity ("Transform the way clothes are designed, sold and used to break free from their increasingly disposable nature"), as mentioned in the literature review. The "future-fit" strategy aims to focus on the "lasting" feature of garments.

The strategy of "collaboration between brands" is particularly correlated with "local production" since one's waste could be the raw materials of others, promoting not only local production but Upcycling. Nevertheless, "collaboration between brands" and "comparison between companies to progress", besides being associated with all value chain stages, are, in a way, indirectly connected with nearly all other strategies. More specifically, the strategy "collaboration between brands", since could ease the process of implementation of most strategies, through brands' mutual support.

A further aspect to highlight is out of the nineteen strategies presented in the model only two are related to the "end-of-life treatment". Additionally, there is only one strategy related to "raw material processing". With this, it is visible that there are more strategies related to the other stages of the value chain than the first and last. This fact could also imply that the most

practical way to implement a circular economy is with strategies associated with central phases of the value chain.

Also, another reflection to be taken from this model is that there is only one identified strategy that involves two separate value chain stages (that are not adjacent). Analyzing this fact from the opposite scope, most of the strategies involve adjacent stages of the value chain, as is exemplified in Figure 7.

With this model and the perspectives taken from the interviews and surveys, it was possible to conduct a broad analysis of the expected effect strategies have on emissions, this analysis is presented in Figure 27.

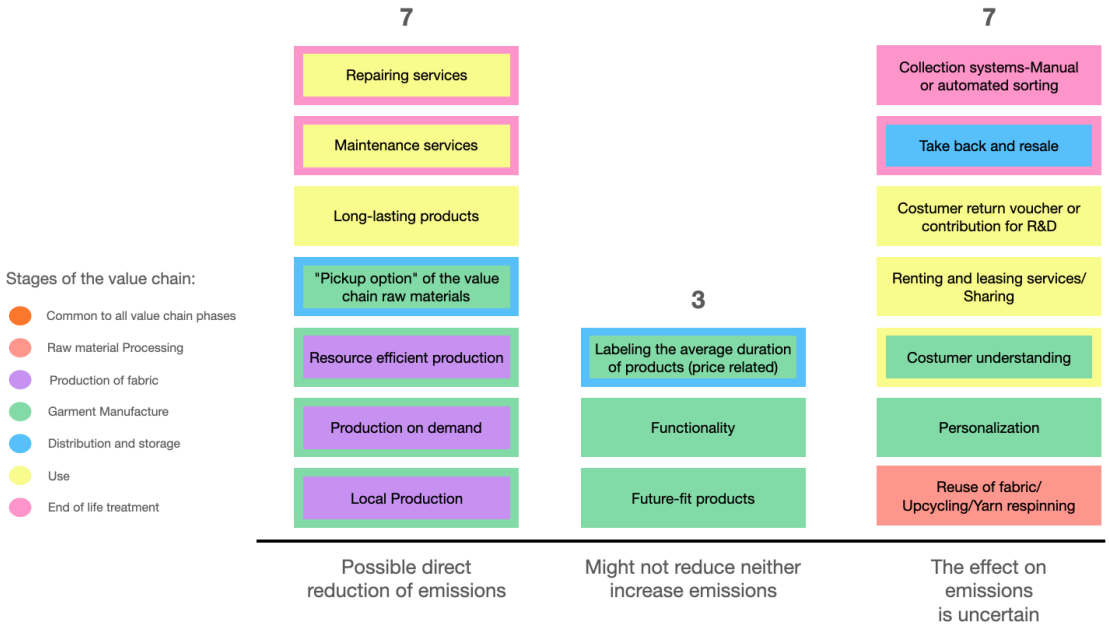


Figure 27- Possible relationship between strategies for circularity and emissions

In the above-presented figure, it is estimated that the number of strategies that might reduce directly CO_2 emissions is the same amount as the ones the effect on emissions is uncertain. For this reason, it is considered that more studies should be conducted in this field to clarify this uncertainty.

Also, it is noticeable that most of the identified strategies linked with the "production of fabric" stage possibly cause a direct reduction of emissions, which could be considered a starting point in decision-making.

Three strategies might not reduce or increase emissions, which are all linked with the "Garment manufacturing stages". This means that even though these strategies contribute to circularity when facing the decision of adopting these strategies is important to consider "resource-saving" or "emissions-saving". An example is a strategy "Labeling the average duration of products (price related)" this strategy can be seen as a way for labels to inform their

clients about the price/duration relationship as well as an incentive to manufacture to the last longer. However, the repercussions of durability are still uncertain regarding emissions, since all of the energy consumption for product care could be, in fact, an emissions source. Given this sequence of thought, the three mentioned strategies pose a dichotomy in the literature review, which complicates the decision-making process for implementing strategies.

4.5.3 Circular actions conceptual model

In Figure 28 is presented the Circular actions, conceptual model. Unlike the strategies model, the actions model has fewer components and, therefore, fewer interrelations. The lack of actions presented in the circular model can be justified by the fact that this term is not frequently mentioned neither in the literature or the interviews or surveys. The concept of "Action", since is connected with "Strategy", the target audience of this model is mostly companies' top management and also policymakers. These last entities can promote/influence companies to implement strategies by announcing or suggesting the actions presented in the model.

It is important to highlight the action "Stopping the destruction of unsold or returned textiles", has the highest amount of interrelations. This action converges with one of the principles of circularity ("Eliminate waste and pollution"), being, for this reason, crucial in this system. One of the core goals of the circular economy concept is to keep materials in a loop to avoid waste, therefore it is key to consider the mentioned action to support strategies that accomplish this goal.

