VILNIUS GEDIMINAS TECHNICAL UNIVERSITY

FACULTY OF MECHANICS

DEPARTMENT OF MECHANICAL AND MATERIALS ENGINEERING

Alessandra Atria

IMPROVEMENT OF PRODUCTION PROCESSES: ASPECTS OF SUSTAINABILITY IN THE FASHION INDUSTRY

GAMYBOS PROCESŲ TOBULINIMAS: TVARUMO ASPEKTAI MADOS INDUSTRIJOJE

Master's degree Thesis

Industrial Engineering and Innovation management, state code 6211EX056

Production and Manufacturing Engineering study field

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THE OBJECTIVES:

Tasks to achieve the goal:
- To analyse the theoretical aspects of improving the sustainability of production processes in the fashion industry:
- To carry out empirical research on improving the sustainability of production processes in the fashion industry:
- To develop a model for improving the sustainability of production processes in the fashion industry.

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Annotation

The aim of this thesis is to develop a framework to provide a structured approach for SMEs to integrate circular strategies in their product development processes, offering a practical and scalable model to transition towards a circular economy. The thesis structure consists in a comprehensive literature review, empirical research, and framework development. The examination of existing literature aims to build a theoretical background on the fashion industry and the role of circularity, including factors impacting successful implementation for product development, frameworks, tools, certifications and policies. The empirical study provides a comprehensive understanding of the current level of adoption of circular strategies among European fashion SMEs, considering their driving factors, challenges, and opportunities. Finally, the development of a framework is intended to offer a practical, step-by-step, and scalable model to guide SMEs in effectively implementing circularity in their operations, from the initial idea phase through production readiness, addressing the challenges identified in the research, such as cost, complexity, lack of clear standards, and limited expertise.

The thesis consists of 7 parts: Introduction, Literature review, Empirical research, Development of framework, Conclusions and Recommendations.

The thesis consists in 67 pages of text without appendixes, 17 figures and 12 tables.

Keywords: Fashion Industry, Product Development, SMEs, Sustainability, Sustainable Fashion, Circular Economy, Circular Strategies

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Pavadinimas	**Gamybos procesų tobulinimas: tvarumo aspektai mados industrijoje**
Autorius	**Alessandra Atria**
Vadovas	**Rolandas Strazdas**

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Anotacija

Šio darbo tikslas – sukurti struktūruotą modelį, kuris suteiktų mažosioms ir vidutinėms įmonėms (MVĮ) aiškų būdą integruoti žiedinės ekonomikos strategijas į jų produktų kūrimo procesus, siūlant praktišką ir lengvai pritaikomą modelį perėjimui prie žiedinės ekonomikos. Darbo struktūrą sudaro išsami literatūros apžvalga, empirinis tyrimas ir modelio kūrimas. Esamos literatūros analizė siekia suformuoti teorinį pagrindą apie mados industriją ir žiediškumo vaidmenį, įskaitant sėkmingam įgyvendinimui svarbius veiksnius: produktų kūrimo aspektus, esamus modelius, įrankius, sertifikatus ir politiką. Empirinis tyrimas suteikia išsamų supratimą apie dabartinį žiedinių strategijų taikymo lygį Europos mados MVĮ, atsižvelgiant į pagrindinius motyvuojančius veiksnius, iššūkius ir galimybes. Galiausiai, sukurtas modelis skirtas pasiūlyti praktišką, nuoseklų ir lengvai pritaikomą žingsnis po žingsnio vadovą, padedantį MVĮ efektyviai diegti žiediškumo principus savo veikloje – nuo pradinės idėjos iki pasirengimo gamybai, atsižvelgiant į tyrime nustatytus iššūkius, tokius kaip sąnaudos, sudėtingumas, aiškių standartų stoka ir ribotas kompetencijos lygis.

Darbas susideda iš 7 dalių: Įvadas, Literatūros apžvalga, Empirinis tyrimas, Modelio kūrimas, Išvados ir rekomendacijos.

Darbas sudarytas iš 67 puslapių be priedų, 17 paveikslų ir 12 lentelių.

Prasminiai žodžiai: Mados industrija, produktų kūrimas, MVĮ, tvarumas, tvari mada, žiedinė ekonomika, žiedinės strategijos

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INTRODUCTION

The fashion industry is the world's second largest polluter. The sector, primarily following a linear approach, according to the "take-make-dispose" model, leads to excessive resource use, pollution, and waste (de Aguiar Hugo et al., 2021). As reported by Aya Abdelmeguid et al. (2024), fashion accounts for 8-10 % of global carbon emissions (4 to 5 billion tonnes annually), contributes to roughly 20% of total world water waste, and each year produces 92 million tonnes of waste. Moreover, underutilized garments and poor recycling result in an annual loss for the industry of approximately $550 billion (Charter et al., 2023). The industry's insatiable desire for new trends leads to excessive consumption of resources and energy, exacerbating its environmental footprint (Aya Abdelmeguid et al. ,2024).

Being one of the most environmentally harmful industries, there is a need to shift from a linear economic model, where items are produced, utilized and ultimately discarded, to a circular economy (CE) model (Jacometti, 2019). CE aims to redefine growth by reducing reliance on finite resources and minimizing waste through smart design. It is built on three core principles: eliminating waste and pollution, keeping products and materials in use through reuse and recycling, and regenerating natural systems by preserving and enhancing renewable resources (Ellen MacArthur Foundation, 2017). However, despite the fact that some CE efforts are already in place across the fashion production chain, progress towards CE remains slow (de Aguiar Hugo et al., 2021).

The fashion sector employs around 1.7 million people across 176,000 European enterprises, with 90% categorized as small businesses. (de Albuquerque Landi et al. 2023). SMEs have a unique advantage in transforming traditional supply chains into circular models or building them from scratch (Piller, 2023). They have the opportunity to achieve their environmental goals and create meaningful impact through innovative business approaches, including autonomy in leadership, the ability to guide long-term planning and the development of supplier relationships. In addition, they have the freedom to try new concepts and experiment with different business models and materials, while pursuing design-led innovations for sustainability (European Commission, 2019). Moreover, the fashion entrepreneur plays a major role in implementing sustainability practices. In particular, early decisions are crucial to enable circularity, as the design stage accounts for

up to 80% of the total environmental impact (SH Tan et al., 2024).

The research problem. The absence of a standardized approach to circular design often creates confusion (SH Tan et al., 2024) and many businesses lack the resources or understanding required to effectively integrate them into their operations. The study revolves around the research questions: How are European SMEs in the fashion industry currently integrating circular strategies into their early-stage design and decision-making processes? How can circular strategies be integrated in product development among SMEs in the fashion industry?

The aim of the thesis. The purpose of this research is to develop a framework to provide a structured approach for SMEs to integrate circular strategies in their product development processes, offering a practical and scalable model to transition towards a circular economy.

Objectives. In order to achieve the purpose of this research, the following will be covered in this work:

1. To perform a theoretical analysis on improving the sustainability of production processes in the fashion industry.
2. To carry out empirical research on improving the sustainability of production processes in the fashion industry.
3. To develop a model for improving the sustainability of production processes in the fashion industry.

The study looks at how SMEs use circular strategies in their product development process, with a focus on sustainable design principles, material selection, waste reduction initiatives and policy incentives. Moreover, it identifies challenges and opportunities that these enterprises face when implementing circular practices as well as providing an analysis of existing tools and frameworks for effective strategies. After a detailed analysis, a circularity framework for SMEs in fashion is developed.

This research is carried out through a combination of a literature review and a mixed-methods study, incorporating both interviews and questionnaires to ensure a comprehensive understanding of the topic. The literature review explores various sources,

including articles, journals, books, and websites, with a focus on the definition of the fashion industry, particularly within the context of small and medium-sized enterprises (SMEs). It emphasizes sustainability in the sector, highlighting the growing importance of circularity in achieving sustainable fashion. The review also examines existing frameworks, tools, certifications, and policies that support the integration of circular strategies in the industry. Complementing this, a questionnaire aims to assess the current state of circular strategy implementation among industry stakeholders in a broader sense, and interviews offer deeper insights and a more nuanced understanding of the challenges and opportunities faced by industry players. Drawing on insights from the literature review and empirical data, and drawing from the analyzed frameworks, a structured model is developed to guide SMEs in effectively implementing circularity in their operations.

This master's thesis is structured in six parts, as follows.

Table 1. Thesis structure

Section	Description
1. Introduction	An overview of the research problem and objectives, background to the study, and research questions.
2. Literature review: Sustainable product development and circularity strategies in European SMEs	Examination of existing literature on fashion industry and the role of circularity, including factors impacting successful implementation for product development, frameworks, tools, certifications and policies.
3. Empirical Research: Circularity strategies in European fashion SMEs	Explaining research approach, questionnaire preparation, interviews, data collection tools and methods, and data analysis processes.
4. Development of Agile stage-gate circularity framework for circular NPD in fashion SMEs	Description of the model for implementing circularity strategies in the fashion industry.
5. Conclusions and recommendations	Summary of main findings and recommendations for future research.

Source: prepared by author

1. LITERATURE REVIEW: SUSTAINABLE PRODUCT DEVELOPMENT AND CIRCULARITY STRATEGIES IN EUROPEAN SMES

1.1. Overview

The fashion industry is a broad sector that can be classified according to a variety of criteria and perspectives. Thus, before digging into the topic, it is crucial to define what is meant by the term "fashion industry" and what aspects would be significant for this thesis.

1.1.1. The fashion industry: definition and classification

Fashion is a “cross-sector concept” that includes different industries, such as clothing, footwear, leather goods, jewelry, fragrances, and beauty products (Macchion et al., 2015). Accounting for 2% of the world’s GDP, it ranks as the fourth largest industry globally (Charter et al., 2023). Furthermore, fashion can be considered as any product or market where style plays a significant and influential role (Macchion et al., 2015).

The fashion industry is organizationally complex and supply chains can be extremely long, often involving numerous partners (Ashby et al. 2013). The clothing supply chain can be divided in different stages: it begins with fiber production, which includes cultivating, harvesting, and cleaning the fibers; followed by spinning, where fibers are converted into yarn; then weaving or knitting the yarn into fabric; next, the fabric undergoes dyeing and finishing processes; after which garment manufacturing takes place; and finally, the finished products are distributed to retailers and consumers. All of these levels can have ecological and social impacts, but at different degrees of intensity (Ashby et al. 2013).

A further classification can be made in terms of the number of employees. The industry can be distinguished in small, medium and large enterprises. Small and medium-sized enterprises (SMEs) have *fewer than 250* persons employed and can be further subdivided into:

- micro enterprises: *fewer than 10* persons employed;
- small enterprises: *10 to 49* persons employed;

- medium-sized enterprises: *50 to 249* persons employed;
- large enterprises: *250 or more* persons employed

(Eurostat, 2016).

While large companies often focus on improving specific products or processes, typically reshaping only parts of their supply chain, smaller companies are more likely to overhaul their entire supply chain, implementing practices that larger firms may struggle to adopt due to their scale (Cimatti et al., 2017). Moreover, compared to large companies, SMEs fashion businesses where sustainability is part of their core values, design managers may have far more ability and agency to lead a more innovative design process (Claxton et al., 2020).

1.1.2. Industry Impact

The sector is considered one of the most polluting industries in the world, often cited as the second largest polluter, impacting the environment through various interconnected issues, including its massive carbon footprint, extensive water waste and pollution, contribution to plastic pollution, generation of waste, and poor recycling. (Charter et al., 2023)

Over the last 15 years, the production of clothing has roughly doubled, thanks to an expanding global middle class and increased per capita purchases in developed nations. The change of market is mainly due to the rise of 'fast fashion', which includes short-lived trends, multiple collections released annually, and, in many cases, lower prices. (Ellen Macarthur Foundation, 2017).

One of the fashion industry’s major impacts is its carbon emissions. About 10% of carbon dioxide (CO2) emissions worldwide are caused by the fashion industry (Aya Abdelmeguid et al., 2024). Two- thirds of the 2.9 Gt of CO2 produced worldwide by the fashion industry is attributed to the manufacturing process. If the trend continues, by 2050, the industry's carbon emissions are expected to reach 26% of global emissions per year (Charter et al., 2023). Just in 2018, the worldwide fashion business produced around 2.1 billion tonnes of greenhouse gas (GHG) emissions, accounting for 4% of the global total (Ellen MacArthur

Foundation, 2021).

In this context, the textile sector is one of the most harmful ones, due to intensive resource consumption and the dependence on natural fibers from crops as well as synthetic fibers from fossil fuels. The production of these fibers requires a lot of land, water, and energy, resulting in a substantial environmental impact (Cimatti et al., 2017). For instance, the typical European produces 12 kg of textile waste annually and consumes 26 kg of textiles. This needs 15 times more resources by weight to create (Circularity Gap, 2024). It is worth noting that the production of roughly 1 kg of textiles emits 20 kg of CO2 (Ellen MacArthur Foundation, 2017). More in specific, the dyeing and finishing processes, involving heavy use of chemical products, are the most environmentally damaging. Each year, about 28 billion kilograms of textiles are dyed, contributing to around 20% of wastewater pollution (Charter et al., 2023).

Moreover, the textile industry is responsible for producing plastic that ends in the ocean. Every year, approximately half a million tons of plastic microfibers released during the washing of plastic-based textiles, such as acrylic, nylon, and polyester, end up contaminating the ocean (Ellen MacArthur Foundation, 2017).

Waste also represents an area of major environmental impact in the sector. Around 73% of materials are lost after garments are used, 10% during production, 2% from unsold stock, and another 2% during collection and sorting. Every second, the equivalent of one garbage truck filled with textiles is either sent to landfill or incinerated (Ellen MacArthur Foundation, 2017). And to worsen the situation, estimates suggest that only less than 1% of textile materials are repurposed into new clothing, with post-use recycling possibly below 0.1%, leading to significant value loss and high disposal costs (Ellen MacArthur Foundation, 2017). However, the European Waste Framework policy has initiated some structural changes, as some countries have implemented national policies, but the process remains slow (European Commission, 2025).

Social concerns are also central to the industry, including unfair wages and poor working practices. In a complex supply chain, where everything is mostly outsourced, the

production is often based in countries like Bangladesh and China, where workers earn respectively as little as $94 and $332 a month (Odabasi et al., 2022). Numerous recent controversies, including the Dhaka catastrophe in 2013, in which around 1200 people were killed when a clothes factory collapsed, have had a detrimental influence on fashion businesses while also raising awareness of social issues like workplace safety and labor conditions. Furthermore, efforts from non-governmental organizations (NGOs) like Greenpeace, highlighted various human rights violations and environmental harms within the fashion industry, increasing customers' and companies' interest in sustainability (Macchion et al., 2018).

Although awareness of these environmental and social issues is increasing, the fashion sector has been relatively slow to engage with the sustainability agenda. However, there are increasing efforts from industry, governments, and consumers to foster more sustainable practices. Achieving sustainability requires addressing both environmental and social aspects, and this can be challenging in a globalized industry with varying regulations and standards. In this scenario, sustainable fashion emerges as a response to these problems, aiming to create a more responsible system (Erminia D'Itria & Reet Aus, 2023).

1.1.3. Sustainable fashion

Over the last few decades, the term "Sustainability" has been a common phrase in discussions regarding global development. In the 1987 Brundtland Report, Our Common Future, the World Commission on Environment and Development (WCED) defined sustainability as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 2025). Despite the fact that there have been several definitions of sustainability over the years, this is still one of the definitions that is most frequently used (Ashby et al. 2013). Furthermore, sustainability can be considered by three main dimensions, also known as the three pillars of sustainability: ecological or environmental, social and economic sustainability (Cimatti et al., 2017).

Sustainability represents a significant challenge in the fashion industry. The correlation between sustainability and fashion lies in applying the principles of sustainability to

address and mitigate the negative effects of the fashion industry along its full value chain. Nowadays, as the needs of the UN 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs) become more urgent, expectations on the fashion industry to improve sustainability across all areas of production are increasing. The aim of the fashion sector's emphasis on sustainability is to facilitate the fashion transition to a model of circular fashion that prioritizes social equity, job security, and seeks to minimize environmental impact by using resources efficiently and producing and consuming more sustainably (Jacometti, 2019).

The concept of sustainable fashion may appear paradoxical, as fashion inherently involves trends that fluctuate over time, as opposed to the long-term perspective of sustainability (Henninger et al., 2016). Nonetheless, the intersection between personal ethics and fashion is not a new concept. The first instances of sustainable fashion came from the 1980s and 1990s. Anti-fur movements began in the 1980s, followed by sweatshop scandals in the late 1990s. This led to increased social pressure on fashion businesses and retailers to improve factory supervision (Lundblad & Davies, 2016). Sustainable fashion evolved from a specialized sector into a mainstream and viable market in the early 2000s, owing to fashion companies' attempts to adopt more environmentally and socially responsible manufacturing approaches, including the use of ethically sourced, eco-friendly, and repurposed textiles (Valerio Schiaroli et al., 2024). In the most recent years, various firms have been active in exploring and advancing innovative eco-conscious materials, textile alternatives, and production techniques, such as bioplastics, vegan leather, lyocell, and plant-based dyes, providing a further expansion in sustainable fashion product offerings. (Valerio Schiaroli et al., 2024).