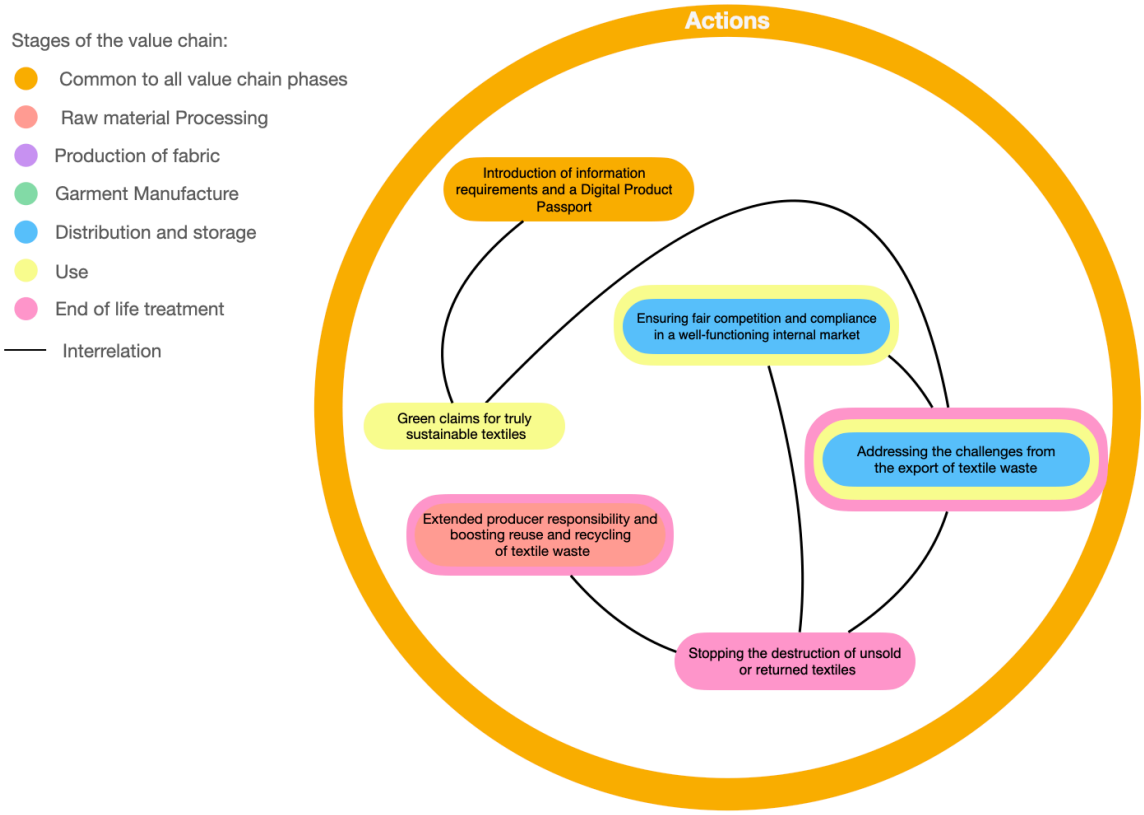


Figure 28- Circular actions conceptual model tailored for the fashion industry

Another particular action that stands out in this model is "addressing the challenges from the export of textile waste" since it is related to three of the value chain stages. Besides, this action is important when it comes to understanding the issues that need to be tackled regarding waste export. Once these issues are addressed it might be easier to implement strategies, such as, "Collection systems-Manual or automated sorting".

From a general perspective, the presented actions can be seen as driving forces for the implementation of strategies, since the majority is associated with structural changes/approaches of the value chain (e.g. "extended producer responsibility and boosting reuse and recycling of textile waste").

Another visible conclusion that is taken from this model is the fact that the "use" phase is key when it comes to actions since it links directly with the "end of life treatment". In other words, the pathway of products during the selling and usage phases can dictate end-of-life actions.

4.5.4 Circular education and awareness conceptual model

Figure 29 is presented the education and awareness practices model. Education and awareness practices are key to reaching a circular economy in the industry. The education and awareness practices are transversal to all models since they consist of the basis for the development of policies, strategies, and actions in reality.

Given this line of thought, the targets of this model go from top managers to policymakers to consumers, since the general knowledge and awareness of circularity within fashion is the key to progress and the emergence of new ideas for all other models (policies, strategies, and actions). Additionally, without knowledge sharing, there isn't unity for the implementation of policies, actions, and strategies.

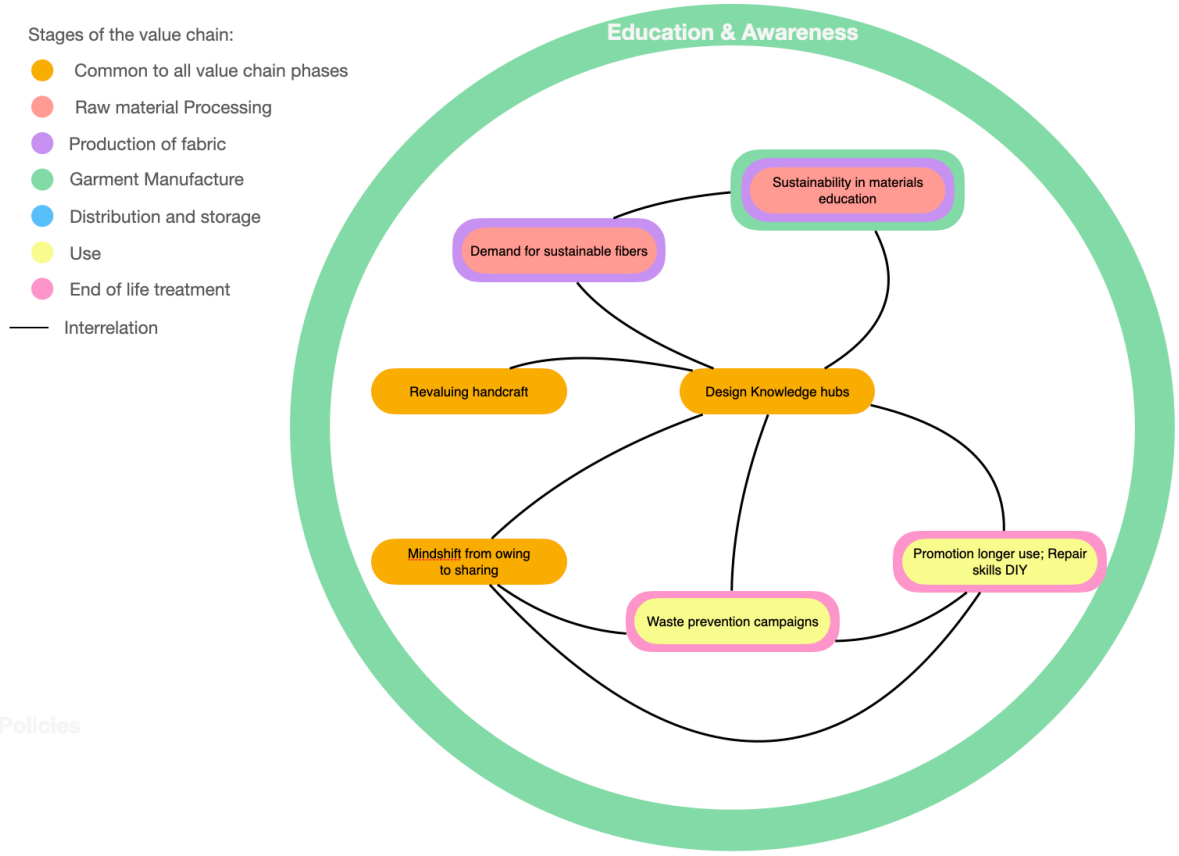


Figure 29- Circular education and awareness conceptual model

In this model, it is worth underlining the importance of the "Design Knowledge Hubs" due to the fact these are driving forces not only to all other education approaches but also to actions, policies, and strategies. Additionally, three out of the seven elements of the model are related to all of the value chain stages.

Out of the presented elements, only three weren't specifically mentioned in the interviewing process which was: Design Knowledge Hubs; Waste prevention campaigns, and sustainability in materials education. This is a very positive observation by virtue of the fact that most of the top management interviewees are aware of the need and importance of these education and awareness practices.

This model can also be used for future studies, on how to connect and apply different education and awareness practices. An example of this is the interrelation of support between "Revaluing handcraft" and "Design knowledge hubs". In order to successfully revalue

handcrafting it might be of interest to gather knowledge (in design knowledge hubs) on the value of handcrafting techniques and how this can be a future fit investment.

It is important to emphasize the common use of all models to reach circularity. All developed circular models to support decision-making processes may be useful to achieve a systemic and functioning circular system in the studied sector.

4.6 Case Studies

As explained in the methodology to obtain a quantitative analysis of circular economy strategies, four were chosen from the conceptual model to test in different contexts.

4.6.1 Reuse of fabric/upcycling/ yarn respinning

The first strategy, "reuse of fabric/upcycling/ yarn respinning (recycled fibers)" was applied exclusively in the second case study(Interview 6- Women's Designer Fashion & luxury clothing brand), since all of the raw materials used by the first were already partially recycled. However, during the interview with case study 1, it was mentioned that the percentage of recycled fabric wasn't higher since the final product could lose quality. This can be seen as a conflicting decision since the usage of less manufactured raw materials can reduce the duration of the products.

The results of the calculations of the first strategy are presented in Figure 14. If case study 2 changed some of their primary, secondary, tertiary, and quaternary raw materials to recycled ones they would have a 37,94% of reduction in the first stage.

Table 14 - Emissions calculations of the first strategy for case study 2

Total tCO_2e	**Total tCO_2e with recycled fabrics**	**Reduction of emissions by using recycled raw materials (%)**
2201	1366	37,94

These results meet the expectation since the usage of recycled fabrics not only decreases the processing of new raw materials but the emissions of CO_2 as well. However, from a financial perspective, this strategy needs to be studied since the purchase of recycled raw materials can be influenced by many variants, such as price and transport distance.

4.7 Local Production

Regarding the second applied strategy, "local production" two approaches were used: the electric transport mode and the reduction of transport distance. The results for the use of electric transport are presented in Table 15.

Table 15 - Results of the calculations of electric transport for case studies 1 and 2

	Case Study 1	Case Study 2
Total emissions on Transport (tCO_2e)	111,3	25,54
Total emissions transport w/ electric charging battery in 2030 (tCO_2e)	80,75	19,94
Reduction of emissions by changing for electric charging battery vehicles in 2030 (%)	27,45	21,92
Total emissions transport w/ catenary battery vehicles in 2030 (tCO_2e)	78,96	19,07
Reduction of emissions by changing for catenary battery vehicles in 2030 (%)	29,06	25,32

When analyzing the results above presented the difference in the total emissions associated with raw materials transport is significantly higher in case study 1 than in case study 2. This can be explained by the fact that the case study's 1 value chain is considerably bigger, given the fact that the bought resources have to travel longer distances. Also, case study 1, includes a bigger value chain when it comes to the variety of products.

Additionally, it is relevant to mention that the percentage of reduction doesn't reach 50% for either option and case study. This fact can be critical for the decision process when switching to electric transport methods since the investment can be significant in terms of environmental impacts but not economically viable in the long term.