But what is sustainable fashion? Although there is no single definition of sustainable fashion, the concept is often associated with adjectives like “green”, “eco”, “slow”, “ethical”, and “sustainable" (Valerio Schiaroli et al., 2024). It is mostly connected with environmental sustainability, including the use of renewable and eco-friendly raw materials, minimizing carbon emissions, and promoting durability and longevity (Henninger et al., 2016). Sustainable fashion, in its broadest sense, addresses a broad spectrum of ethical and environmental concerns related to the manufacturing and

consumption of clothing, footwear, and accessories. (Lundblad & Davies, 2016). It represents a move towards creating a system that is capable of being maintained over the long term without depleting natural resources or compromising human well-being (Valerio Schiaroli et al., 2024). It involves a shift from market-based strategies to value-based ones, with circular economy (CE) emerging as a key model for solving supply chain sustainability challenges (Erminia D'Itria & Reet Aus, 2023).

1.2. Implementation of circularity

1.2.1. Circular Economy and Circularity in the Fashion Industry

The greatest challenge for the fashion industry lies in the fact that it mostly operates in accordance with a linear model (Erminia D'Itria & Reet Aus, 2023). This system is commonly known as the "take-make-waste" model (Jacometti, 2019), because it consists of a sequential process where raw materials are first extracted, then manufactured into garments, then sold to consumers, and, ultimately, they are thrown away (Charter et al., 2023).

Mass-market brands each year release up to 24 collections on average, leading to overproduction and significant waste, and 30% of the total garments produced remain unsold. At the same time, the quality of garments is declining, as brands rely on synthetic materials and focus primarily on maximizing production volumes (Circularity Gap Report, 2024).

The circular economy model emerged as a response to the traditional linear economic model. This model synthesizes several influential schools of thought, such as the functional service economy, biomimicry, Cradle to Cradle design, industrial ecology, natural capitalism and the systems-based blue economy approach. (Ellen MacArthur Foundation, 2017). The concept was first proposed by Walter Stahel in 1976, who suggested an "economy in loops" as an alternative to the linear model (Pillar, 2023). Building on this, McDonough and Braungart (2009) introduced the concept of cradle-to-cradle design, which emphasizes the need to design products in such a way that they can be continuously reused or recycled without losing value (Pillar, 2023). According to the

European Commission (2015) Circular Economy is defined as “where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized”. A circular economy seeks to reshape economic growth by reducing dependence on finite resources and minimizing waste through thoughtful design. It is based on three principles:

- **Design out waste and pollution:** Focusing on eliminating harmful effects caused by economic activities which can negatively impact human health and the environment, including water, land, and air pollution, greenhouse gas emissions, and structural waste.
- **Keep products and materials in use:** It encourages practices that help maintain the value of resources, like energy, labor, and materials. This means designing for durability, reuse, remanufacturing, and recycling. It also promotes using biodegradable materials in ways that allow them to be reused before they are returned to nature.
- **Regenerate natural systems:** It avoids using non-renewable resources and works to protect or improve renewable ones. For example, it supports practices like returning nutrients to the soil for regeneration or using renewable energy sources instead of fossil fuels.

(Ellen Macarthur Foundation, 2017).

The concept of circularity can be seen as the implementation of circular economy principles operationally (Charter et al., 2023). Essentially, the aim of circular fashion is to reduce the discard of materials and to keep resources circulating through the production and consumption cycle for the longest feasible time (Jacometti, 2019).

Achieving circularity requires considering the entire lifecycle of a product, creating durable products that are designed to be regenerated or recycled. This allows materials to flow back into the system, creating value across different supply chains (Erminia D’Itria & Reet Aus, 2023). Various circular strategies (CS) exist. Their goal is to keep products continuously circulating through reuse and recycling, minimizing reliance on natural resources and avoiding waste generation (Piller, 2023).

1.2.2. Circular Strategies in Fashion

R-Strategies represent foundation principles for circularity, outlining the methods and approaches by which circular economy is put into practice (Tan et al., 2024). According to the European Commission (2020), there are 9 different R-strategies, in order of priority:

Table 2. 9R-strategies

R1. Refuse	"Make product redundant by abandoning its function or by offering the same function by a radically different (e.g. digital) product or service" (European Commission, 2020). During the design phase this could mean avoiding using certain materials that could be harmful., like non-recyclable ones. The aim is to limit the consumption of resources in the first place.
R2. Rethink	"Make product use more intensive (e.g. through product-as-a service, reuse and sharing models or by putting multi-functional products on the market)" (European Commission, 2020). The goal is to reevaluate product designs and the business models in a more circular perspective.
R3. Reduce	"Increase efficiency in product manufacture or use by consuming fewer natural resources and materials" (European Commission, 2020). In the designing of products that could mean aiming for minimal material and. energy usage to reduce waste
R4. Re-use	"Re-use of a product which is still in good condition and fulfils its original function (and is not waste) for the same purpose for which it was conceived" (European Commission, 2020). In practice, design products that can be easily reused.
R5. Repair	"Repair and maintenance of defective product so it can be used with its original function" (European Commission, 2020). The aim is to design products with features that allow easy repairs.
R6. Refurbish	"Restore an old product and bring it up to date (to specified quality level)" (European Commission, 2020). The target of the designer is to make products that can be easily renewed or upgraded to extend their lifespan.

R7. Remanufacture	**"**Use parts of a discarded product in a new product with the same function (and as-new-condition)" (European Commission, 2020). The goal is to allow product or textiles to be reused in the production of new items.
R8. Repurpose	"Use a redundant product or its parts in a new product with different function" (European Commission, 2020). The mission is to design products that can be repurposed.
R9. Recycle	"Recover materials from waste to be reprocessed into new products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations" (European Commission, 2020). The purpose is to design garments with the intention of them being fully recyclable.

Source: prepared by author, based on (European Commission, 2020)

Additionally, **recovery** is often mentioned in combination with the 9Rs. Recovery means reusing waste and residues as a form of energy (European Commission, 2020). Nevertheless, the gains in resource efficiency through waste-to-energy and waste-to-fuel approaches are limited compared with the gains from the other 9Rs, especially considering the financial loss from the incineration of recyclable materials. Therefore, activities that focus only on using waste and residues for energy generation are excluded in the circular economy classification system (European Commission, 2020).

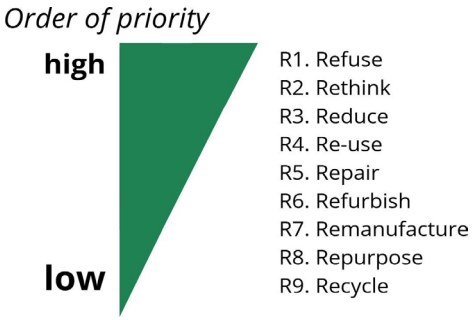

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Fig. 1. Hierarchical order of R-Strategies

Source: prepared by author, based on (Charter et al., 2023)

Although the 9Rs is the most complete framework, among the R frameworks that have been adopted by academics and experts, the 3R framework is the most widely recognized, while the 4R model, comprising reduce, reuse, recycle, and recover, forms the foundation of the EU Waste Framework Directive (Jacometti, 2019).

Table 3. Different R-frameworks

3R/4R framework	**6R framework**	**9R framework**
Reduce Re-use Recycle + Recover	Repurpose Direct Re-use Repair Refurbish Remanufacture Resynthesise	Refuse Rethink Reduce Re-use Repair Refurbish Remanufacture Repurpose Recycle Recover

Source: prepared by author, based on (SH Tan et al., 2024)

1.2.3. Circular approaches in the Fashion industry

But how can the 9Rs strategies be applied in the fashion industry? Although there is no clear answer to this question, there are different approaches that can help these companies for a more sustainable and circular product development. Among the responses to fast fashion, the slow fashion movement stands out as a push toward circularity. Slow fashion is often mistaken as the antithesis of fast fashion. According to Fletcher, K. (2010) it actually represents an entirely different perspective, with distinct economic principles, business models, values, and processes, with a new dynamic of power between fashion creators and consumers based on trust and more feasible at smaller scales.

The concept draws inspiration from the Slow Food movement (Italy, 1986) that aimed to connect the enjoyment of food with an understanding of its responsible production,

preserving cultural and regional traditions and diversity. In a similar way, slow fashion goes beyond just the concept of speed, focusing on small-scale production, traditional craftsmanship, the use of locally sourced materials, and local markets, aiming to keep the diversity (Cimatti et. al., 2017).

Slow fashion offers a meaningful alternative to the fast fashion model, by focusing on selling fewer items, often at higher prices. (Fletcher, K. 2010). Slow fashion directly addresses the environmental impact of the fashion industry by implementing strategies to slow material loops and reduce waste, which lowers the need for new resources and lowers emissions. It also slows the rate of new product production, allowing for more sustainable use and recovery of materials (Bocken et al., 2014).

Local production also emerges as a meaningful direction toward circularity. Companies embracing slow fashion practices usually have more local general infrastructures, use traditional craft techniques and local materials and produce smaller batch sizes (de Aguiar Hugo et al., 2021). In fact, producing locally can often mean making collections that utilizes garments created by local (small) designers or manufacturers, supporting the community empowerment and shortening the supply chain between creation and consumption (Valerio Schiaroli et al., 2024). The consideration of physical and social resources with a local character can lead to the idea of a "multi-local society" and a "distributed economy" in which, globally, there are a number of interconnected local systems. This economy, where items that cannot be produced locally are exchanged and shared, creates a society that is both local and cosmopolitan (Clark, 2008).

In terms of waste management, one reduction technique followed by some companies in the fashion industry is the zero-waste practice, whose aim is to minimize material waste during the production of garments. This includes using efficient fabric cutting techniques like patchwork to maximize material use. Additionally, this process can not only help reduce the consumption of raw materials and natural resources, but also eliminate harmful chemicals, such as dyes used in the finishing process. (de Aguiar Hugo et al., 2021).

Recognizing the growing global concern over textile waste, the EU launched the European

Clothing Action Plan to promote sustainability throughout the entire textile life cycle, from design to disposal. This initiative highlights the importance of shifting to a circular economy, with a strong focus on waste reduction (Jacometti, 2019).

1.3. Material Selection and the Role of Design

1.3.1. Design for circularity

The role of designers is central in creating a circular model for the fashion industry. Design decisions made at the initial stages significantly affect products throughout their entire life cycles. In fact, it is estimated that over 80% of environmental impacts are determined during the design and development process (Charter et al., 2023). Designers have the power to influence the production and consumption of the products. This includes meeting the customer's needs, taking in consideration the whole product lifecycle and selecting materials and manufacturing methods (Karell & Niinimäki, 2020). According to Ellen MacArthur Foundation (2021), designers need to create products that are physically and emotionally durable, and capable of being remanufactured or recycled after their lifecycle ends.

Designing for durability focuses on increasing a product’s lifecycle by addressing both the garment's style and its physical qualities (Valerio Schiaroli et al., 2024). It allows products to have extended lifespans through models like second-hand, vintage clothing, and product-services such as leasing or renting (Claxton et al., 2020). Physical durability plays a fundamental role in the effectiveness of circular business models. For example, Lacoste has implemented durability standards across its textile products through a dedicated durability protocol that considers customer usage patterns and concerns, and includes testing both individual materials and the final products to ensure long-lasting quality (Ellen MacArthur Foundation, 2021).

But to ensure that garments remain valued over time, it's not enough for them to be physically durable, they must also maintain emotional relevance. For instance, Nudie Jeans offers an interactive online platform where customers can share photos and stories of their worn jeans. This storytelling approach helps build a personal connection between the wearer and the maker (Nudie Jeans, 2025). In fact, emotional durability refers to the lasting

connection a consumer feels toward a product, influenced by qualities like timeless style, uniqueness, personal meaning, or a compelling history, and sharing stories about a product's origins can deepen this bond, while personalization services that tailor items to individual users can enhance their sense of ownership and long-term attachment (Ellen MacArthur Foundation, 2021).

In addition to physical and emotional durability, designers should focus on designing products so that they can be disassembled and their components and materials be remade or recycled into new products. Strategies such as *recyclability, upcyclability* and *refurbishment* all contribute to extending the life cycle of materials and components**.** A key principle that supports these strategies is *design for disassembly*. According to ISO 14021:2016, the aim is to design products with the intent of allowing components and materials to be reused, remade, or recycled. Upcycling, in particular, is a technique often used in the fashion sector. It is a way to repurpose leftover materials from production into new designs. The residual waste generated during upcycling can then be recycled, keeping materials circulating either within the fashion sector or passed on to another (Erminia D'Itria & Reet Aus, 2023).

1.3.2. Material Selection and Innovation

The environmental impact of a product is mostly determined by the materials used for its production. For this reason, an accurate and careful material selection can contribute to a reduced environmental impact. For instance, optimizing fabric cutting through efficient pattern use, as well as reducing or eliminating harmful chemicals in processes like dyeing and finishing can be all ways to minimize environmental impacts during the manufacturing stage (Claxton et al., 2020).

There are a wide range of fibers. Nowadays, the most used ones, making up 65% of global fiber production, are the synthetic fibers such as nylon, polyester and acrylic, given their low cost (Circularity Gap, 2024). Among these, polyester consumption has grown the most dramatically in the 21st century and has become the most commonly used textile fiber. Polyester is a synthetic fiber derived from petrochemicals, meaning it is fundamentally based on non-renewable fossil resources. Its production is also highly energy-intensive,

relying primarily on non-renewable energy sources. Similarly, the manufacturing of nylon fibers emits harmful environmental pollutants into the atmosphere, such as greenhouse gases and fine particulate matter (Shayan Abrishami et al, 2024). While avoiding their use can be entirely feasible due to their widespread adoption, extending their lifespan through reuse and recycling could help to reduce their impact (Circularity Gap, 2024).

On the other hand, natural fibers, including plant-based fibers like cotton and linen, man-made cellulosic fibers (MMCFs) such as viscose, and animal fibers like wool account for the remaining 35% of global production (Circularity Gap, 2024). Although these fibers are often praised for their biodegradability and lower environmental impact, air and water pollution have a negative influence also on natural fibers, throughout their lifecycle. For instance, cotton, being the most widely used natural fiber in the industry, uses 2.6% of the world's total water consumption, and on average its cultivation consumes 11% of global pesticide consumption each year (Shayan Abrishami et al, 2024).

Materials can be also recycled as a way to reduce the environmental impact. Recycled materials are generated from discarded materials that are processed through physical or industrial methods and transformed into new textiles and can be further distinguished in upcycled products and products from recycled waste (Valerio Schiaroli et al., 2024).

Another category of materials gaining increasing attention in the context of circularity is innovative materials. These emerging materials, often bio-based or derived from waste, could contribute to more sustainable production practices. For instance, Orange Fiber repurposes waste from orange juice production to produce cellulose-based fibers, QMILK utilizes surplus dairy by-products, AgraLoop transforms agricultural residues into cellulose-based fibers and EcoAlf converts used coffee grounds into textile fibers (Ellen MacArthur Foundation, 2017).

1.3.3. Ecodesign.

Eco-design (or environmentally conscious design) is an approach focused on reducing the environmental footprint of products and processes throughout their entire lifecycle, thus

aiming to lower resource consumption, minimize waste and emissions, while also encouraging the use of renewable resources and improving energy and material efficiency (Tejendra Singh Singhal et al., 2024). Basically, the environment is a focal point during the design decisions, and it is put on the same level as more traditional industrial values such as profit, functionality, aesthetics and quality. In some cases, it can even enhance traditional business values (Kuljanic, 2002).

In eco-design, Life Cycle Assessment (LCA) is widely regarded as the leading decision support tool, offering insights that help designers choose the most sustainable options from the earliest stages of product development (Cimatti et. al., 2017).

Eco-design has many benefits, but is also faced with several challenges in its practical application. Several factors need to be considered including environmental impacts, economic costs and social consequences, making it complex and challenging to apply. Moreover, for SMEs, the eco-design tools and resources are not often easily available or within their financial reach (Tejendra Singh Singhal et al., 2024). In the fashion industry, eco-design can be implemented by opting for sustainable materials like wool and cotton instead of synthetic fibers, and by choosing processes that minimize environmental impact, replacing harmful chemicals with natural alternatives (Cimatti et. al., 2017).

1.4. Tools, certifications and policies

1.4.1. Tools and indexes

When it comes to sustainability in the fashion industry, various tools and indexes have been developed to measure, guide, and drive better practices.

Lifecycle analysis (LCA) can be considered a useful tool to examine the whole fashion supply chain**,** giving designers criteria guidelines for selecting sustainable design strategies (Claxton et al., 2020). LCA evaluates the environmental impacts and resource consumption linked to the existence of products throughout their entire life cycle, from raw material extraction, through processing, manufacture, distribution, use, maintenance and repair, and disposal (Cimatti et. al., 2017). The accuracy of the LCA results depends mostly on how detailed and specific the data is. According to Charter et al., (2023), when

specific traceable data is used, the environmental impact results could differ by as much as 36%, highlighting how important it is to have good traceability in order to properly measure environmental impacts.