The other approach used to analyze the "local production" strategy was the reduction of the sea and land transport distances. The decision of the kilometers reduced, as explained, in the methodology, was based on 300 km for land transport, which was the minimum traveled distance in case study 1. For sea transport, the same logic was applied. The results are presented in Table 16.

Table 16- Results of the reduction of distances approach

	Case Study 1	Case Study 2
Total emissions of transport (tCO_2e)	25,5	111
Emissions of sea transport by reducing 10 000 km (tCO_2e)	22,0	50,6
Percentage of reduced emissions by decreasing 10 000 km on sea transport (%)	14,0	54,5
Emissions of sea transport by reducing 5 000 km (tCO_2e)	23,8	62,5
Percentage of reduced emissions by decreasing 5 000 km on sea transport (%)	6,99	43,9
Emissions of land transport by reducing 300 km (tCO_2e)	22,7	86,8
Percentage of reduced emissions by decreasing 300 km on land transport (%)	11,2	22,0
Emissions of land transport by reducing 100 km (tCO_2e)	24,6	103,0
Percentage of reduced emissions by decreasing 100 km on land transport (%)	3,73	7,48

When analyzing the results above presented, it is visible that the decrease of 100 km in land transport causes a very small reduction of emissions (less than 10%) for both case studies. However, all of the other distances were reduced to generate a decrease of over 10% in emissions, except for the first case study when decreasing 5 000 km on sea transport.

It is also important to note that for the second case study the emissions values are higher since this company outsources most of its value chain stages. This means that if this company had outsourcing contracts with other companies that are closer to each other it could reduce its emissions significantly. When comparing both case studies it is noticeable that the second generates almost the double first's emissions on materials transport.

4.8 Resource efficient production

When it comes to the "resource-efficient production" strategy the results are presented in Table 17. To apply this strategy in LCA's calculations the electricity EF was changed to 0 since it was considered that the energy source was 100% renewable.

Table 17- Results of the "Resource-efficient production" strategy

	Case Study 1	Case Study 2
Total emissions on production electricity (tCO_2e)	499	220
Total emissions on production with renewable energies (tCO_2e)	11,3	19,6
Percentage of reduced emissions with renewable energy (%)	97,7	91,1

As visible in the results of Table 17, the reduction of emissions is significant, more specifically, almost 100%. With this, it is possible to affirm that the usage of renewables is a good strategy to reduce emissions at the manufacturing stage. This strategy can be achieved, for example, through contracts with renewable energy companies or agreements with outsourcing companies.

4.9 Long-lasting products

For the last chosen strategy ("long-lasting products") the calculation approach was different for each case study since the LCA calculations were different. In the first case study, the use phase was calculated according to the type of materials while the second was according to the type of product. The results of case study 1 are presented in Table 18. In this case, the EF of the electricity of the drying machine was changed to zero. The usage of drying machines besides reducing the lifetime of garments can also be an unnecessary waste of energy.

Table 18- Results of the "Long lasting products" for case study 1

Total emissions on the use stage (tCO_2e)	Total of emissions if the products were air dried (tCO_2e)	Percentage of reduced emissions (%)
1058	293	72,3

Observing the above-shown values it is perceptible that air drying garments decreases significantly the emissions of the use stage. For this reduction to be achieved it is necessary to generate awareness of these values among customers, which is linked with the model in Figure 29.

The calculations of the second case study are presented in Table 19. For this case study, various approaches were adopted, starting with the reduction of the number of washes per year by 2. The value chosen was according to the lowest amount of washes out of all products.

The second approach consisted in analyzing the reduction of emissions by handwashing some types of products namely: cotton cardigans, cotton coats, cotton vests, wool blazer, and wool vest. The selected products were according to their materials' sensitivity and type. Besides these pieces, it was assumed the "hat" wouldn't be washed at all. The last considered approach for the calculation of this strategy was the same one as case study 1.

Table 19-Results of the "Long lasting products" for case study 2

Total of emissions of use phase (tCO_2e)	6052
Total emissions by Lowering 2 washes per piece per year (tCO_2e)	5651
Percentage of reduced emissions by lowering 2 washes per piece (%)	6,63
Total emissions if some products were handwashed (tCO_2e)	5545
Percentage of reduced emissions if some products were handwashed (%)	8,39

Total emissions if the products were air dried (tCO_2e)	170
Percentage of reduced emissions if the products were air dried (%)	97,2

Considering all the results above presented it is possible to conclude that "air drying" is the most effective option of them all since it presents the highest percentage of reduction.

When comparing the result of both case studies, it is noticeable that the total emissions of the "use" stage of the second case study are significantly higher than the first one. There are two possible explanations for these values: the calculations of the first study were made according to the material type, which causes a difference in the total emissions value or the second case study has a wider range of products, influencing considerably the total emissions.

In general, all of the strategies used for the presented calculations met the expectations, this is, all of them helped reduce CO_2 emissions. However, some of the values of the reduced percentages were lower than predicted. Also, when analyzing recycled materials research for new EF's was conducted, yet it was concluded that some of the recycled materials could cause more emissions produced than the original ones (e.g silk). This brings the dichotomy of saving resources or saving emissions to the companies.

Another aspect to underline is that out of all strategies calculated the most effective one when it comes to reducing emissions is "resource-efficient production". Being this one the best to invest in the first place, since it is the most efficient. Besides, it is also important to mention that the strategies should be applied together instead of separately. The application of these models should be synergetic to reach circularity.

4.10 General Reflections

Throughout the present study, it was also possible to create links between the literature review and the obtained results from other methodological stages.