Regarding the integration of material choices in product development process, the Circular Design Guide, represents a practical toolkit specifically designed to support circular economy and sustainable design practices (Methods, n.d.). Developed through a collaboration between IDEO and the Ellen MacArthur Foundation, the guide offers research insights, techniques for defining problems, methods for generating ideas, and strategies for sharing solutions (IDEO Circular Design Guide, 2018).

Another relevant tool is Close the Loop. Developed by Flanders DC in 2018, it aims to speed up the shift toward a circular economy within the fashion industry and among other stakeholders, encouraging the adoption of various strategies and concrete actions. The tool examines six key stages in a garment's life cycle: 1) resources, 2) design, 3) production, 4) retail, 5) consumption, and 6) end of life. For each stage, it proposes five strategies that can help drive the fashion sector toward greater circularity (Flanders DC, 2025).

Moreover, several tools have been developed to assess and measure the industry impacts, one of which is the Higg Index. Created and managed by Cascale (Sustainable Apparel Coalition), a global non-profit network of over 300 brands, retailers, and manufacturers, it consists of five tools designed to evaluate and measure both the social and environmental performance across the value chain, as well as the environmental impacts of individual products (Charter et al., 2023). The five tools include: the Higg Facility Environmental Module (FEM), Higg Facility Social & Labor Module (FSLM), Higg Brand & Retail Module (BRM), Higg Materials Sustainability Index (MSI), and the Higg Product Module (PM) (Worldly, 2025). This tool can be particularly important for SMEs to measure their sustainability efforts.

1.4.2. Certifications and labels

Sustainability certifications serve as a valuable tool for demonstrating a company's commitment to environmental and social responsibility in its processes and products. Additionally, they can assist in introducing sustainability thinking in the planning stage

and definition of strategies and in the actual implementation (Rinaldi & Bandinelli, 2018). The following table, adapted from Rinaldi & Bandinelli (2018) summarizes some of the main certifications and labels for fashion enterprises.

Table 4. Certifications and labels

Certification name	Focus
OEKO-TEX®	Certifies that textile products are both chemically safe and sustainably produced.
Cradle to Cradle (C2C)	Reviews items based on material safety, material reuse, renewable energy consumption, emission and water management and fair labor practices. Based on lifecycle performance, five certification levels are awarded.
Environmental Product Declaration (EPD)	Offers certified, validated, and standardized data on a product's environmental impact throughout its lifecycle, based on ISO 14025 and LCA methodologies.
The EU Ecolabel	Voluntary certification encouraging environmentally responsible products and services in the EU, based on lifecycle analysis revised every 3 years.
The Global Organic Textile Standard (GOTS)	Certifies the organic status of textile products by evaluating the entire product lifecycle based on environmental and social criteria. To qualify for certification, at least 70% of the fibers must come from organic farming.
The Global Recycle Standard (GRS)	Examines the supply chain and implements environmental and social assessment criteria to ensure the quality of products made from recycled materials.
NATURTEXTIL iVN certified BEST	Created by iVN (International Association of Natural Textile Industry), it supports the evaluation of the entire supply chain of a textile product by assessing environmental and social indicators.

ISO 14001	Requires companies to build and maintain a structured Environmental Management System (EMS) to control environmental impacts and ensure continuous improvement.

Source: prepared by author, based on (Rinaldi & Bandinelli, 2018)

1.4.3. European Policies

Crucial for SMEs is also to navigate and understand the evolving regulatory landscape. In Europe, recent initiatives, such the Circular Economy Action Plans, have identified the sector as a key area for future policy development (Charter et al., 2023).

The Green Deal, presented by the European Commission (EC) in 2019, aims to make the EU climate- neutral by 2050 (European Commission, 2024). As part of the Green Deal, the EU launched the Circular Economy Action Plan (CEAP) in 2020, which focuses on making products, production, and consumption more circular and sustainable (Charter et al., 2023). Specifically, the objectives are to make all textile products in the EU market durable, repairable and recyclable, mainly composed of recycled fibers, free of hazardous substances, and manufactured in a way that respects both social rights and environmental standards (European Commission, 2022).

As part of the CEAP, in 2022 the EC introduced the Eco design for Sustainable Products Regulation (ESPR), which aims to set eco design requirements for products, including textiles (European Commission, 2022). An essential part of the ESPR is a new measure called Digital Product Passport (DPP), which is essentially a digital identity card for products, components, and materials. The information stored includes the product's technical performance, the materials and their origins, any repair activities, recycling capabilities and lifecycle environmental impacts (European Commission, 2024). The DDP is mandatory for every company that will manufacture or place products in the EU market and it is set to be fully required by 2030 (GS1, 2023).

Furthermore, the ESPR introduces a ban on destroying unsold goods. While this regulation is not yet fully implemented at the EU level, France has already taken action through Décret n° 2022–748 (The Anti-Waste Law for a Circular Economy [AGEC]), which prohibits producers, importers, and distributors from destroying unsold items, including

clothing and accessories (Charter et al., 2023).

In regards to waste management, the Waste Framework Directive sets the basic concepts and definitions including definitions of waste, recycling and recovery (Waste Framework Directive, 2018). The policy sets out core principles, including the requirement to manage waste in a manner that protects human safety and ecological systems. It also establishes the waste hierarchy as a guiding approach and requires that the costs of waste disposal must be covered by the current or previous holders of the waste, or by the producers of the original products that generated the waste (Jacometti, V. ,2019). In 2023 the EC proposed a revision to the WFD, introducing Extended Producer Responsibility (EPR) schemes for textiles in all EU Member States (European Commission, 2025). EPR is an environmental policy strategy where the responsibility of the producer extends beyond production and use, covering the product's post-consumer stage throughout its entire life cycle (Jacometti, V. ,2019). By 2025, every EU country is supposed to implement national policies in regards to waste management by 2025. Some countries already have policies implemented; some others are at risk of not meeting the target (European Commission, 2025).

1.5. NPD and Agile-stage Gate hybrid model

1.5.1. NPD

By embedding circularity and sustainability in early decision-making and design choices, fashion SMEs can significantly improve production outcomes and ensure alignment with future industry standards. In this context, it is critical to take in consideration New Product Development (NPD). This process involves several stages, including concept development, product design, prototyping, manufacturing, marketing, and other market-related activities. It typically involves multiple stakeholders such as customers, users, distributors, suppliers, intermediaries and competitors. Companies can form various types of collaborations such as strategic alliances, shared research projects, joint ventures, informal and social networks, competitions, and cooperative initiatives (Rinaldi & Bandinelli, 2018).

NPD in SMEs differs significantly from the ones of larger companies. According to Iqbal, M., & Suzianti, A. (2021), SMEs' NPD practices are characterized by low levels of

formality, informal strategic planning, limited resources, and centralized decision-making. They require adaptable and user-friendly design methods, must manage constantly changing priorities, and proactively anticipate risks and challenges. Despite these limitations, they possess the potential for high agility and adaptability.

1.5.2. Agile-stage Gate hybrid model

Given the flexibility of fashion SMEs, the Agile-stage Gate model, developed by Cooper, R. G., & Sommer, A. F. (2016), can be analyzed as an NPD model. Stage-Gate is a comprehensive system of “idea-to-launch system” and macro-planning, while Agile is a micro-planning project management methodology (Rinaldi & Bandinelli, 2018).

Agile encompasses a set of software development approaches built around iterative and incremental processes, where requirements and solutions develop through collaboration among teamwork among self-managed, multidisciplinary groups. In practice, it typically involves a series of short cycles called sprints, each carried out by a project team. The outcome of each sprint is a functional product that can be showcased to stakeholders, such as customers (Cooper, 2016).

In contrast, the Stage-Gate process is a structured approach to NPD that aims to avoid investing resources in projects with low potential. The development journey is divided into multiple phases called stages, that are each separated by a decision checkpoint called gate where the project's continuation is reassessed with go/kill decisions (Vedsmand et al., 2016).

In the hybrid model proposed by Cooper and Sommer (2016), agile methods are added into the development and testing stages of the traditional Stage-Gate process. The structure of Stage-Gate stays the same except that for developing physical products, Agile-Stage-Gate uses "sprints" similar to those in Agile-Scrum (used in IT). During each sprint, teams build something, test it, get feedback, and revise it to make the product more flexible and better aligned with customer needs (this feedback is called Voice of the Client, or VoC). At the end of each sprint, teams must show a working version of the product to customers and management. Moreover, visual tools like charts and diagrams help the team stay organized and show progress (Cooper & Sommer, 2016).

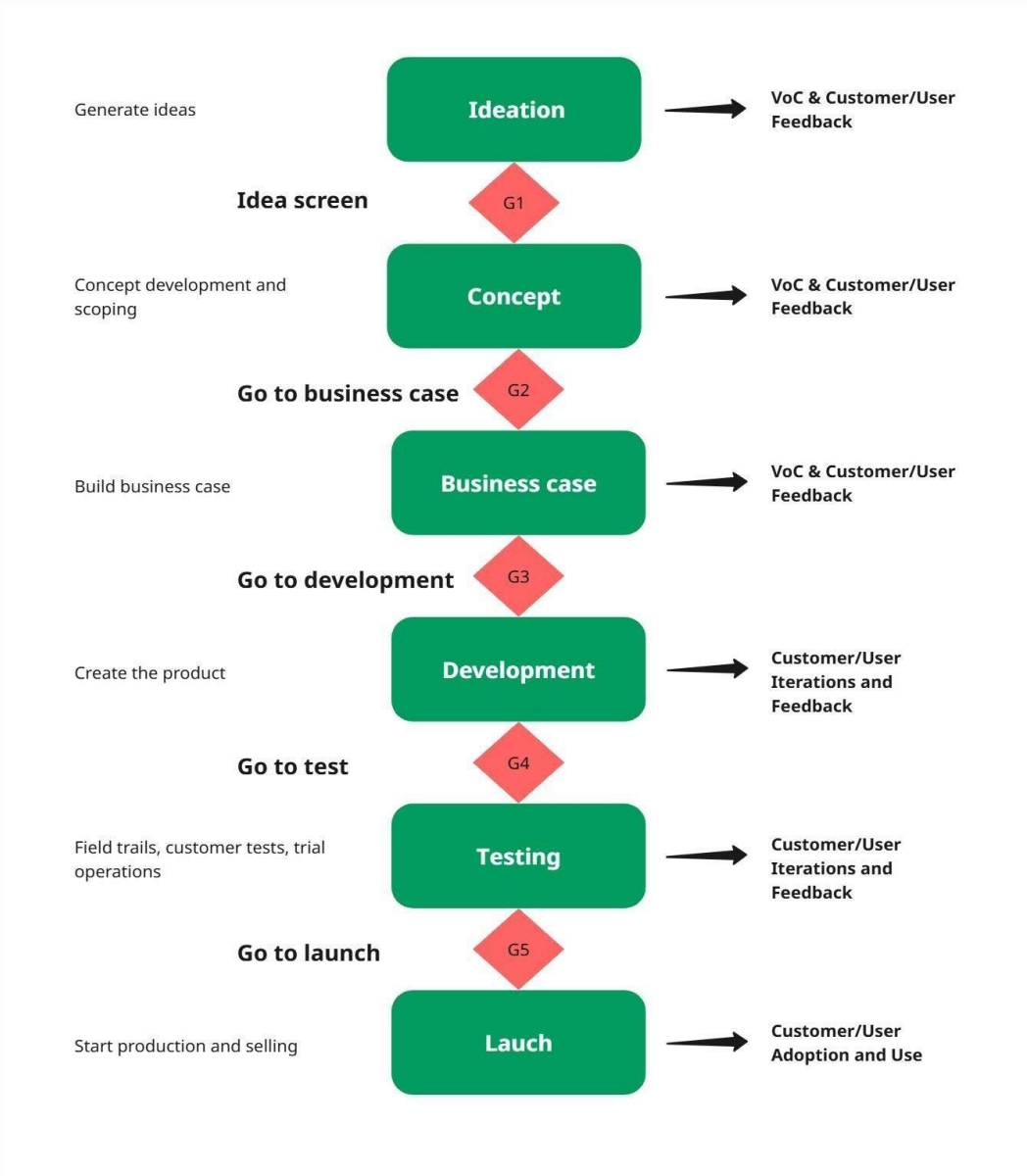


Fig. 2. Simplified Cooper and Sommer Agile stage-gate model

Source: prepared by author, based on (Cooper and Sommer, 2016)

According to Cooper & Sommer, (2016), a study of five leading Danish manufacturing companies that adopted Agile–Stage-Gate hybrid models found increased design flexibility, improved productivity, communication and coordination within project teams, stronger project focus, better prioritization and higher team morale. For SMEs, agile production can support collaborative design and decision-making with consumers, promoting greater sustainability (Charter et al., 2023).

2. EMPIRICAL RESEARCH: CIRCULARITY STRATEGIES IN EUROPEAN FASHION SMES

2.1. Research methodology

This research is implemented by conducting a literature review and a mixed methodology study, using both questionnaires and interviews. As the foundation of the research, the literature review establishes the broad context of the research, delimiting what is and what is not included in the research, and justifying those determinations (Boote & Beile, 2005). The literature review therefore sets the theoretical background of the fashion industry, focusing on European SMEs, and analyzing the role of circularity in product development, including factors impacting successful implementation, frameworks, tools, certifications and policies. Using the mixed-method approach, based on the sequential exploratory approach made possible to explore the research questions through different, complementary methods. The expert interviews contained only a handful of detailed and nuanced descriptions, while, the survey broadened the study pertained to brief concise answers and more numerical evidence (Karell, E., & Niinimäki, K. ,2020). While surveys capture *what* is happening across a sample, interviews explore *how* and *why*. Moreover, since the study's topic is relatively sensitive and companies may feel that their practices are being evaluated in some way, the survey was created with a view to minimize barriers for participation and allow companies for their anonymity (Karell, E., & Niinimäki, K. ,2020). The combination of both ensures a comprehensive understanding on the current level of adoption of circular strategies among European SMEs, considering driving factors, challenges and opportunities, and sets the bases to construct a guiding framework. Due to a lower response rate across interviews and surveys, additional secondary data was collected in the form of 24 sustainability reports. The reports were found via online research and prior contacts (e.g. some companies that did not directly participated in the study but suggested to analyze their reports).

Literature review, questionnaires, interviews and secondary data were gathered and built around 4 different sections, following the same pattern to better draw conclusions:

- SECTION 1: Overview
- SECTION 2: Implementation of circular strategies

- SECTION 3: Material Selection and role of design
- SECTION 4: Tools, certification and policies

An additional section in the literature study on NPD and Agile Stage-Gate provides the analysis of a structured model providing a basis for the development of the proposed framework.

2.2. Data collection process

The literature review aims to build a theoretical foundation on the implementation of the circularity strategies on product development in fashion SMEs, with an emphasis on the early phases of the decision-making process. Relevant information was gathered through systematic searches in databases like Google Scholar, Web of Science, and Scopus using keywords such as sustain*, circular, fashion, assess, criteria, process, eco design.

A questionnaire was designed to provide a structured method to gather valuable insights in understanding the current implementation of circularity strategies in fashion SMEs. The companies were searched mostly through sustainability-focused online groups, social media platforms such as LinkedIn and Instagram, fashion-related websites, and personal networks. In addition, approximately half of the respondents were Italians, as many were located using an Italian search engine. Most companies were contacted directly via email, while a few were reached through social media. The questionnaire was created using Google Forms and gave all respondents anonymity in the survey process. It consisted of 17 multiple choices questions, developed following the structure and the content of the literature review and revolving around common themes found, such as reasons for implementation of circular strategies and opportunities and challenges.

In addition to surveys, two semi-structured interviews were held with the CEOs of fashion SMEs and an additional written interview was gathered from one participant that, due to time constraints, couldn't participate to a proper interview. The interviews were recorded and transcribed and each interview was between 30 to 60 minutes long. To properly gather information, the interviews were structured around an interview guide. Following the questionnaire, the guide was structured in 17 open end question that aimed to investigate

more in detail how these companies implement circular strategies in their product development process.

2.3. Results and Analysis: Survey based findings on circularity strategies in fashion SMEs

The questionnaire was sent to 100 different European SMEs in the fashion industry that identified themselves as sustainability-oriented. Nonetheless, the response rate was very low, with only eight companies participating. This indicates low engagement or interest from the majority of companies surveyed and could be attributed to multiple factors, such as having no perceived benefit from participating in the questionnaire or avoiding to share information, even anonymously, due to concerns of being exposed or judged, especially if their sustainability claims do not fully align with their actual practices. Moreover, as a reason for not taking part, a few non-respondents also cited a lack of time and resources.

2.3.1. Overview

7 out of 8 respondents were CEOs, while 1 respondent was an Operation Manager. This shows a **genuine commitment** in these few companies, and suggests that in regards to circularity strategies the decisions are likely to be driven from the top. This is further supported by an additional survey response indicating that in all cases, the CEO holds the most influence over sustainability and circularity decision.

Moreover, **all the respondents came from micro-enterprises** (1-9 employees). This could indicate that when it comes to a smaller company, management level could be more directly involved in day- to-day operations, making it easier for circularity to be a strategic part into the core of business practices. Moreover, it may also reflect that, compared to larger companies, smaller companies have more flexibility and ease in adopting circular strategies.