In the literature review, it was mentioned that the "average number that a piece of clothing is worn before it stops being utilized has reduced by 36%". When comparing this fact with the answers of the top management and experts, it is possible to conclude that part of them is aware of this problem (namely the fashion activist, interviewee 6, and the second case study). However, during the interview with the second case study, it was also mentioned they are not willing to reduce their production rates but to change their ways of manufacturing. This last

statement from an economic perspective is reasonable, yet possibly disruptive if the goal is to reach circularity in the fashion industry.

Another fact taken from the literature review was that "for some products, home laundry and dry cleaning chores can be responsible for more environmental impacts than any other phase of the product's life cycle. Besides, it is estimated that "up to 80% of the garment's carbon footprint occurs during the stage of consumer care". When relating this with the case study values the highest amount of emissions comes, indeed, from the use stage. This stands out the need for awareness regarding clothing care and how to save resources while doing so.

Nevertheless, the above-mentioned is conflicting with what is shown in Figure 9 where the stage with a higher percentage of emissions is "manufacturing". Yet, according to the case study values, that doesn't apply. With this it is possible to confirm that the facts vary according to their source, being, in some cases, conflicting.

Another diverging conclusion from the literature review was the emissions associated with recycled polyester. According to Qian et al.(2021), recycled polyester accounts for a higher carbon footprint than virgin one. However, the EF values obtained from Bezero Carbon affirm the contrary. This is because the EF of virgin polyester is higher than that of recycled one. This fact should be confirmed in further studies and explored different approaches.

Looking now at both interviews and survey outcomes it is possible to conclude that both types of brands (multinational and small brands) are doing efforts towards circularity. Nonetheless, it is still unclear the level of knowledge and how much effort brands make to change the end-of-life treatments of their products. An example of this is that most collaborators did not know exactly what happened to the garments after being sold in outlets.

Relating now the survey answers with the "approaches for circularity in the fashion industry chapter", it was noted that only the Springfield employee mentioned the reduction of water use with their UV technology. H&M, on the other hand, presents sustainable strategies and labels on their website, however, the surveyed employee wasn't aware in detail of their circularity approaches. In general, with the surveys, it was verifiable that the brands' initiatives weren't transmitted to in-store employees and, therefore, neither to in-store customers, even though most are mentioned on the brands' websites.

It is also important to mention that considering the brands' approaches and perceptions there is a need for unanimity when it comes to knowledge of the circular economy concept and the synergies between the presented models (Figure 25, Figure 26, Figure 28 and Figure 29). A circular economy demands the perception of the interrelations between strategies and the possibility of applying them simultaneously. For example, all the tested strategies in the case studies can be applied at the same time, allowing the reduction of emissions at different stages of the value chain.

When comparing the quantitative analysis of strategies with the companies' perceptions (interviews) it was possible to conclude that some of the brands' goals weren't aligned with the

value chain stages that needed the most intervention, such as the use stage. Brands may have shown more concern about informing their customers about the impacts of the use stage, which account for the highest amount of emissions. An important aspect is that smaller brands' perceptions could be biased since they were contacted at a sustainability event.

Another visible reflection can be taken from the answer of interviewee 9 to the 6th question (Table 11), they aim to open more physical stores and grow as a company. This shows that some interviewees are not concerned about their production rates and saving resources but to keep on growing and producing "sustainably". This shows the antagonism between their vision and the steps to reach circularity.

With all the methodological approaches it was conceivable to draw the necessity of a holistic vision of circularity in the fashion industry, connecting the knowledge of the concept with applicable and effective measures.

Furthermore, it is essential to mention the 12th Sustainable Development Goal (SDG) presented by United Nations: "Responsible Consumption and Production". This SDG is directly aligned to reach circularity in the industry, mentioning the need to reach sustainable management and have efficient use of natural resources till 2030. Besides, it also refers to the need to promote sustainable practices in public shopping, guaranteeing that people are well-informed and conscious about sustainable devolvement. This links back to the conceptual model of "education and awareness" practices (Figure 29) outlining its importance and the need to guarantee knowledge sharing in this theme.

4.11 Methodological Reflections

The present study integrated a multitude of different approaches to obtain both qualitative and quantitative results, as explained in the previous chapter. This combination of methods allowed us to get insights and identify important aspects to be developed in the future. However, it was also possible to identify adversities along the process, that could be used for future improvements.

During the development of the literature review, it was a chance to observe that there is a lot of information related to both the circular economy and the fashion industry. However, when the same keywords were inserted in different databases the disparity in the number of results available was visible. This observation hindered the process of filtering the presented scientific articles since there were either too many articles (e.g over 2 000 in Science Direct) or too specific.

It is also important to emphasize that in a so practical topic, with a mixture of brands and approaches, it was found interesting to complement the found articles with information from recognized organizations in this area, such as Ellen Macarthur Foundation.

Regarding interviews, the biggest adversity faced consisted of contacting directly the brand's top management. Out of the 41 contacted brands (excluding the fashion activist), only 12 replied, out of which 9 were interviewed. It is also important to mention that 4 interviews were presential. On the other hand, the interviewing process was effective and the interviewees were open to answering all of the asked questions and adding comments and information multiple times.

For the surveys suffer more difficulties since it was attempted to ask employees during working hours. Thus, they were less flexible to answer the inquiry in both shopping centers.

The fact that the surveys of these multinational brands were only made in Portugal might be an influencing factor since the sample does not include a worldwide scale. In this case, it would have been beneficial to have a sample on a wider scale to have accurate results on the circular approaches of the top management of the brands.

The process of conceptual model development was marked by the difficulty of the concepts segregation requiring, therefore, a stage for the accurate identification and definition of each.