In terms of business activity, there was some overlap, as some companies were involved in multiple product categories. Multiple choice option was given to the companies and as a result **4 companies produced clothing**, **2 footwear**, **6 accessories**, **1 textile,** and **1**

lifestyle products. This data gives the survey a wider range of perspectives across the industry, although the small sample size limits broader conclusions.

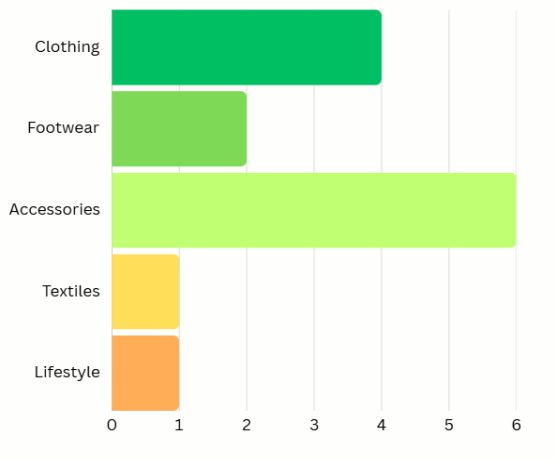


Fig. 3. Type of products (multiple choices)

Source: prepared by author, based on survey

As for location, **4 companies were based in Italy, 2 in Greece, 1 in the Netherlands**, and **1 in Belgium**. It is notable to mention that the survey was distributed exclusively to European companies, with a significant portion (around 50 of the 100 contacted) being Italian. To the Italian companies it was possible to deliver the questionnaire in their native language. The result was that **Italian companies showed a higher response rate**. suggesting that language accessibility and national affiliation may have positively influenced participation.

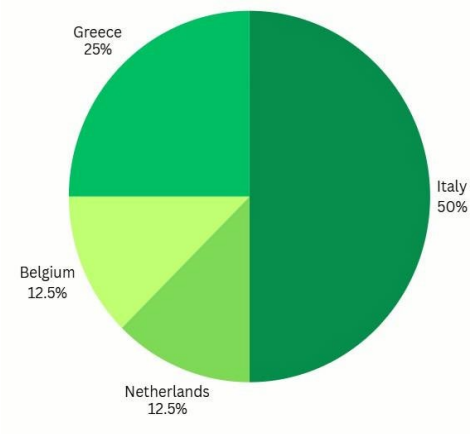


Fig. 4. Geographic location

Source: prepared by author, based on survey

2.3.2. Implementation of circular strategies

When asked about the implementation of circularity strategies, the majority of the companies stated that such strategies are fully integrated into their operations, while the rest indicated only partial integration. Given that all participating companies already position themselves as sustainability- oriented, this distribution reflects a commitment to circularity. Furthermore, going more in detail in trying to identify which strategies were adopted, **“Reduce”** was the most widely implemented approach, cited by **7 out of 8 companies**. **“Refuse”** also showed strong adoption (**6 out of 8**), indicating an overall aim to avoid unnecessary consumption and waste from the start. **“Rethink”** and **"Remanufacture”** were each adopted by **5 out of 8 respondents**, while “Repair was adopted by **50% of the respondents**, reflecting moderate engagement with approaches that extend product life cycles and encourage innovation in design. **“Recycle”** was adopted only by **3 companies** suggesting that it may not be a central strategy for SMEs, possibly due to costs, resources, or scalability limitations. In the same way, **"Reuse"**, **"Refurbish"** and **"Repurpose"** were the **least adopted strategies**, which may reflect practical challenges in implementing these approaches at a small scale. Overall, the results suggested that while there is a strong awareness and engagement with circular principles among these companies, there is still a tendency to prioritize preventative strategies (such as reduce and refuse) over end-of-life solutions (such as reuse or recycle). This may be due to resource limitations and costs typical of micro-enterprises.

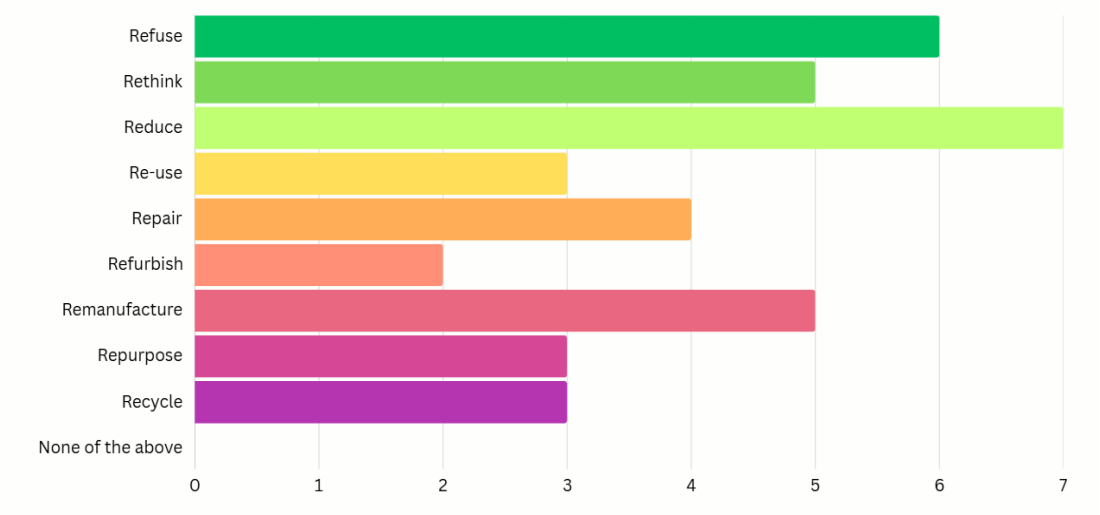


Fig. 5. Adoption of circularity strategies

Source: prepared by author, based on survey

As for their primary reasons for adopting circular strategies, **all 8 companies** mentioned the desire to **reduce environmental impact**, highlighting a shared commitment to sustainability as a core value. Additionally, **7 companies** pointed to **innovation and differentiation in the market** as a driving force, suggesting that circularity can also constitute a competitive advantage. Only 2 companies reported being driven by **customer demand** and **by improving their image and reputation (2 responses each)** and **1 company by regulatory standards**, indicating that external pressures may play a secondary role compared to strategic positioning and internal values. This is further supported by one respondent's qualitative response, offering a particularly insightful perspective in regards of circularity linked directly to the company's founding mission:

"It is part of the mission with which the company was created. After negative experiences in the fast fashion industry, we launched a made-to-order brand that uses sustainable fabrics, because we believe this is the most ethical way to produce clothing. We focus on product quality for the consumer rather than on following trends or maximizing profit at all costs."

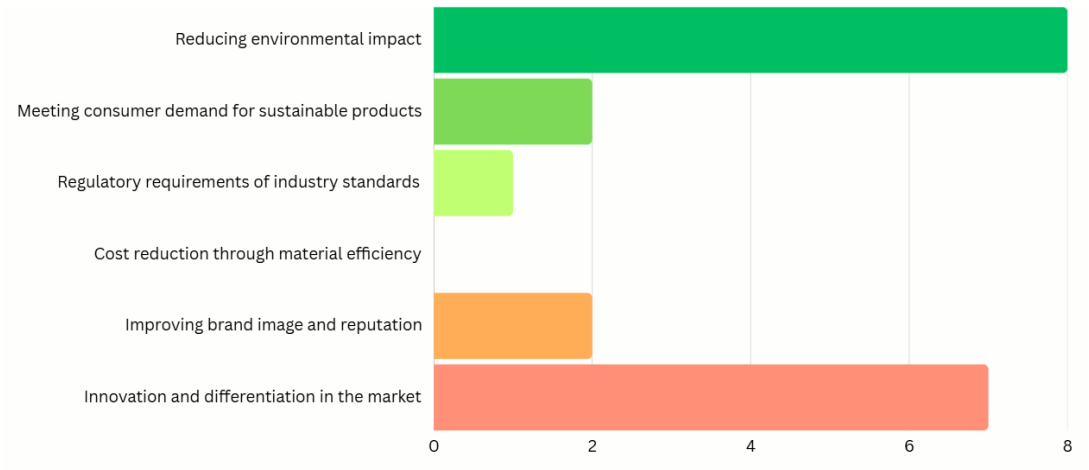


Fig. 6. Driving factors of adoption of circularity strategies

Source: prepared by author, based on survey

When asked which circularity-related approaches their company follows (with the option to select multiple), **7 out of 8 respondents** chose **local production**. Moreover, **6 companies chose slow fashion**, indicating a widespread commitment to quality,

durability. Only **3 companies reported** implementing **zero-waste practices**, suggesting the challenge of completely eliminating waste, especially for SMEs operating with limited resources. These findings align with elements of the 9R circularity framework, where strategies like "Rethink," "Reduce," and "Refuse" tend to be more cost- effective for smaller firms, while approaches like "Recycle," "Repurpose," or "Re-use" often require more resources and might be less accessible.

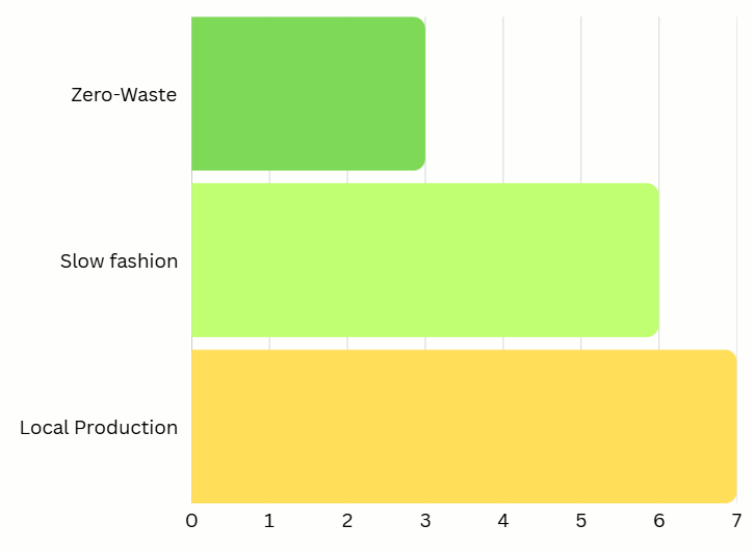


Fig. 7. Main circularity approaches

Source: prepared by author, based on survey

Following up, a question was asked to identify the main challenges faced in implementing circular strategies (with a maximum of two possible choices). The result was that **7 out of 8 companies** cited the **high cost of sustainable materials** as the most significant barrier. This represents an important insight, as it places economic availability as a key structural limitation in the shift toward circularity, especially in regards to micro-enterprises. Other challenges reported were **lack of knowledge or expertise in circular design** and **lack of consumer demand for sustainable products** (each selected by 3 companies), pointing to gaps in both internal capabilities and market readiness. Additionally, the **absence of clear industry standards or guidelines** was selected by 2 companies, and **limited availability of sustainable suppliers** by only one company, indicating that while they can be both challenges to consider, they don't represent the main barriers in the implementation of circular strategies.

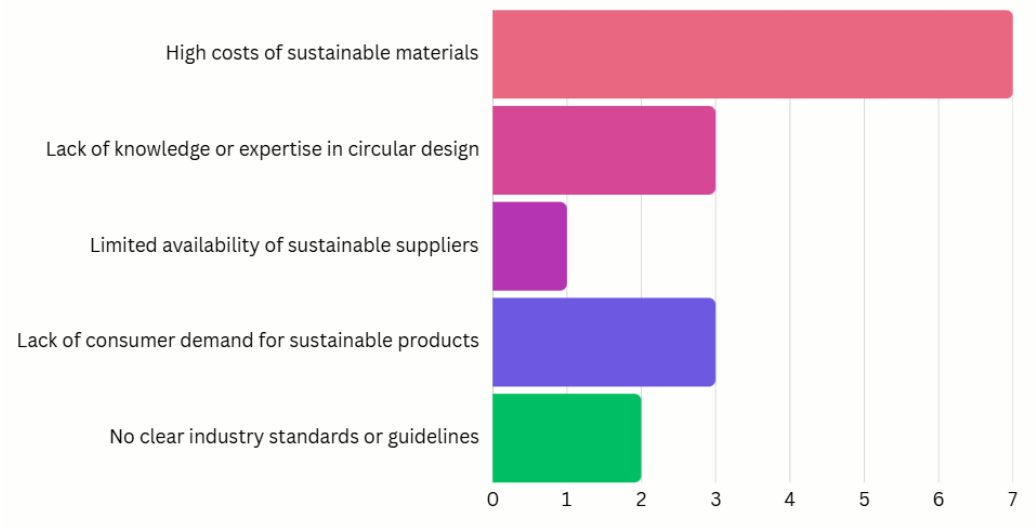


Fig. 8. Barriers in the adoption of circularity strategies

Source: prepared by author, based on survey

2.3.3. Material Selection and role of Design

When asked which factors most influence design decisions within their company, **62.5% of respondents identified material availability and cost** as the primary driver. The financial burden of sourcing sustainable materials emerges as the most pressing concern, aligning with previous responses where high cost of sustainable materials was highlighted as the most significant challenge. This is further supported by a qualitative response from one company, which elaborated on their dependency on sustainable materials:

"We produce clothing using 90% certified sustainable fabric stock (Oeko-Tex, GRS, GOTS), so we are heavily dependent on the availability of these materials. Since we choose only those made in Italy and from natural sources, our options become even more limited."

This supports the idea that material constraints have a huge impact on sustainability goals, especially when there is a strict sourcing selection and it highlights the complexity of aligning design choices with sustainability values, particularly in micro-enterprises which might have more limits in sourcing broadly compared to larger companies.

Consumer demand and market trends and **environmental impact and sustainability**

were also the mostly selected opinions after material costs. Industry regulations and guidelines were not selected by companies as main factors influencing design decisions. Overall, this data suggests that environmental factors and the materials available are the most influential factors in driving decisions, especially for SMEs, whose budget might be limited.

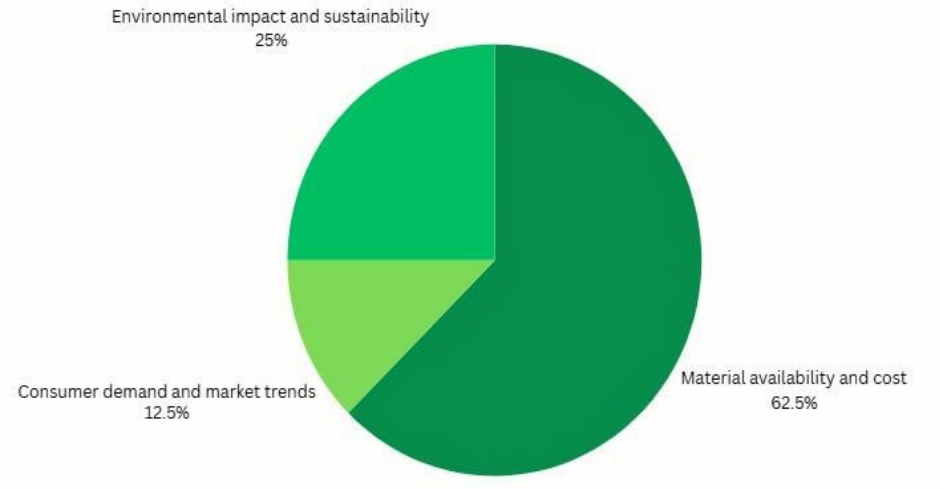


Fig. 9. Factors influencing design decisions

Source: prepared by author, based on survey

As for choice and prioritization of materials to ensure sustainability (with the option to select multiple responses), the most selected categories were **recycled materials** and **natural materials**, each chosen by **5 out of 8 respondents**. **Synthetic but sustainable materials** (such as recycled polyester) were selected by **4 respondents**, making it a still common choice between companies. **Biodegradable materials** and **upcycled or reclaimed materials** were each chosen by **3 companies**, reflecting more niche but impactful strategies. These results underline a diverse and various approach among micro-enterprises, when it comes to sustainable material sourcing. However, the reliance on more accessible options like recycled or natural fabrics also highlights the **importance of material availability and cost**, which, as reported earlier, remains a significant barrier.

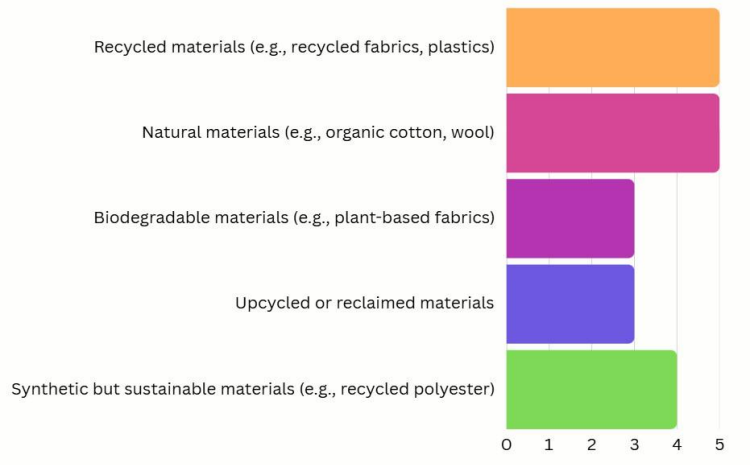


Fig. 10. Material Selection

Source: prepared by author, based on survey

Linked to material selection and design choices, it was also asked how important was eco-design in their product development process (on a scale from 1 to 4, with 1 being “not important at all” and 4 being "very important"). As a result, **6 companies rated it as 4 - very important**, and **2 companies rated it as 3 out of 4**. No company rated it below 3, indicating a consistently high level of importance of eco-design across respondents. Overall, eco-design is then considered a core component of product development by the majority of companies, reflecting a strong alignment with sustainability values and the absence of low scores reinforces the idea that environmental considerations are well integrated into design decisions among the companies analyzed.

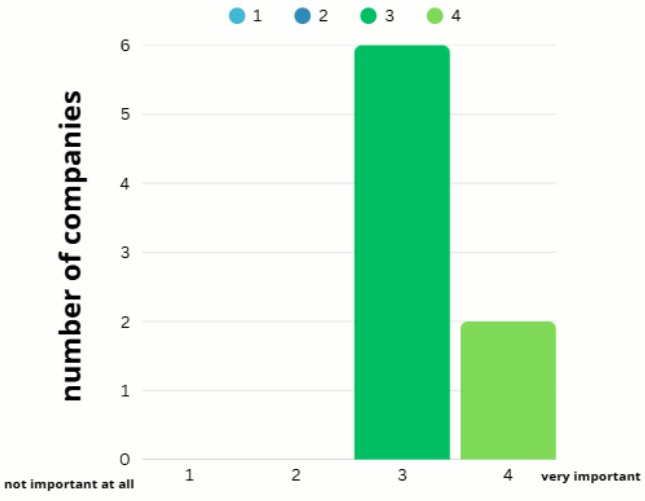


Fig. 11. Importance of eco-design

Source: prepared by author, based on survey

2.3.4. Tools, certifications and policies

First, respondents were asked to indicate which frameworks, tools and sustainability indexes they were familiar with. The most widely recognized tool was LCA, selected by **5 respondents**. Moderate recognition was the **circular Design Guide by the Ellen MacArthur Foundation** (selected by 3 respondents). **Higg Index** and **Close the Loop Tool** (each selected by 2 respondents). The findings suggest that tools like LCA and the Ellen MacArthur Foundation's resources are more familiar to micro-enterprises. In contrast, specialized or less broadly promoted tools like the Higg Index show lower levels of recognition.

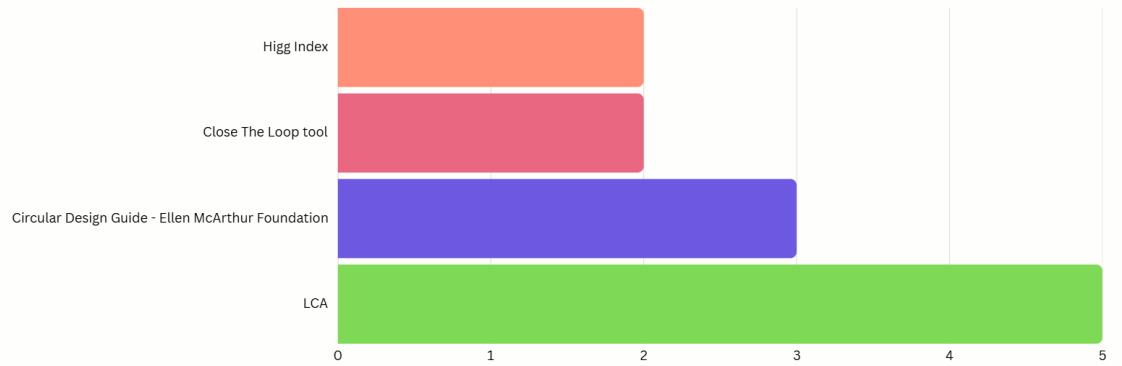


Fig. 12. Tools and indexes

Source: prepared by author, based on survey

Following this question, it was asked to rate the adoption of the mentioned design tools. When asked how frequently their company uses sustainability-related tools to support decision-making (on a scale from 1 to 5, with 1 being "never" and 5 being "very frequently"), the responses were varied. **1 company** selected **5** (very frequent use), **1 company** selected **4** (frequent use) **2 companies** selected **3** (moderate use) **1 company** selected **2** (infrequent use) and **3 companies** selected **1** (never). This distribution indicates that while some companies are integrating sustainability tools into their decision-making processes, the overall level of usage remains relatively low or inconsistent, suggesting a gap between awareness and practical application.

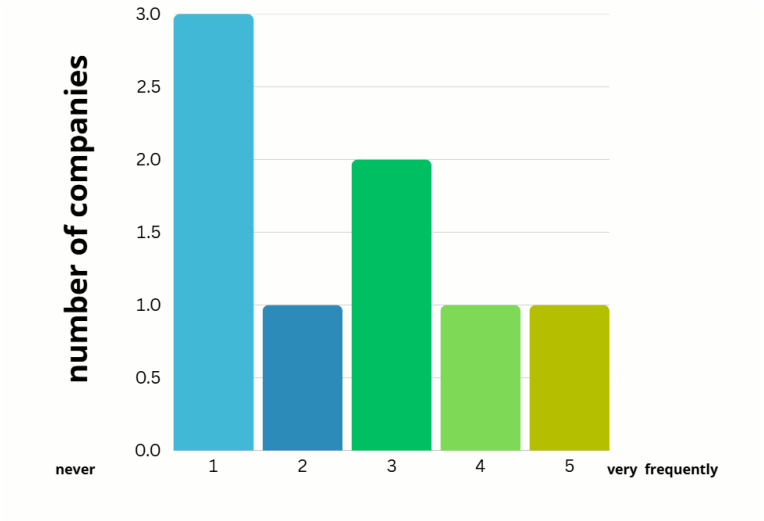


Fig. 13. Adoption of Design tools and indexes

Source: prepared by author, based on survey

In regards to European policies, it was asked whether and which policies have influenced product design decisions. The responses showed a broad awareness of regulatory frameworks but with limited impact or at least limited perception of impact among these companies, with each option being selected **only once**. Policies selected include: **ESPR (Ecodesign for Sustainable Products Regulation), EPR (Extended Producer Responsibility)**. **EU Green Deal. EU Waste Framework Directive** and **national or regional policies** were not selected at all.

Furthermore, **5 out of 8 respondents** stated that no policy has influenced any decision, indicating that for most respondents, policies have not played a significant or role in shaping design strategies, or that the policy influence is not well understood. These results suggest a limited policy impact at the micro-enterprise level, potentially due to lack of awareness, clarity, or enforcement. It may also reflect a gap between policy development and its practical application within SMEs.

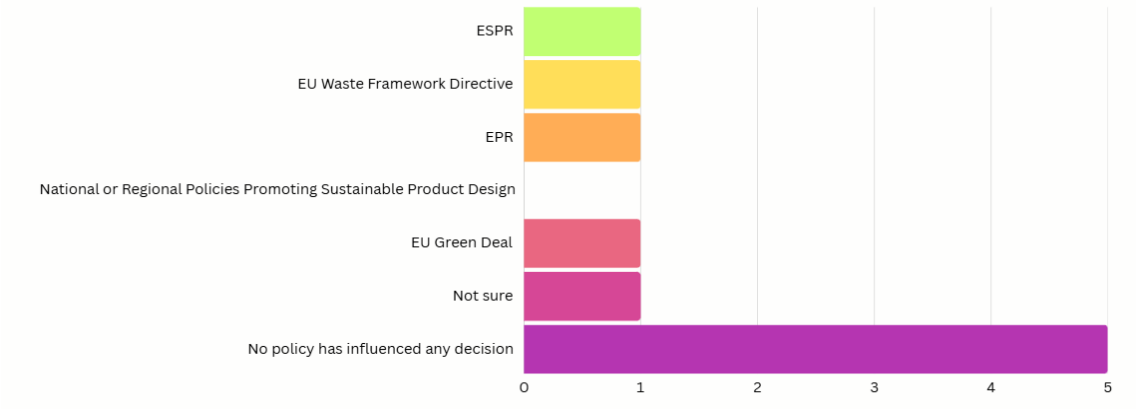


Fig. 14. European Policies affecting SMEs decisions

Source: prepared by author, based on survey

Lastly, it was asked which certifications related to circular product design were obtained. The result was that **6 out of 8** companies didn't select any, highlighting a widespread absence of standardized certifications among these micro-enterprises. **GOTS** and **OEKO-TEX®** were each selected by **1 respondent**, showing isolated cases of companies obtaining certified sustainable materials. **Cradle- to-Cradle, EU Ecolabel, NATURTEXTIL iVN, GRS, ISO 14001** were not selected at all. This data may reflect several barriers for these companies, such as the high costs, limited relevance for a small-scale company, or lack of awareness. It might also reflect the fact that since many of the certifications are in relation to the materials, the obtainment of those might fall on their supplier rather than on themselves.

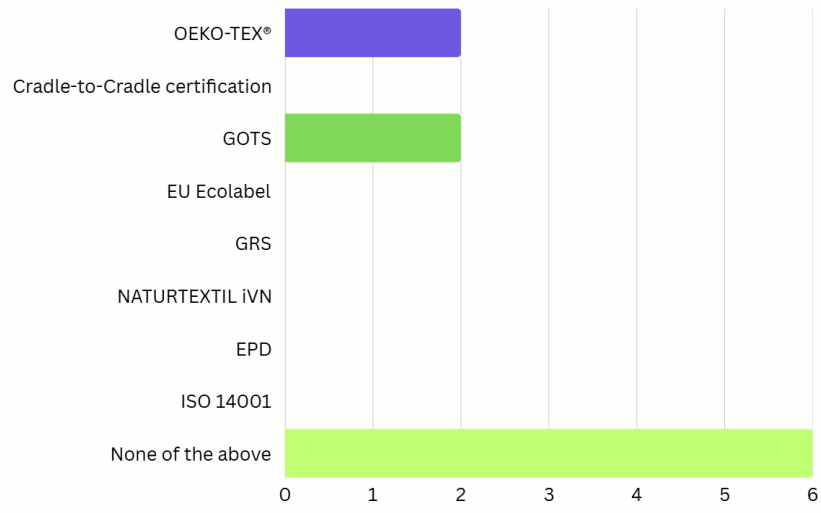


Fig. 15. Certifications

Source: prepared by author, based on survey

2.4. Results and Analysis: Interview-based insights on circular product development

In this section, the findings from the interview are reported and analyzed. The three interviewees from the three companies are referred to as Interviewee A, Interviewee B and Interviewee C.

2.4.1. Overview

Interviewee A is the founder of a micro-enterprise that specializes in clothing and accessories. The company originated in London, was relocated to Italy, and is now in the process of expanding to Switzerland. The interviewee has been in the eco-friendly space for about 15–20 years and, by having a background in the natural medicine and homeopathy disciplines, where sustainability, particularly packaging, has always been a core value, the brand was founded with the idea of being eco-friendly and respecting both the environment and animals from the start.

Interviewee B is the owner of a small women's shoe brand based in Amsterdam and with production located in a family factory in Portugal. The founder highlighted having over a decade of experience in designing shoes and how, through experience, began to understand what a large impact mainstream brands have on the environment, serving as an inspiration to create a more responsible and sustainably made footwear label.

Interviewee C is the CEO of a small accessory brand based in Greece. The company began in 2015 with a vision of circularity as a core principle and is currently made up of just four people. From the very start, the company operated with the intention of including circularity as much as possible. However, they encountered challenges such as not enough access to suitable materials and lack of good collaboration opportunities.

2.4.2. Implementation of circular strategies

According to Interviewee A, sustainability decisions are part of the company's DNA, meaning that non-sustainable aspects are never included in the design process. The brand operates under a very strict internal ethical code where environmental decisions are always given precedence to economic decisions. A big decision for them was to produce exclusively in Italy, which allowed the company to be in total control of all the supply

chain and to make sure ethical and environmental practices are being observed. The company produces in very small quantities based on expected demand only, aiming to reduce overproduction and waste of materials. They launch their products through limited edition runs, where the goal is to sell out. As for waste management, and end of life strategies, the company uses leftover garments from productions for future projects and , as the interviewee A explained, they have currently no take-back programs, but they plan to implement one in the near future. As reported by the interviewee, future plans also include a continuing investment in research for future sustainable innovations. As far as barriers faced, the company stated that the biggest challenge at first was internal resistance to sustainable practices because of their cost. However, the company was small and agile enough that it was able to embed sustainability from the beginning.

Interviewee B explained that sustainability decisions are based on their experience with eco-friendly materials. The founder is deeply involved in both determining materials as well as production and is able to utilize their technical knowledge in balancing sustainability with quality. As a small, agile brand, the founders can stop any design if a particular product does not meet their quality or business expectations/commitments to sustainability/ethics. Because sustainability is such a large area of interest, they spend a lot of time educating customers how to properly care for the shoes to extend the life cycle of the products, and to instruct and outline steps for shoe repair to help reduce consumption. They also utilize high quality materials to extend their durability. Despite the brand's commitment to circularity, due to current recycling infrastructure, they cannot recycle their products at end of life, but the brand is actively trying to find a viable recycling solution at end of life for their product. Additionally, same as for the other company, the brand's number one challenge is balancing cost efficiencies with environmentally sustainable initiatives.

Interviewee C described that their decisions are informed by an internal guideline that seeks maximum efficiency and minimum waste. All decisions, whether made in a meeting or by an individual, must adhere to these circularity principles. The brand offers both a repair and a take-back option. They receive requests for repairs every couple of months. However, no customer has ever returned an item in ten years of business, despite the continuous attempt of advertisement through tags, website, and through their own retail store. The team is still investigating the issue of not having take-backs, although this is likely because the drop-off system is less convenient than larger brands, as it requires

multiple steps and more effort from the customer.

Sustainability is always prioritized, which also comes with higher prices, making it difficult for potential customers to understand the cost, even when explained, and potentially discouraging them from buying. The highest expense of the brand lies in local production, which is the foundation of their approach. Their production runs in Athens in a historically manufacturing area of small business, aiming to continue the traditions. Although the company has had offers to produce in Southeast Asia, they chose intentionally not to, as they prefer to keep it locally to maintain their ethics and their values.

Furthermore, Interviewee C noted how large corporations reinforce consumerism by using their marketing tools that make it increasingly difficult to learn independently about sustainability. Many consumers are used to low prices for items like bags and t-shirts and may overlook or are not aware of aspects such as production ethics, fair pay, working hours, and conditions. To address this, the company is committed to create meaningful collaborations with large cultural organizations. The interviewee believes that working with these institutions is a way to raise public awareness of circularity, to demonstrate that repurposing and upcycling are legitimate methods for handling textile waste and to normalize the reuse of synthetic textile waste.

2.4.3. Material Selection and role of design

Interviewee A' s company sources materials that balance high performance, that are similar to conventional materials, and that maximize sustainability. If a material is not sustainable enough for the company, the whole project is turned down. The company usually attends major trade fairs to learn about material development and supply. They only work with trusted partner organizations that can provide certifications and guarantees and that conduct material testing. When choosing materials, Interviewee A highlights that they always prioritize ethical considerations over potential aesthetic benefits. The brand always sources recycled content (e.g. plastic bottles) and plant-based materials (e.g. apple, pineapple, cactus, leather), organic cotton, and hemp-certified where possible by OEKO-TEX standards. To keep recycling easier and end of life simpler, they do not mix materials. They even utilize AI to visualize models at the prototyping stage so they can limit the use of physical samples and unnecessary meetings.

Interviewee B only uses materials that are of natural-origin (e.g. linen, cotton, responsibly sourced leather, specifically chrome-free and vegetable-tanned). Material choices are determined by three core criteria: quality, the least harm done to workers, and the least damage to the environment. Sustainability is always the core of their designs, and it is integrated from sourcing materials to production practices.

Interviewee C said the company's use of materials and design comes from their internal document guideline, that they use to embed circularity strategies in their decisions. Although they consider supplier information and materials' functionality they prefer a more holistic approach to materials. For example, they explored hemp to supply bag strap, but ultimately, they found it unreliable for their specific use and difficult to source within Europe, and decided instead for something more durable.

The brand largely uses existing textile waste and only sources new materials when their options are limited, such as zippers and straps. All the material is sourced locally (within an estimated 20-30 km radius). For example, they have recovered balcony sun-shade curtains that they found accessible in Athens. Considering a local availability of around 300 tons per year, the brand is relying daily on the sun-shade fabric resource and refuses to import material from distribution areas outside of Athens.

2.4.4. Tools, certification and policies

Interviewee A discussed how their company has internal protocols that align with their ethical code. All materials must be certified by credible suppliers, and they work with trusted partners to ensure transparency and quality. The company does not use formal sustainability tools and indicators, such as LCA. However, they have an internal database to track product lines and expected sales. In this way the brand assesses performance, but it does not formally assess environmental impacts.

Interviewee B also does not use formal sustainability tools or metrics. As mentioned by the interviewee, cost is a reason that small businesses do not pursue formal tools. They prefer to draw from their experience and to depend on their personal relationships with suppliers to provide transparency and sourcing sustainably. Instead of using analytical tools, the company engages in sensible actions. As for policies, according to EU

environmental waste directives, the company works with the factory in which it is produced, to manage production waste and especially leather offcuts.