Finally, the case study data analysis was characterized by the difficulty of applying strategies that are, in a way, qualitative in an LCA which is a quantitative process. For this reason, some of the chosen strategies, in the beginning, had to be adapted to possibly calculate the reduction of emissions.

5 | CONCLUSIONS

5.1 Synthesis of contributions

The present study permitted the gathering of both perceptions from the sector and quantitative conclusions of four circular strategies.

Regarding the initial research of the literature review, it is possible to affirm that the concept of circular economy in the fashion industry is growing, since there are a lot of recently published articles related to this topic. However, it was difficult to find articles that made the connection between circular economy strategies and the impact they have on emissions.

According to top management, the size of the company is not necessarily an influencing factor when it comes to knowledge of the value chain. This means, for example, that independently of the size of the value chain companies can know what happens to the waste in the different stages, as well as, influence their suppliers. Also, it was noted that smaller brands might have a more accurate perception of circular economy than the bigger ones.

Collaborators' perceptions allowed the understanding of multinational brands' approaches towards circularity. More than half of the interviewed brands had training about their sustainability, showing care when it comes to the collaborators' knowledge on the topic. It was also concluded that the average price of the sold garments does not influence the investments/amount of sustainability/circularity approaches. Another aspect to highlight from the collaborators' perceptions, was the fact that most collaborators didn't know what happened to the garments after being sold in outlet. This means that the collaborators aren't aware of what happens at the end-of-life treatment stage, being this process still unknown for most multinational brands.

Regarding the conceptual models, these were made not only as a tool for further studies but also to understand the interrelations between policies, strategies, actions, and education approaches. In the policies model, it was concluded that the value chain stage that might have the biggest influence on policymaking is the first ("Raw material processing") followed by the "End of life treatment" stage.

With the strategies model, it was possible to conclude that most strategies implied adjacent stages of the value chain and the majority of interrelations were of "support", which means that even though most strategies are not dependent on each other they still can be

implemented through support systems. This is, the implementation of a determined strategy can be a driving force to implement another.

The actions model had the particularity of its essence since actions can be considered means to accomplish strategies. In this model "use" phase was not only the most present one but also it is directly linked with the "end of life treatment" which is key for circularity. In summary, the adoption of "use" actions will facilitate strategies related to "end-of-life treatment".

Regarding the education and awareness model, it was possible to note that 3 of the educational/awareness practices are related to all of the value chain stages, outlining the importance of the knowledge throughout the value chain. In general, from one conceptual model to another it was observed that the relevance/presence of each value chain stage varies according to the model's type (strategies, actions, policies, education, and awareness).

Concerning the case studies, out of all analyzed strategies, it was possible to identify the most effective one, which is "Resource-efficient production". However, it is important to underline that more than one strategy can be applied simultaneously to decrease emissions and promote circularity.

Additionally with the calculations presented it was also possible to confirm the expected, this is: all of the chosen strategies cause a reduction of emissions, more specifically, over at least 5%. However, it is important to mention the fact that the quantitative analysis was a small sample of the reality that is quantifying emissions for the circular economy of the industry in question, not being possible to reach every strategy or solution mentioned. Further studies are needed to support this sort of calculation.

5.2 Conclusions

Given the methodology adopted and the reflections made throughout the whole process of the present dissertation, it is possible to affirm that the circular economy within the fashion industry is a complex system and requires multiple decision processes. Decision process such as: which are the best strategies to adopt; which value chain stages could be prioritized for circularity; what is the best zero waste-emissions solution, among many others…

Besides, considering the diversity of parties that are included in the circular system it is important to corroborate the necessity to guarantee that these parties are aware and have knowledge of the multiple variants that circularity includes. All the actors mentioned are part of the fashion industry, which means that their perceptions and approaches to circularity might have an impact not only on each other as parties but also on the effectiveness of circular approaches. These actors go from top management, brand administrates, and politicians to in-store collaborators and outsourcing companies that constitute part of the value chains (e.g interviewee 2).

All of the used methods also permitted the understanding that there are numerous paths to circularity, being these through policies, strategies, or actions, dependent on the circular

education and awareness practices, which serve as fundament. Furthermore, these paths demand a clear understanding not only of the circular economy concept itself, but also of the connections between each other, with a focus on the principles presented by EMF that are the pillars of the concept in question ("Phase out substances of concern and microfiber release"; "Transform the way clothes are designed, sold, and used to break free from their increasingly disposable nature"; "Radically improve recycling by transforming clothing design, collection, and reprocessing"; "Make effective use of resources and move to renewable inputs")

Finally, the dichotomy of emissions vs materials not only poses in question the effectiveness of determined strategies but the choice, in some cases, of saving resources over emissions and vice-versa. The study of these two variants is also dependent on multiple factors as was proved in the experts and top management interviews and case studies: the size of the value chain; the amount and type of materials involved; the prioritized strategies for circularity; collaboration and cooperation of outsourcing companies, and several others… For this reason, a solution to be considered is the possibility of the development of tailor-made approaches for companies.

5.3 Limitations

The contact with brands top management of multinational and national brands was a barrier to having an accurate perception of their approaches to the conceptual models' development. For this reason, the survey approach was adopted to have a wider sample, since multinational brands represent an important role in the industry.

Given the lack of available information regarding the interrelations between policies, strategies, actions, and education/awareness practices the interrelations in the presented models have a high level of uncertainty. This interrelation was defined according to the author's perceptions given the developed work in the literature review, interviews, and surveys.

Finally, it was possible to notice the difficulty of choosing quantifiable strategies for circularity, which had to be adapted to analyze their associated emissions in the case studies.

5.4 Future work

From an overall perspective, it would be useful to have complementary studies regarding the economic implications of the proposed strategies to understand their investment viability. Also, there is still the need to study further this interrelation, since in the present study only four strategies were analyzed.

An additional conclusion from the present study is that there's a need for knowledge sharing in the context of circular economy. The knowledge can also promote collaborations between companies, which is one of the most important strategies mentioned. Collaborations between brands not only promote synergies for the circular economy but also unanimous

consciousness of the topic. Another aspect to consider in future studies would be a participatory evaluation of the interrelations between the elements in the conceptual model, to reanalyze their accuracy.

It is important to emphasize the importance of sustainability certificates (ISO 14001 or EMAS) as tools to guarantee the monitoring of the progress of the applied strategies for circularity. In addition, it is also recommended that brands try to understand their customer's behaviors to make sure they have “long-lasting products” and are well-informed on how to take care of them.

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A | APPENDIX

Appendix 1- Principles for circularity (1- Raw material Processing; 2- Production of fabric; 3- Garment Manufacture; 4- Distribution and storage; 5- Use; 6- End of life treatment)

	CE Approach	Description	Source	Value Chain Phase
Principles	"Phase out substances of concern and microfiber release"	Frequently textile products include substances and microfibers that during the washing process or equivalent can be released to water courses, such as rivers and ultimately oceans	Ellen MacArthur Foundation, 2017	1; 2
	"Transform the way clothes are designed, sold, and used to break free from their increasingly disposable nature"	This consists on the application of strategies along the value chain that promote the long usage of products instead of their fast disposal	Ellen MacArthur Foundation, 2017	3; 4; 5
	"Radically improve recycling by transforming clothing design, collection, and reprocessing"	This consists on finding ways to approach the end of life of textile products (more specifically garments) in order to recycle them efficiently	Ellen MacArthur Foundation, 2017	3; 6
	"Make effective use of resources and move to renewable inputs"	Lower the consumption and associated impacts of resources during the garments production (e.g energy, water etc…)	Ellen MacArthur Foundation, 2017	1; 2; 3; 4; 5; 6
	"Reversing the overproduction and overconsumption of clothing: driving fast fashion out of fashion"	Encouragement of a new paradigm of new alternatives to change fast fashion trends . The re-shape of consumers purchasing habits has to start with the provision of circular business models (e.g product as service)	European Comission 2022	1; 2; 3; 4; 5; 6

Appendix 2- Policies for circularity (1- Raw material Processing; 2- Production of fabric; 3- Garment Manufacture; 4- Distribution and storage; 5- Use; 6- End of life treatment)

	CE Approach	Description	Source	Value Chain Phase
Policies	"Supporting research, innovation and investments"	Enhancement of research, innovation and promotion of investments within the sector to promote sustainable growth.	EEA 2019	1; 2; 3; 4; 5; 6
	"Tax on resource use & environmental impacts"	This policy involves collaborations between companies such as donations, innovations and reuse	EEA 2019	1; 2; 3
	Support and Investment funding for shared use management in startup and SME	This policy aims to encourage small and medium size enterprises to have shared systems in order to promote the longer use of materials/products	EEA 2019	5
	Reduced VAT on sharing Legal Support	Encouragement of shared services/businesses with the reduction of the Value Added Tax	EEA 2019	5
	Reuse as a Product: Reduce VAT in second hand; Competion support to second hand stores	Promotion of second hand services/businesses with reduction of the VAT. Encouragement of the competition between second hand stores	EEA 2019	5
	Sepparated Collection Obligations	This policy consists on the implementation of obligations to separate the generated waste	EEA 2019	6

CE Approach	Description	Source	Value Chain Phase
Quality Requirements for recycled fabrics	Often the recycling process of fabrics and even the fabrics themselves might not be as sustainable as expected (e.g emissions; water pollution; waste generation)	EEA 2019	1; 6
Taxes and bans on incineration and Landfill	The incineration and landfill process are some the most threatening processes of the textile products lifecycle. Therefore one the solutions to avoid the occurrence of these processes is to either tax or ban them	EEA 2019	6
Resource taxes on new fibers	The application of taxes on new fibers helps to avoid the extraction of new raw materials	EEA 2019	1
Use of recycled fabrics	Encouragement of the usage of recycled fabrics on the first two stages of the value chain	EEA 2019	1
Sustainable sourcing labelling	In order to help the consumers have awareness and consciousness about their purchases it is necessary to label the products with viable sustainable labels	EEA 2019	1; 2; 3
Durability standards	During manufacturing processes it is essential to guarantee the durability of the materials used	EEA 2019	3
Ecodesign guidelines	This policy serves for encouragement of the "designed to last" purpose	EEA 2019	1; 2; 3; 4; 5; 6

Appendix 3- Strategies for circularity (1- Raw material Processing; 2- Production of fabric; 3- Garment Manufacture; 4- Distribution and storage; 5- Use; 6- End of life treatment)

	CE Approach	Description	Source	Value Chain Phase
Strategies	Local Production	The adoption of a local production reduces emissions associated with transports	EEA 2019 & Interviews	2; 3
	Production on demand	Production on demand avoids the overproduction and, therefore, the generation of unnecessary waste	EEA 2019 & Interviews	2; 3
	Resource efficient production	The resource efficient production strategy reduces the usage of energy, water and raw materials.	EEA 2019 & Interviews	2; 3
	Renting and leasing services/ Sharing platforms	This strategy promotes the purchasing of secondhand products instead of the production of new ones	EEA 2019	5
	Long-lasting Products	The durability of garments is essential since the necessity to buy many times comes from the lack of quality/durability of the already purchased products	EEA 2019 & Interviews	5
	Maintenance services	The maintenance of garments supports their durability and consequently reduces the need to purchase new products	EEA 2019 & Interviews	5; 6
	Repair Services	The repair of garments supports their durability and consequently reduces the need to purchase new products	EEA 2019 & Interviews	5; 6
	Take back and Resale	The "take back" and resale campaigns encourage the circularity of the industry	EEA 2019 & Interviews	4; 6