Interviewee C voiced considerable concern over how little institutional support exists for small businesses seeking sustainability. With larger systemic ideology, such as fast fashion and the unconstrained global trade, they are concerned that the EU is failing to address proper ways to implement circularity strategies among SMEs, offering only vague guidelines. While the brand refers to LCA literature to evaluate their impact, they noted that many certification schemes are designed with large corporations in mind and often have minimum sales benchmarks that are unrealistic for smaller brands. Interviewee C believes many policies and tools are therefore reactive rather than intentional and expressed concern over the absence of mechanism to verify their claims as sustainable small business compared to bigger companies who can easily make carbon neutral statements, seen as an illustration of institutional failure to regulate greenwashing.
Moreover, the brand has been closely monitoring the proposed EU digital product passport for the last 2-3 years. However, the company's upcycled materials (e.g. discarded ferry life rafts, balcony sun shade curtains) make it especially challenging to implement, unlike new materials with a regular supply chain and traceability pre-acquisition, these upcycled inputs are untraceable prior to purchase. Furthermore, the cost of implementing a digital passport constitutes a barrier, as it is estimated to be between €1-2 per product potentially, which is a high amount for a small brand. In conclusion, Interviewee C noted that there is no acknowledgement or assistance given at the moment for the sustainable practices they certify, and that policy frameworks seem inadequate for the realities of small-scale circular businesses.

2.5. Secondary data: Sustainability Reports

2.5.1. Overview

To provide a more comprehensive analysis, data gathered from the questionnaire and the interviews was integrated with secondary data sourced from 24 European SMEs in the fashion sector. All the information was obtained from their sustainability reports and official company websites. The table below gives an overview of all the companies analyzed.

Table 5. SMEs analyzed

Company	Reporting year	Country	Company	Reporting year	Country
Armed Angels	2023	DE	Mini Rondini	2023	FR
Ecoalf	2021	ES	MUD Jeans	2023 - 2024	NL
Dedicated	2024	SE	NAZ	2020	PT
Haglöfs	2023	SE	Nudie Jeans	2023	SE
Hessnatur	2022 - 2023	DE	Pangaia	2023	UK
Houdini	2024	SE	Pure Waste	2022	FI
Organic Basics	2024	DK	Rifò	2024	IT
Isto	2023	PT	RKNIT Studios	2024	IT
Jan n June	2023	DE	Sézane	2023	FR
Kings of Indigo	2024	NL	Swedish Stockings	2023	SE
Kuyichi	2022	NL	Underprotection	2023	DK
Lanius	2023	DE	Veja	2018	FR

Source: prepared by author

Some f these companies explicitly stated their size, such as Veja, which reported 50-249 employees in 2018, and Jan n June, which listed around 7-8 full-time employees plus others in 2023. The products covered by these companies span a wide range, including clothing, footwear, accessories, and textiles.

2.5.2. Implementation of circular strategies

In line with the structure of the research, another key aspect examined in the sustainability reports is material selection and sourcing practices. The table below provides an overview

of the materials used by selected companies and their alignment with circularity principles.

Table 6. Examples of circular strategies

Company	Strategies
Haglöfs	Mentions Repair and Repurpose in their contents and refers to "Haglöfs Restored" programs.
Houdini	Offers repair instructions, a take-back program and a second-hand webshop to facilitate product reuse. 85% of Houdini products are recycled.
Kings of Indigo	Implements in-store repairs, holds Repair & Upcycling Workshops, and includes in-store repairs in their pop-up store. They also track repair data to improve quality and durability.
Nudie Jeans	Offers paid express repair in London, having Repair Shops, and integrating circular activities into design, materials, and even retail spaces.
Underprotection	Introduced a take-back program offering rewards for returned items.

Source: prepared by author based on sustainability reports

2.5.3. Material Selection and role of design

Each company was analyzed regarding material selection, considering recycled materials, natural materials, bio-based materials, sustainable synthetics and upcycled materials. The table below provides an overview of the materials used by the selected companies.

Table 7. Companies use of materials

Company	Country	Recycle d Materials	Natural Materials	Bio-Based Materials	Sustainable synthetics	Upcycle d Materials
Armed Angels	DE	✓	✓	✗	✗	✗
Ecoalf	ES	✓	✗	✓	✓	✗
Dedicated	SE	✓	✓	✗	✗	✗
Haglöfs	SE	✓	✓	✗	✓	✗
Hessnatur	DE	✓	✓	✗	✗	✗
Houdini	SE	✓	✓	✓	✓	✓
Organic Basics	DK	✓	✓	✓	✓	✓
Isto	PT	✓	✓	✗	✗	✗
Jan n June	DE	✓	✓	✓	✓	✗
Kings of Indigo	NL	✓	✓	✗	✓	✓
Kuyichi	NL	✓	✓	✗	✓	✗
Lanius	DE	✓	✓	✓	✗	✓
Mini rondini	FR	✗	✓	✗	✗	✗
MUD Jeans	NL	✓	✓	✗	✓	✓
NAZ	PT	✓	✓	✗	✗	✗
Nudie Jeans	SE	✓	✓	✗	✓	✓
Pangaia	UK	✓	✗	✓	✓	✓
Pure Waste	FI	✓	✗	✗	✓	✓
Rifò	IT	✓	✓	✓	✓	✓
RKNIT Studios	IT	✓	✓	✗	✗	✗
Sezane	FR	✓	✓	✓	✓	✓
Swedish Stockings	SE	✓	✓	✗	✓	✗
Underprotection	DK	✓	✓	✓	✓	✗
Veja	FR	✓	✓	✓	✓	✗

Source: prepared by author based on sustainability reports

From this analysis emerges the most used materials are recycled materials (used by 23 out of 24 companies) and natural materials, (used by 21 out of 24 companies). Synthetic but sustainable materials (such as recycled polyester) were mentioned by 16 SMEs, making it a still common choice between companies. On the other hand, biodegradable materials and upcycled or reclaimed materials were mention by only 10 companies, reflecting on more niche strategies. In alignment with the survey findings, the sustainability reports underline the reliance on more accessible options like recycled or natural fabrics and confirm the importance of material availability and cost.

Moreover, from the reports emerges that many companies use internal material standards or a material lists to guide choices towards lower-impact options. For instance, ECOALF's Preferred Materials List ranks materials by environmental impact, requiring that any material not on the list must not be used.

2.5.4. Tools, certifications and policies

To support the data gathered through surveys and interviews, the following table was developed to provide examples of tools, certifications and policies adopted by a random sample of 10 companies selected from the 25 of the reports taken in consideration.

Table 8. SMEs use of tools, certifications and policies

Company	Country	Tools	Certifications	Policies
Houdini	SE	LCA, Higg Index	GOTS, OEKO-TEX, Bluesigned Certified	Not mentioned

Ecoalf	ES	internal tools for traceability and impact reporting, chemical analyses (with external companies/labs).	GRS, OEKO-TEX Standard 100®, Bluesign®, ISO14001.	Green Deal - (REACH on chemical strategy for sustainability)
Mud Jeans	NL	LCA	OCS-certified (organic cotton), GRS Certified	EU la laws on labour work
Kings of Indigo	SE	Product Sustainability Checklist (tool to check supply chain on product level, track certification and processes), EIM score (used to measure denim washes impact and improve processes)	GOTS, GRS, and OEKO-TEX®	Not explicitly mentioned, but refers to local and international regulations.
RKNIT Studios	IT	Internal tools	Certified and traceable materials (85% of assortment).	Not Mentioned
Kuychi	NL	LCA, Higg Index	ISO 9001, OEKO-TEX 100, GOTS, GRS	REACH

Source: prepared by author based on sustainability reports

From the analysis emerges how tools are known but underused, with only a few brands like Houdini and MUD Jeans applying them systematically. Certifications, on the other hand, are commonly used and valued across all companies, while policies are rarely a direct influence, but many SMEs operate in ways that align with EU goals.

3. DEVELOPMENT OF CIRCULAR AGILE STAGE-GATE FRAMEWORK

3.1. Development process

From the literature review and the empirical research few challenges for implementation of circular strategies among fashion SMEs were identified. In particular, from the questionnaire emerges that the biggest challenge for these companies is the high cost of sustainable materials, followed by lack of expertise in circular design and lack of consumer demand and lastly by lack of clear standards. A key conclusion is that fashion SMEs face limited capacity to implement structured circular practices due to cost, complexity, and limited access to clear frameworks or support infrastructure.

Therefore, considering the challenges mentioned above, this section is focused on the development of a framework whose goal is to provide a structured approach for SMEs to implement circular strategies. The step-by-step framework offers practical action for making product development decisions that are aligned with circularity goals, in line with industry tools, material constraints, and policy environments. The framework is constructed upon the Agile stage to gate model proposed by Cooper and Sommer (2016). Grounded in empirical data, and aligned with EU policy, the model is based on all the knowledge gained within the research and developed visually with Miro.

For a development of a clear and structured framework there are few things that need to be considered. First of all, the aim is to support early-stage decision-making (pre-design & design). Secondly it must include accessible tools/certifications actually used or known and must consider European regulatory context. Lastly, but not most importantly, it must be scalable and adaptable for all SMEs.

The framework is organized in 5 sprints as follows:

1. Product ideation
2. Material Selection
3. Design
4. Prototyping
5. Finalization

Agile methods are added into the product ideation, design and prototype stages of the

traditional Stage-Gate process. The structure of Stage-Gate stays the same except that for developing physical products, Agile-Stage-Gate uses "sprints". During each sprint, teams build something, test it, get feedback, and revise it to make the product more flexible and better aligned with customer needs (this feedback is called Voice of the Client, or VoC).

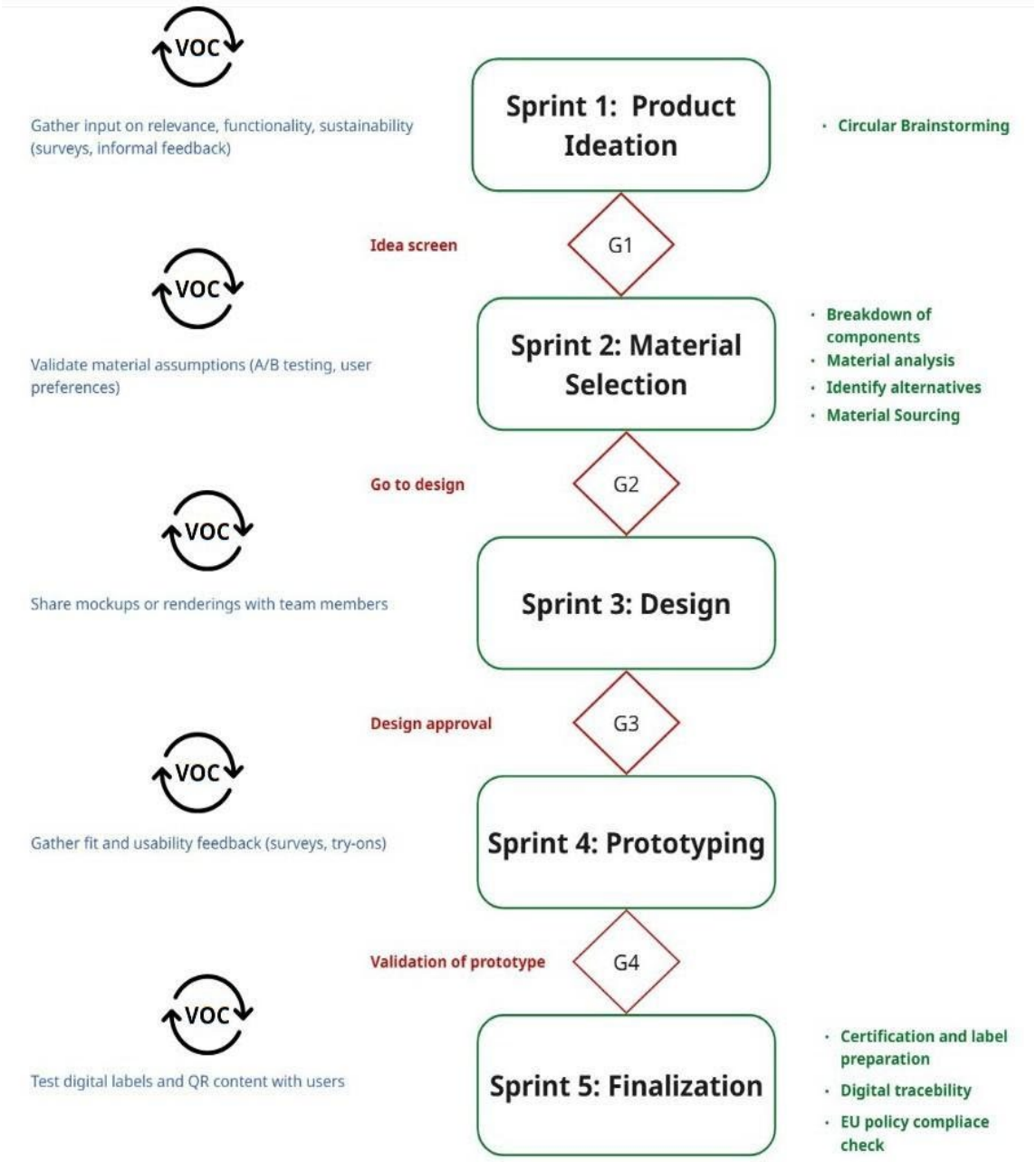


Fig. 16. Agile Stage to Gate Circularity Framework for fashion SMEs

Source: prepared by author, based on Cooper and Sommer (2016)

3.2. Sprint 1: Product Ideation

This first sprint of the framework aims to determine whether a product design concept is feasible and in line with circularity strategies. This phase is very important as the decisions taken in this stage have a big impact overall. For SMEs, which often have limited resources, this phase is critical to avoid misalignment and unnecessary costs.

3.2.1. Circular Brainstorming

The creation of this sprint was inspired by the concept of Circular Brainstorming developed by the Ellen MacArthur Foundation (2016). Whether the product concept already exists or is being developed from scratch, SMEs are encouraged to conduct a team-based brainstorming session to determine if the product should proceed to development.

The following questions, based on the 9R framework and formulated in alignment with the questionnaire, constitute a helping tool in evaluating whether a product should exist before design or development begins.

Table 9. Guiding questions

Question	**Strategy**	**Suggested action**
Can harmful materials be avoided entirely during the design phase?	Refuse	Identify potentially toxic, synthetic, or non-renewable inputs early. Prioritize certified materials (e.g., GOTS, OEKO-TEX). Remove materials that do not meet ethical or ecological standards.
Can the product design and business model be re-evaluated to prioritize circularity?	Rethink	Explore nonlinear delivery models such as rental, repair services, or customization. Consider digital platforms or shared ownership.
Can the product be designed to minimize material and energy use, thereby reducing waste?	Reduce	Simplify the number of materials, avoid mixed- materials, use efficient cutting methods (e.g., zero- waste pattern making). Opt for low-impact processes.

Can the product be designed to enable easy and repeated use?	Re-use	Ensure physical durability (e.g., robust fabrics, reinforced seams) and emotional longevity (timeless design). Test for multiple use cycles.
Can the product include features that make it easy to repair?	Repair	Use modular parts and non-permanent joins (e.g., buttons, screws). Provide access to repair instructions or spare parts.
Can the product be easily renewed or upgraded to extend its usable life?	Refurbish	Design replaceable or upgradable elements (e.g., zippers, linings). Allow for style updates without discarding the full product.
Can the product or its materials be reused in the manufacturing of new items?	Remanufacture	Use mono-materials or components that are easy to separate. Plan for closed-loop systems or collaborate with upcycling manufacturers.
Can the product be designed in a way that allows it to serve a new function after its initial use?	Repurpose	Design flexibility into the form or material (e.g., adjustable fit, reversible garments, multi-purpose shapes).
Can the product be designed to be fully recyclable at the end of its life?	Recycle	Avoid fabric blends. Use materials with known recycling streams (e.g., 100% cotton, recycled polyester). Label components and add recycling info (QR codes, DPPs).

Source: Developed by author

After the session, the ideas should all be put on a board. Post-its or stickers can help to visualize them. What do people gravitate towards? After the first sprint, product ideas are mapped, and each idea should be evaluated using a simple matrix based on 9R-aligned questions. The decision matrix was developed based on matrix found in the Concept

selection workshop in the Circular Design Guide (Ellen MacArthur Foundation & IDEO, 2017). Based on this matrix the ideas can either receive a go and pass to the next sprint, can be killed or need to be rethought.