Collection systems- Manual & automated sorting	The collection systems facilitate the process of reprocessing of materials to be reused	EEA 2019 & Interviews	6
Reuse of fabric/Upcycling/Yarn respinning	Reusage of materials in order to maintain them within the cycle	EEA 2019 & Interviews	1; 6
Personalization	The personalization allows the costumer to get attached to the product and also to fit the costumer's needs. Therefore, they might keep the products longer, since it has a personal meaning	EEA 2019 & Interviews	3
Collaboration between brands	The collaborations between brands allow them to have sharing systems and close cycles within the industry saving, consequently, resources	Dragomir & Dumitru 2022; Interviews	1;2;3;4;5;6
Comparison beteewn companies in order to progress	The knowledge sharing systems and platforms help brands to grow sustainably together	Interviews	1;2;3;4;5;6
Better management of the "Dead stock": reusage/resale	Instead of sending "Deadstock" for sale and storage and, subsequently, landfill or incineration, brands should guarantee the reusage of the materials	Interviews	6
"Pickup option" of the value chain raw materials	This can be seen as an option of transport for brands. This means, companies can either chose to pick up the needed resources by their means of transport or choose the delivery options (e.g sea transport; rail etc...). This can be a strategy for circularity if the "pickup" system is associated with the reusage of materials	Interviews	3;4
Costumer understanding	Understanding the needs of the consumer in order to help them fulfill their necessities and keep their products longer	Piippo *et al.* 2021	3;5
Future-fit products	Creation of products that are thought to last through generations	Piippo *et al.* 2021	3

	Functionality	The functionality of a product makes it useful and therefore last longer	Piippo *et al.* 2021	3
	Labeling the average product's duration (price related)	This strategy informs the costumers about the durability of the product they are buying helping them with their purchasing decision, regarding the relationship between price and durability	Interviews	3,4
	Costumer return voucher or contribution for R&D	Incentive for consumers to return their products and help with new to technologies to promote circularity in the sector	Interviews	6

Appendix 4- Actions for circularity (1- Raw material Processing; 2- Production of fabric; 3- Garment Manufacture; 4- Distribution and storage; 5- Use; 6- End of life treatment)

	CE Approach	**Description**	**Source**	**Value Chain Phase**
Actions	"Stopping the destruction of unsold or returned textiles"	This action is more specifically a policy that obligates large fashion brands to publish the number of products discarded and destroyed and correspondent treatment in terms of reusing, recycling, incineration or landfilling. Furthermore, the European Commission will also ban the destruction of unsold or returned items.	European Commission, 2022	6
	"Introduction of information requirements and a Digital Product Passport"	This action involves the implementation of a "Digital Product Passport" which will be composed with information requirements on circularity and other key environmental aspects.	European Commission, 2022	1; 2; 3; 4; 5; 6; 7
	"Green claims for truly sustainable textiles"	This action aims for the empowerment of consumers for green transition, as well as rules that ensure the consumers knowledge about commercial guarantee of	European Commission, 2022	5

	durability and repair information at the sale point		
"Extended producer responsibility and boosting reuse and recycling of textile waste"	This action of the European Commission is focused on the producers responsibility for the generation of waste, being essential the decoupling the textile waste production from the growth of the sector	European Commission 2022	1; 6
"Ensuring fair competition and compliance in a well-functioning internal market"	This action promotes the necessity of structured and coordination and cooperation between national enforcement authorities and "streamline surveillance practices". This also includes support cross-border market and other surveillance practices within the EU	European Commission 2022	4
"Addressing the challenges from the export of textile waste"	This action addresses the export of textile waste to non-OECD (Organization for Economic Co-operation and Development) countries which would only be allowed "under the condition that such countries notify the EU their willingness to import specific types of waste and demonstrate their ability to manage it sustainably	European Commission 2022	4;5;6

Appendix 5-Policies and awareness practices for circularity (1- Raw material Processing; 2- Production of fabric; 3- Garment Manufacture; 4- Distribution and storage; 5- Use; 6- End of life treatment)

CE Approach	**Explanation**	**Source**	**Value Chain Phase**

Education and Awareness	Informing the consumer about reason for the pricing/Product background	Informing the consumer about the product they're buying helps them having awareness and consciousness about their purchases	Interviews	4
	Sustainability and designer education	This education method will generate awareness among designers to design for longevity	Interviews	3
	Design Knowledge Hubs	The education method will generate awareness among designers to design for longevity and easy access to information	Interviews	1;2;3;4;5;6;7
	Sustainability in materials education	This education method will generate awareness among designers and manufacturers to create products that last	Interviews	1; 2
	Demand for sustainable fibers	Sustainable fibers avoid the farming and extraction of new raw materials	EEA 2019	1; 2
	Waste separation and collection campaigns	Education of consumers to give back the unwanted or damage products to viable sources	EEA 2019	5; 6
	Revaluing handcraft	Handcraft not only helps local economies but also	EEA 2019	1;2;3;4;5,6
	Waste prevention campaigns	Education of consumers to not dispose product unnecessarily	EEA 2019	5; 6
	Promotion longer use; Repair skills DIY	This education method will generate awareness among consumers to keep their garments longer	EEA 2019 & Interviews	5; 6
	Mind shift from owning to sharing	Sharing systems help keeping the entire garment within the loop	EEA 2019 & Interviews	1;2;3;4;5;6

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