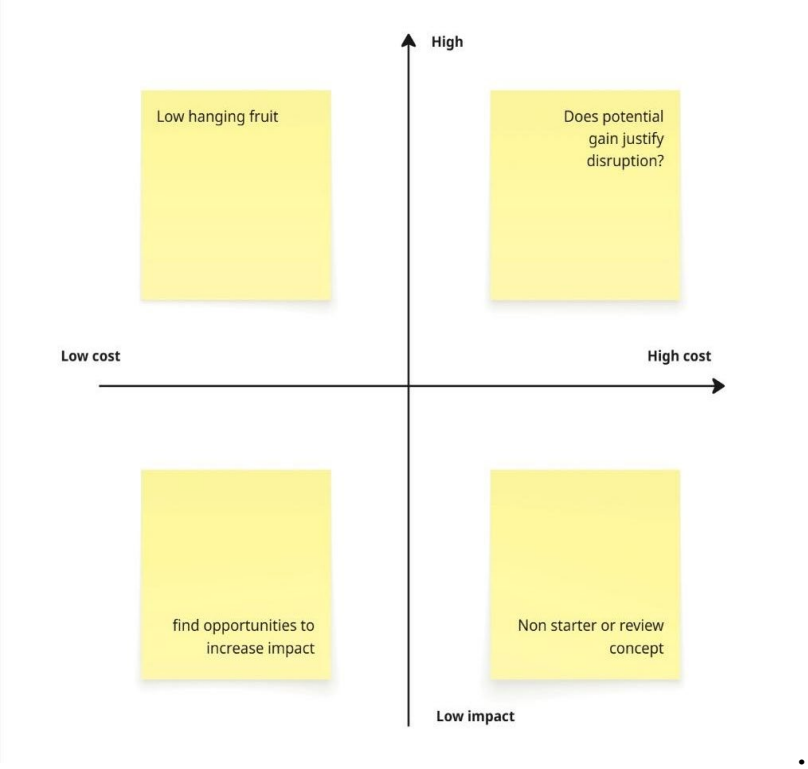


Fig. 17. Concept decision matrix

Source: prepared by author, based on the *Circular Design Guide (Ellen MacArthur Foundation & IDEO, 2017).*

3.3. Sprint 2: Material selection

Once a product concept is validated through strategic screening, the next critical step involves identifying which materials will be used to realize the design. This section builds on concepts from the Close the Loop (Flanders, 2018), the Circular Design Guide by the Ellen MacArthur Foundation & IDEO (2016), and is further informed by empirical data from interviews and surveys conducted with fashion SMEs.

3.3.1. Breakdown of components

The material selection process begins by deconstructing the product into its primary and secondary elements. Core fabrics (e.g., outer shell, lining), structural parts (e.g., zippers,

buttons, elastic), decorative or branding elements (e.g., tags, labels, embroidery) are all considered at this stage. In this stage it would be useful to create a detailed bill of materials (BoM), listing all the inputs required. This encourages transparency, traceability, and informed sourcing.

3.3.2. Material analysis

Now that the product is divided in its components, a decision tree can help assess each material. The following decision tree was adapted from the decision tree worksheet of Circular Design Guide (EMF, 2017).

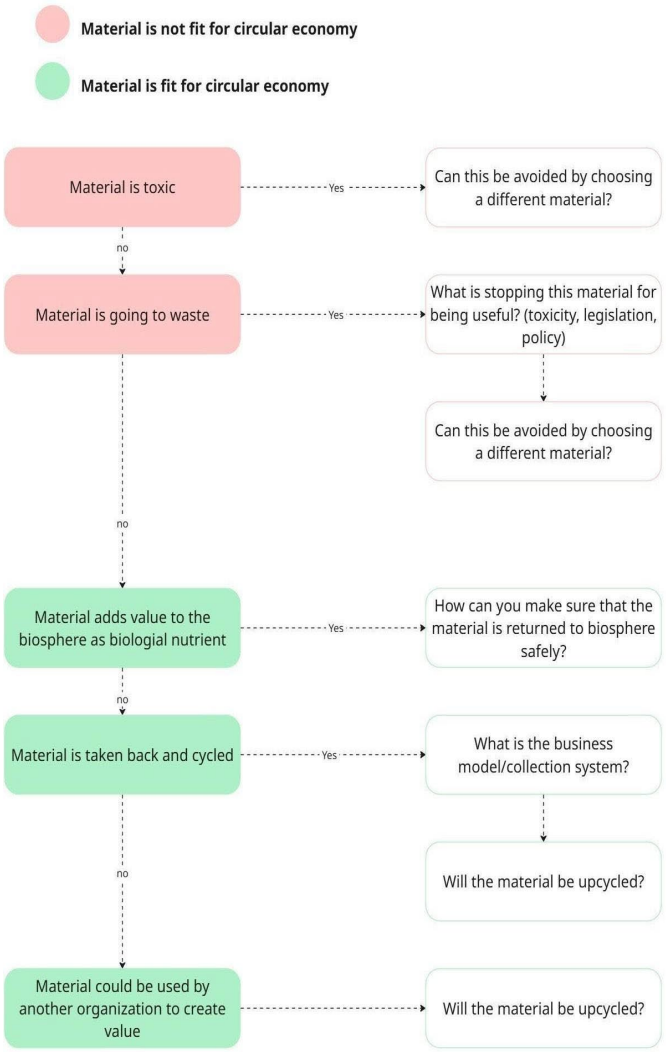


Fig. 18. Material decision tree

Source: prepared by author, based on the *Circular Design Guide (Ellen MacArthur Foundation & IDEO, 2017).*

3.3.3. Identify Alternatives

If one or more required materials are not yet fit with circular economy goals, designers are encouraged to rethink their selection:

- What would be better alternatives?
- Can the design be altered to eliminate problematic materials?
- Can the same user need to be met in a different way?

3.3.4. Material Sourcing

Material sourcing not only comes from the product itself, but could derive from sourcing relationships. SMEs often depend on strong, local partnerships with suppliers who offer sustainable stock and, in some cases, the availability of a specific material can inspire the product idea itself. As mentioned also in the interview, sometimes a product idea comes from a material choice. At this stage it is important to contact trusted or local suppliers and to prioritize those who offer transparency and traceability, work with leftover stock or certified materials, and can offer small-volume or on-demand orders, which is particularly needed for SMEs.

To support this, designers can consult the cradle-to-cradle certified materials for designers database, which provides examples of materials evaluated for material health, reusability, renewable energy usage, water stewardship, social fairness. Some certifications they can look for include the ones discussed previously which are GOTS (Global Organic Textile Standard) and OEKO-TEX® Standard 100.
At this point a key decision must be made: Is the product feasible to produce using materials that are circular, locally available and aligned with SMEs values and resources? Categorizing and evaluating each criteria can help guide the process. Therefore, each criteria is graded on a scale of 1 to 10. If the concept has at least a sufficient score (6/10) then it can go to the next sprint, otherwise it is killed.

Table 10. Criterias for material sourcing

Criteria:	Score:
Use of circular materials	

Local availability	
Alignment with brand values	
Alignment with available resources	

Source: prepared by author, based on empirical findings

3.4. Sprint 3: Design

Once a product idea has been validated and its material selection confirmed to be feasible and in line with circularity principles, the next step is to translate this into its design. As highlighted in the literature review, design decisions made at this stage influence up to 80% of the product's environmental impact. The goal is to transform a concept (validated in Gate 1) and a material set (approved in Sprint 2) into an actual product design that is circular in how it's made, used, and disposed of. This sprint was adapted by taking inspiration from Close the Loop Framework (Flanders, 2018).

In this stage, designers take the approved idea and begin sketching, modeling, or digitally visualizing the product design, but with circularity as the core design constraint, not just aesthetics. Design decisions are evaluated using **Design for X (DfX)** methodologies. The following table presents the various design strategies and some circular application examples.

Table 11. Dfx methodologies

Dfx Type	Circular Application examples
DfD (Disassembly)	Avoid gluing materials, use stitching that's easy to take apart
DfR (Repairability)	Add visible seams, modular closures, or accessible components
DfD (Durability)	Reinforce stress points, use double-stitched seams

Source: prepared by author based on literature review (1.3. Material selection and the Role of Design)

Finally, once the designs are done, the team reunites and decides collectively which designs are ready for production.

3.5. Sprint 4: Prototyping

Before implementation, a functional prototype is created. The prototype can be physical or digital. More and more companies are using digital 3D samples or AI to facilitate this process. From one of the interviews, a company declared that they use AI for their prototyping. The design is then tested for comfort, fit, and performance and according to circularity criteria.

3.6. Sprint 5: Finalization

With the design finalized and validated through prototyping, this final stage focuses on preparing the product for launch, ensuring it is circular by design. During this stage, the product is analyzed in line with appropriate certifications, tools and regulations. European Commission (2022). This stage was modeled based on EU Strategy for Sustainable and Circular Textiles, Digital Product Passport Briefing by Ellen MacArthur Foundation (2023).

3.6.1. Certifications and label preparation

The goal is to validate that the final product and all its materials meet relevant sustainability and safety certifications. Certifications for materials already discussed in 3.2.3. are:

- GOTS (Global Organic Textile Standard)
- Cradle to Cradle Certified™
- OEKO-TEX® Standard 100
- GRS (Global Recycled Standard)

Some possible actions at this stage include collecting certificates from suppliers, to include certification details in tech packs and marketing materials and to prepare care labels or hang tags reflecting certifications.

3.6.2. Digital Traceability

The next step is to ensure that all components of the product are traceable, in anticipation of future legal requirements such as the DPP under the EU Ecodesign for ESPR. SMEs should add digital or QR codes including material composition, care instructions, repair guidance, and take-back or return options.

3.6.3. EU Policy Compliance Check

The final stage is to check if the product is aligned with the EU policies, particularly focused on textiles. In alignment with ESPR the company should prepare to document design strategies and material lifecycles and, additionally, in alignment with EPR it could explore strategies that include resale, repair, or local recycling partnerships. If the product receives a go, typically decided by the management team, then it is considered ready for production, in line with all the circularity, and regulatory criteria established in this framework.

3.7. Embedded feedback mechanism

Throughout the whole process, companies should listen to the voice of customers (VOC). Designing for circularity isn't just about making the product; it's about how it's used, repaired, returned, or resold. Designers should anticipate and visualize how users will wear, care for, and eventually dispose of the item. Understanding how the user interacts with the product across its life is essential.

Based on the Circular Design Guide (Ellen MacArthur Foundation & IDEO, 2017), Voc is taken at this stage to ensure that products are designed for long-term success. Several methods are used to gather insights from users:

- Interviews: Conduct one-on-one conversations to understand users' experiences and needs.
- Surveys: Distribute questionnaires to collect feedback based on users' interactions with the product.
- Forums: Monitor discussions on social media and online communities to observe organic user feedback.

- Analytics: Use tracking tools to analyze user behavior if the product includes a digital component.
- Data Exhaust: Use data such as cookies and browsing activity, which are generated indirectly through users' online behavior.
- Sensors: Integrate sensors into physical products to monitor real-time usage and performance.

Table 12. VoC throughout all the sprints

Product ideation	Gather input from potential users on product relevance, functionality and sustainability expectations through surveys, informal feedback and so on.
Material Selection	Validate material assumptions through user preferences. Ex: Use A/B testing
Design	Share mockups or early rendering with other team members.
Prototype	Gather fit and usability feedback through surveys, try-ons
Finalization	Test digital labels and QR content with users

Source: prepared by author

3.8. Discussion

The framework developed is based on the Agile Stage-Gate hybrid model developed by Cooper and Sommer (2016). The literature review section 1.5. covers the outlined characteristics of the model and its possible advantages for SMEs, including more flexibility, productivity, and better understanding of customer needs. The framework organizes the NPD process into 'sprints' organized by 'gates', as a direct application of this literature-based approach. The framework is also rooted in core circular economy

principles and incorporates the 9R strategies (European Commission, 2020) as a foundation element for product ideation and development. This theoretical backing from the literature provides the guiding philosophy for circularity within the process.

As noted in the literature review, early design choices can decide as much as 80% of a product's environmental impact (SH Tan et al., 2024). The model responds to this by devoting sprints (Sprint 2: Material Selection and Sprint 3: Design) to these important elements, underscoring their importance in the process. In addition, the designer needs to consider creating products that are physically and emotionally durable (Ellen Macarthur Foundation, 2021) and can be dissembled and recycled (ISO 14021, 2016.). Incorporating findings from the literature, the framework adds principles of designing for durability, repairability and recyclability.
In addition, the literature review identifies tools (LCA, Circular Design Guide), certifications (GOTS, OEKO-TEX, GRS, Cradle to Cradle), and EU policies (ESPR, DPP, EPR) relevant to sustainable and circular fashion. The framework includes checks and considerations for these elements mostly directly in a finalization check in the last sprint (Sprint 5) acknowledging their importance as outlined in the literature.

Furthermore, the suggested framework addresses the main barriers identified through the empirical research. For instance, the Material Selection Sprint (Sprint 2) includes evaluative criteria of "Alignment with available resources" and "Local availability" in Gate 2. These criteria recognize arguments expressed by interviewees of having economic constraints and their prioritization of sourcing locally, and, by assessing feasibility early in the process, the model also helps SMEs avoid costly missteps. In addition, to address the significant desire for clearer direction and guidance underlined in both surveys and interviews, the proposed model provides a structured, step-like approach with guiding questions (Table 9), decision matrix (Figure 17), and material analysis trees (Figure 18), which are drawn from established ideas (e.g., the 9Rs and circular design). Moreover, the framework includes a Voice of the Client (VoC) component across all sprints, addressing the reported barrier of weak consumer demand, therefore ensuring that user needs and preferences are captured throughout development and increasing the chances that a circular product will be accepted by consumers.

In essence, the Agile Stage-Gate circularity framework syntheses the theoretical concepts of circularity and established NPD models from the literature into a practical, structured process, specifically tailored to the realities, challenges, and strengths of European fashion SMEs. It provides a structured pathway for fashion SMEs to navigate the practical process of integrated circularity from initial idea phase through production readiness.

CONCLUSIONS AND RECOMMENDATIONS

The research aimed to investigate how European SMEs in the fashion industry are currently integrating circular strategies into their early-stage design and decision-making processes and how circular strategies can be integrated in product development among SMEs in the fashion industry.

Through looking at literature and empirical research, this investigation highlighted key barriers and opportunities faced by SMEs, indicating that while there is a clear interest in sustainability from SMEs, they each faced varying challenges, including high costs for sustainable materials, minimal knowledge of circular design, limited customer demand, and the absence of frameworks or standards for the implementation of circular strategies. Additionally, the literature review demonstrated some opportunities to improve circularity, such as various strategies, tools, and certifications that SMEs can follow, if implemented correctly.

The developed Agile-Stage Gate Circularity framework aims to bridge the gap identified for sustainable NPD in fashion SMEs. The model offers a structured step-by-step approach to help SMEs move from a product idea to material selection, design, prototype and then finalize their product, while considering circularity and European regulations. Overall, this research highlights the critical role of early-stage decision-making in transforming fashion production and provides a scalable, adaptable model that SMEs can apply in practice.

Limitations and suggestions for future work

There are several limitations associated with this research that should be acknowledged. The main primary data relied upon a small sample size, specifically regarding the surveys (8 respondents out of 100 contacted) and interviews (3 participants). The small number of participants meant these findings were not broadly representative but provided useful in-depth insights nonetheless. The sustainability reports of 24 companies, while providing additional context, were still secondary data which was likely to have been manipulated for public view. The low survey response rate might also suggest the findings represent the views of companies with a far greater commitment to sustainability than others, and that the findings overall may not fully represent the range of challenges being faced by SMEs that are not committed to sustainability. Additionally, the limited focus on European

SMEs potentially impacted the findings' generalization to other geographic contexts. The described limitations collectively mean that the study, while providing useful insights and rationalizing the framework's development, should be interpreted with caution and future research with a larger sample size and more varied response sample would be needed in order to obtain more accurate and realistic results.

REFERENCES

Abrishami, S., Shirali, A., Sharples, N., Kartal, G. E., Macintyre, L., & Doustdar, O. (2024). Textile recycling and recovery: An eco-friendly perspective on textile and garment industries challenges. *Textile Research Journal, 94*(23–24). https://doi.org/10.1177/00405175241247806

Ashby, A., Smith, M. H., & Shand, R. (2017). From principle to practice: Embedding sustainability in clothing supply chain strategies. In *Sustainability in fashion and textiles: Values, design, production and consumption* (pp. 61–81). Taylor and Francis. https://doi.org/10.4324/9781351277600

Bocken, N. M.P., S. W. Short, P. Rana, and S. Evans. "A Literature and Practice Review to Develop Sustainable Business Model Archetypes." Journal of Cleaner Production 65 (2014): 42–56. https://doi.org/10.1016/j.jclepro.2013.11.039.

Boote, David & Beile, Penny. (2005). Scholars Before Researchers: On the Centrality of the Dissertation Literature Review in Research Preparation. Educational Researcher. 34. 3-15. 10.3102/0013189X034006003.

Bruce, M., & Daly, L. (2011). Adding value: Challenges for UK apparel supply chain management – a review. *Production Planning & Control, 22*(3), 210–220. https://doi.org/10.1080/09537287.2010.498574

Charter, M., Pan, B., & Black, S. (2023). *Accelerating sustainability in fashion, clothing and textiles*. Routledge. https://doi.org/10.4324/9781003272878

Cimatti, B., Campana, G., & Carluccio, L. (2017). Eco design and sustainable manufacturing in fashion: A case study in the luxury personal accessories industry. *Procedia Manufacturing, 8*, 393–

400. https://doi.org/10.1016/j.promfg.2017.02.050

Clark, H. (2008). SLOW + FASHION – An oxymoron – Or a promise for the future …? *Fashion Theory, 12*(4), 427–446. https://doi.org/10.2752/175174108X346922

Claxton, S., & Kent, A. (2020). The management of sustainable fashion design strategies: An analysis of the designer's role. *Journal of Cleaner Production, 268*, 122112. https://doi.org/10.1016/j.jclepro.2020.122112

Close the loop. (2025). Flanders DC. https://close-the-loop.be/en

Cooper, R. G., & Sommer, A. F. (2016). Agile-stage-gate: New idea-to-launch method for manufactured new products is faster, more responsive. *Industrial Marketing Management, 59*, 167–

180. https://doi.org/10.1016/j.indmarman.2016.10.006

Ellen MacArthur Foundation. (2017). *A new textiles economy: Redesigning fashion's future*. https://www.ellenmacarthurfoundation.org/a-new-textiles-economy

Ellen MacArthur Foundation. (2020). *Vision of a circular economy for fashion*.

Ellen MacArthur Foundation. (2021). *Rethinking business models for a thriving fashion industry*. https://www.ellenmacarthurfoundation.org/fashion-business-models/overview

Erminia D'Itria & Reet Aus (2023) *Circular fashion: evolving practices*

in a changing industry, Sustainability: Science, Practice and Policy, 19:1, 2220592, DOI: 10.1080/15487733.2023.2220592

European Commission. (2022, March 30). *EU strategy for sustainable and circular textiles*. https://environment.ec.europa.eu/strategy/textiles-strategy_en

European Commission. (2024). *Ecodesign for sustainable products regulation*. https://commission.europa.eu/energy-climate-change-environment/standards-tools-and- labels/products-labelling-rules-and-requirements/ecodesign-sustainable-products-regulation_en

European Commission. (2024). *The European Green Deal*. https://commission.europa.eu/strategy- and-policy/priorities-2019-2024/european-green-deal_en

Fletcher, K. (2010). Slow fashion: An invitation for systems change. *Fashion Practice, 2*(2), 259–

265. https://doi.org/10.2752/175693810x12774625387594

Glossary: Enterprise size. (2016, October 31). *Eurostat*. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Enterprise_size

GS1. (2023). *The new EU sustainability textile strategy*. https://gs1.eu/wp-content/uploads/2023/03/The-DPP-ApparelTextile-Industry-Briefing-Document.pdf

Henninger, C. E., Alevizou, P. J., & Oates, C. J. (2016). What is sustainable fashion?

Journal of Fashion Marketing and Management: An International Journal, 20(4), 400–416. https://doi.org/10.1108/jfmm-07-2015-0052

Hirsch, P., & Schempp, C. (2020). Categorisation system for the circular economy: A sector-agnostic approach for activities contributing to the circular economy. *European Commission*.

IDEO. (2018, May 31). *Circular design guide*. https://circulardesigneurope.eu/oer/circular-design- guide/

Interviewee A(2025). Interviewed by Alessandra Atria, 15 April, Online.

Interviewee B (2025). Written Interview., 4 April

Interviewee C (2025). Interviewed by Alessandra Atria, 12 May, Online.

Iqbal, M., & Suzianti, A. (2021). New product development process design for small and medium enterprises: A systematic literature review from the perspective of open innovation. *Journal of Open Innovation: Technology, Market, and Complexity, 7*(2), 153. https://doi.org/10.3390/joitmc7020153

ISO. (2016). *ISO 14021:2016 Environmental labels and declarations – Self-declared environmental claims (Type II environmental labelling)*. https://www.iso.org/standard/66652.html

Jacometti, V. (2019). Circular economy and waste in the fashion industry. *Laws, 8*(4). https://doi.org/10.3390/laws8040027

Karell, E., & Niinimäki, K. (2020). A mixed-method study of design practices and designers' roles in sustainable-minded clothing companies. *Sustainability, 12*(11), 4680 .https://doi.org/10.3390/su12114680

Kuljanic, E. (Ed.). (2002). *Advanced manufacturing systems and technology* (CISM Courses and Lectures, No. 437). Springer.

Lundblad, L., & Davies, I. A. (2016). The values and motivations behind sustainable fashion consumption. *Journal of Consumer Behaviour, 15*(2), 149–162. https://doi.org/10.1002/cb.1559

Macchion, L., Da Giau, A., Caniato, F., Caridi, M., Danese, P., Rinaldi, R., & Vinelli, A. (2018). Strategic approaches to sustainability in fashion supply chain management. *Production Planning and Control, 29*(1), 9–28. https://doi.org/10.1080/09537287.2017.1374485

Macchion, L., Moretto, A., Caniato, F., Caridi, M., Danese, P., & Vinelli, A. (2015). Production and supply network strategies within the fashion industry. *International Journal of Production Economics, 163*, 173–188. https://doi.org/10.1016/j.ijpe.2014.09.006

McDonough, W., & Braungart, M. (2009). *Cradle to cradle: Remaking the way we make things*. Vintage. https://doi.org/10.4337/9781847203052.00011

Nudie Jeans. (2025). *User story: Chris & the 500-wear Tuff Tonys – Nudie Jeans | Create tomorrow's vintage organic cotton*. Nudiejeans. Nudiejeans.com. https://www.nudiejeans.com/blog/user-story-chris-and-the-500-wear-tuff-tonys

Odabasi, S., von Busch, O., Moon, C., Sansone, L., & Rissanen, T. (2023). Transition design and fashion. *Fashion Practice*. https://doi.org/10.1080/17569370.2022.2133183

Methods. (n.d.). Www.ellenmacarthurfoundation.org. https://www.ellenmacarthurfoundation.org/circular-design-guide/methods

Piller, L. W. (2023). Designing for circularity: Sustainable pathways for Australian fashion small to medium enterprises. *Journal of Fashion Marketing and Management, 27*(2), 287–310. https://doi.org/10.1108/JFMM-09-2021-0220

Proposal for a targeted revision of the Waste Framework Directive. (n.d.). *European Commission*. https://environment.ec.europa.eu/publications/proposal-targeted-revision-waste-framework- directive_en

Rinaldi, R., & Bandinelli, R. (2018). Business models and ICT technologies for the fashion supply chain. In *Lecture Notes in Electrical Engineering*. Springer. https://doi.org/10.1007/978-3-319- 98038-6

Schiaroli, V., Dangelico, R. M., & Fraccascia, L. (2024). Mapping sustainable options in the fashion industry: A systematic literature review and a future research agenda. *Sustainable Development*. https://doi.org/10.1002/sd.3129

Singhal, T. S., Jain, J. K., Ramacharyulu, D. A., Jain, A., Abdul-Zahra, D. S., Manjunatha, N., & Srivastava, A. P. (2024). Eco-design of products and processes: A review on principles and tools for sustainable manufacturing. *E3S Web of Conferences, 505*, 01033https://doi.org/10.1051/e3sconf/202450501033

Tan, E. S., Lee, A. W. L., Shekar, Y. C., & Tan, Y. S. (2024). Design for circularity: A framework for sustainable product redesign. *Procedia CIRP, 122*, 479–484.

https://doi.org/10.1016/j.procir.2024.01.070

Textiles. (2024). *Circularity-Gap.world*. https://circularity-gap.world/textiles

United Nations. (2025). *Sustainability*. https://www.un.org/en/academic-impact/sustainability

Vedsmand, T., Kielgast, S., & Cooper, R. G. (2016). Integrating agile with stage-gate: How new agile-scrum methods lead to faster and better innovation. *SE: Innovation Management*.

Woodside, A. G., & Fine, M. B. (2019). Sustainable fashion themes in luxury brand storytelling: The sustainability fashion research grid. *Journal of Global Fashion Marketing*. https://doi.org/10.1080/17569370.2019.1588435

Wordly. (2025). *Tools Higg Index*. https://worldly.io/tools/higg-index/

APPENDIX A: Questionnaire for European SMEs in the fashion industry

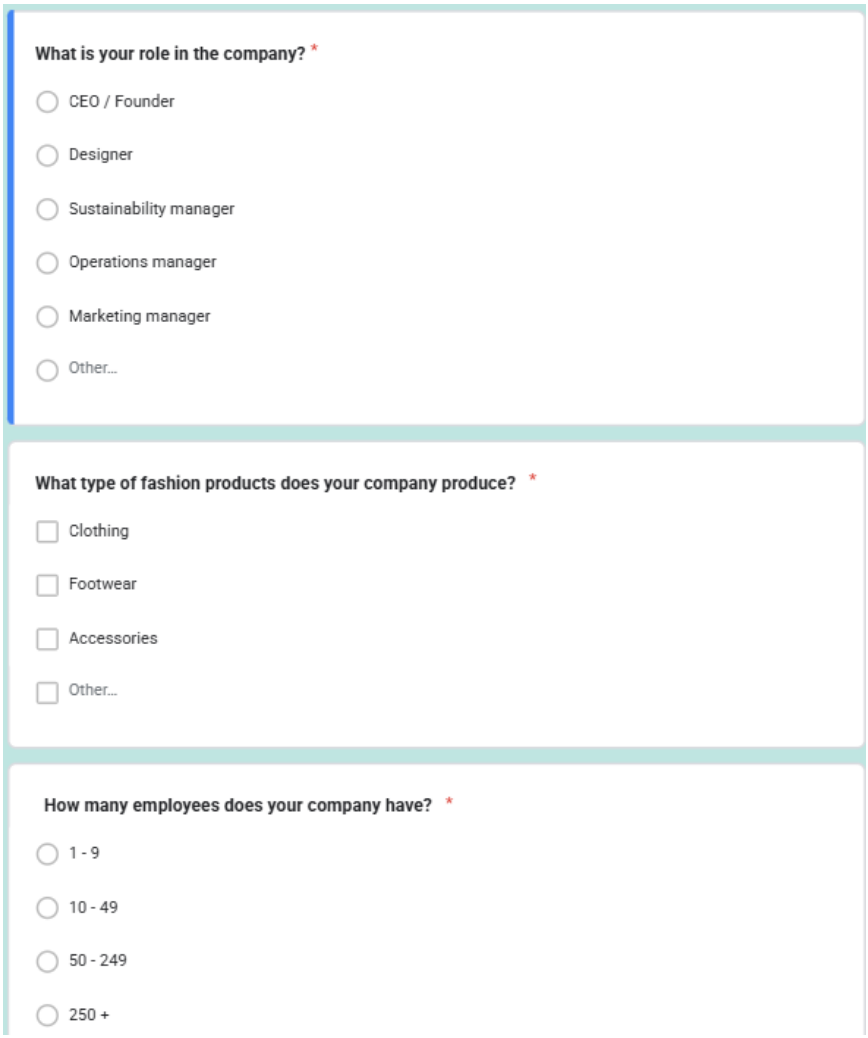
Survey: Circularity Strategies in European SMEs in the Fashion Industry

Dear Participant,

The survey is designed to determine **how small and medium-sized enterprises (SMEs) in the fashion industry integrate circularity strategies in their design processes in the early stages of decision-making**. Your insights will help me develop a framework to support SMEs in transitioning toward a more sustainable and circular approach.

The survey will take **approximately 10–15 minutes** to complete. Your responses, your identity, and the name of the company **will remain confidential** and will only be used for research purposes.

Thank you for your time and valuable insights!



What is your role in the company? *

- CEO / Founder
- Designer
- Sustainability manager
- Operations manager
- Marketing manager
- Other...

What type of fashion products does your company produce? *

- Clothing
- Footwear
- Accessories
- Other...

How many employees does your company have? *

- 1 - 9
- 10 - 49
- 50 - 249
- 250 +

Where is your company based? *

1. Austria
2. Belgium
3. Bulgaria
4. Croatia
5. Cyprus
6. Czechia
7. Denmark
8. Estonia
9. Finland
10. France
11. Germany
12. Greece
13. Hungary
14. Ireland
15. Italy
16. Latvia
17. Lithuania
18. Luxembourg
19. Malta
20. Netherlands
21. Poland
22. Portugal
23. Romania
24. Slovakia
25. Slovenia
26. Spain
27. Sweden
28. Other

Who in your company has the most influence on decisions about sustainability and circular strategies?

- ◯ Business Owner/CEO
- ◯ Designer
- ◯ Sustainability Team/Manager
- ◯ Other...

Which of the following factors influence design decisions the most in your company? *

- ◯ Material availability and cost
- ◯ Consumer demand and market trends
- ◯ Industry regulations and guidelines
- ◯ Environmental impact and sustainability goals
- ◯ Other...

Does your company implement circular economy strategies in the design of its products? *

- ◯ Yes, fully integrated
- ◯ Yes, partially integrated
- ◯ No, but planning to
- ◯ No

Which of the following circularity strategies does your company currently use? *(Select all that apply)* *

- [ ] Refuse - Avoiding the use of harmful materials during the design phase
- [ ] Rethink - Revaluate product design and business model to focus on circularity
- [ ] Reduce - Design products aiming for minimal material and energy usage to reduce waste
- [ ] Re-use - Designing products that can be easily reused
- [ ] Repair - Design products with features that allow easy repairs
- [ ] Refurbish - Design products that can be easily renewed or upgraded to extend their lifespan
- [ ] Remanufacture - Allowing product or textiles to be reused in the production of new items
- [ ] Repurpose - Designing products that can be repurposed
- [ ] Recycle - Designing garments with the intention of being fully recyclable
- [ ] None of the above

What are the primary reasons your company adopts circular design strategies for its products? *(Select maximum 3 options)* *

- [ ] Reducing environmental impact
- [ ] Meeting consumer demand for sustainable products
- [ ] Regulatory requirements or industry standards
- [ ] Cost reduction through material efficiency
- [ ] Improving brand image and reputation
- [ ] Innovation and differentiation in the market
- [ ] Other...

What are the biggest challenges your company faces when implementing circularity strategies? *(Select maximum 2 options)* *

- [ ] High costs of sustainable materials
- [ ] Lack of knowledge or expertise in circular design
- [ ] Limited availability of sustainable suppliers
- [ ] Lack of consumer demand for sustainable products
- [ ] No clear industry standards or guidelines
- [ ] Other...

Which of the following approaches related to circulatity does your company follow? *(Select all that apply)* *

- [ ] Zero-Waste - Design to minimize textile waste
- [ ] Slow Fashion - Prioritizing creating durable, timeless, and ethically made products
- [ ] Local Production
- [ ] Other...

How important is eco-design in the product development process if your company? *

	1	2	3	4	
Not important at all	○	○	○	○	Very important

What materials does your company prioritize in the design of products to ensure sustainability? (Select all that apply) *

- [ ] Recycled materials (e.g., recycled fabrics, plastics)
- [ ] Natural materials (e.g., organic cotton, wool)
- [ ] Biodegradable materials (e.g., plant-based fabrics)
- [ ] Upcycled or reclaimed materials
- [ ] Synthetic but sustainable materials (e.g., recycled polyester)
- [ ] Other...

Are you familiar with any of the following design tools and index? *(Select all that apply)* *

- [ ] Life Cycle Assessment (LCA)
- [ ] The Circular Design Guide by Ellen MacArthur Foundation
- [ ] Close The Loop tool
- [ ] Higg Index
- [ ] None of the above

How frequently does your company use these tools in decision-making processes related to sustainability? *

	1	2	3	4	5	
Never	○	○	○	○	○	Very frequently

Have any of the following regulations or policies influenced the product design choices of your company? (Select all that apply) *

- [ ] ESPR (Eco-Design for Sustainable Products Regulation)
- [ ] EU Waste Framework Directive (requirements for recycling and waste management)
- [ ] Extended Producer Responsibility (EPR) regulations
- [ ] National or regional policies promoting sustainable product design
- [ ] EU Green Deal
- [ ] No, regulations have not influenced our product design choices
- [ ] Not sure

Is your company pursuing or has it obtained any of the following certifications related to circular product design? *(Select all that apply)* *

- [ ] OEKO-TEX®
- [ ] Cradle-to-Cradle certification
- [ ] GOTS (Global Organic Textile Standard)
- [ ] EU Ecolabel
- [ ] Global Recycle Standard (GRS)
- [ ] NATURTEXTIL iVN certified BEST
- [ ] EPD (Environmental Product Declaration)
- [ ] ISO14001
- [ ] None of the above

APPENDIX B: Interview guide

1. Can you briefly describe your company (sector, size, main products/services), and what led you to adopt circular economy strategies
2. How are decisions regarding sustainability and the circular economy made in your company? Is there a dedicated team or is it a shared process?
3. What criteria guide your choices in terms of materials, design, and circularity? (e.g., environmental impact, economic feasibility)
4. Are there specific tools or indicators you use to support decision-making in the area of sustainability?
5. How do you make decisions regarding material selection (recycled, recyclable, innovative)?
6. Has your company adopted eco-design practices? If so, how are they integrated into the design process?
7. How do you address the challenge of avoiding the use of unsustainable materials and processes?
8. What measures have you adopted to reduce resource consumption and environmental impact? Do you have strategies for product reuse or repair?
9. How do you manage the end of life of your products? Are you able to adapt, remanufacture, or recycle them?
10. How do you balance economic needs with environmental ones in your business decisions?
11. What are the main obstacles or advantages you have encountered in adopting circular economy strategies?
12. How do you measure the success of your circular economy strategies? Do you use specific indicators or assessment methodologies?
13. What upcoming actions or initiatives does your company intend to introduce in the coming years in the field of circular economy?