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A Situational Analysis and an Action Strategy for the Circular Economy in the Textile Industry

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ABSTRACT

This study examines the transition from the traditional Linear Economy to the Circular Economy model, focusing on the Spanish textile industry. Given the sector's significant environmental impact, characterized by pollution, excessive water consumption, high waste generation, and the use of harmful materials, circularity emerges as a crucial strategy for fostering sustainability and resilience. Through a survey administered to a panel of experts, including industry managers, academics, policymakers, and practitioners, this research explores the sector's circular practices, key challenges, and future expectations. The collected data is analyzed using Principal Component Analysis to identify critical factors influencing the transition. Findings highlight the urgent need to shift away from the linear production model to minimize resource consumption and environmental impact. Based on these insights, the originality of this study lies in its proposed action strategy to advance circularity in the textile industry, which is intended to promote sustainable production, improve profitability, and enhance both customer and societal satisfaction.

1 | Introduction

Historically, driven by increasing consumer demand, companies have relied on a Linear Economy model characterized by the intensive exploitation of natural resources, the production of short-lived goods, and a high rate of waste generation. This approach has contributed to a severe environmental crisis. In contrast, the Circular Economy (CE) has emerged as a viable alternative to mitigate these impacts. Its core objective is to close the loop between manufacturers and consumers by maximizing the reuse of materials, reintegrating them into production systems, and minimizing waste. This model represents a fundamental shift in how society interacts with natural resources, aiming to prevent resource depletion, combat climate change, close energy and material loops, and promote sustainable development (Rashid and Malik 2023).

This study examines the current state of the CE adoption in the Spanish textile industry, focusing on its perception and implementation. The transition to a circular model in this sector seeks to improve product and service quality while advancing environmental regeneration and prioritizing the rights and equity of all stakeholders. By fostering distributed, diverse, and inclusive growth opportunities, the CE approach offers economic and environmental benefits, positioning the Spanish textile industry for a more sustainable future.

The textile sector was selected as the subject of this study due to its numerous challenges. Since the early 2000s, clothing consumption in high-income countries has increased rapidly, with global production doubling and per capita consumption rising by approximately 250% over the past five decades. This growth has been driven primarily by globalization, reduced manufacturing costs, and the expansion of the fast fashion model, which has significantly increased the number of garments purchased and discarded in affluent markets. The textile industry is among the most environmentally damaging sectors, contributing approximately 8%–10% of global CO_2 emissions, around 4% of global freshwater withdrawals, and nearly 20% of industrial water pollution worldwide. It is also responsible for about 9% of global municipal solid waste and contributes roughly 35% of microplastics released into the oceans, primarily through the washing of synthetic fibers (UNEP 2019). The environmental burden disproportionately affects developing countries, as negative impacts occur throughout the textile value chain (EPRS 2019). A lack of transparency in the industry exacerbates these issues: limited access to supply chain information enables unsafe working conditions and environmental harm while hindering accountability and delaying substantial reforms (Fashion Revolution 2023). Environmental concerns represent only one facet of the sector's challenges. Achieving sustainable growth necessitates improvements across all three pillars of sustainability: social, economic, and environmental (Raut et al. 2019).

This research is structured around two central questions: (1) What is the current state of the CE in the textile industry? And (2) How can a strategy be developed to facilitate the adoption of circular-based production systems? Addressing these questions will provide a framework for enhancing sustainability and environmental responsibility while ensuring compliance with regulatory and societal demands.

The main contribution of this study lies in the formulation of a strategic action plan that offers a holistic approach to implementing the CE principles within the textile industry. Based on a situational analysis of the Spanish textile sector, the proposed strategy addresses key challenges in the transition toward sustainability and provides a sector-specific framework that is both comprehensive and adaptable. Although prior research has explored circularity in textile industries in other countries, this study distinguishes itself through its integrated methodology and contextualized design, tailored to the Spanish case. Despite its contextual grounding, the results are generalizable and offer insights that can be applied to comparable national or regional settings.

This paper is organized into eight sections. Following the introduction, Section 2 presents the background, including a comprehensive literature review and a conceptual framework. Section 3 analyzes the current state of the Spanish textile sector, emphasizing its value chain and key industry data. The research methodology is described in Section 4, detailing the design and distribution of a questionnaire targeting sector experts. Principal Component Analysis is applied to extract relevant insights, which inform the discussion of results in Section 5 and underpin the development of a strategic action plan for implementing the CE in the textile sector, presented in Section 6. Section 7 presents the conclusions, and lists the references.

2 | Background

2.1 | Literature Review

The advancement of the CE has led to a substantial body of scholarly literature. Below, a selection of the most relevant contributions is reviewed, focusing on key works that have shaped the field. This analysis prioritizes publications from 2011 onward, a year widely recognized as a pivotal moment in the evolution of the CE, and presents them in chronological order.

Hu et al. (2011) explore the impact of the CE on enhancing eco-efficiency and resource productivity, highlighting the crucial role of industry in driving this transformation. Liu et al. (2012) present a pilot project aimed at achieving zero emissions, which makes a significant addition to sustainable development. Webster (2013) explores the fundamental differences between the CE and improvements achieved through reverse engineering of supply chains, offering a systematic perspective on CE's central role. Bonciu (2014) takes an optimistic view of the implementation of the CE within the European Union and the global context, drawing conclusions from an analysis of human activity throughout history. Andrews (2015) critiques the unsustainability of the linear economy and introduces the CE as a model for radical transformation. He emphasizes the role of designers as key contributors to this shift and concludes that the CE not only promotes education for sustainability but also enhances employability. Lieder and Rashid (2016) provide a comprehensive review of research articles covering aspects such as resource scarcity, waste generation, and economic advantages, with the aim of exploring the CE landscape in context, especially when considered simultaneously. A strategy based on the above pillars is implemented for environmental and economic regeneration. Mcdowall et al. (2017) present evidence of the CE implementation in China and Europe. China's approach to the CE is broad, addressing pollution and other environmental challenges in addition to waste and resource management, framed as a response to the environmental impacts of rapid growth and industrialization. In contrast, the European view of the CE is narrower, focusing primarily on waste, resource management, and business opportunities. Kirchherr et al. (2018) examine a representative sample of stakeholders to identify the barriers to the CE implementation, with companies and policymakers citing the lack of consumer interest and awareness, along with a hesitant business culture, as the main cultural obstacles. Corona et al. (2019) explore the rationale behind metrics used to assess the CE, aiming to evaluate them and provide recommendations for measuring circularity. Barreiro-Gen and Lozano (2020) emphasize the need for organizations to enhance their efforts in applying the 4Rs (reduce, reuse, recycle, repair) to better align theory with practice and contribute more meaningfully to the CE. They also advocate for a holistic implementation of the CE beyond organizational boundaries, through improved collaboration with external stakeholders. Fernández de Arroyabe et al. (2021) establish how the shift to circular business models could provide significant competitive advantages over companies that still operate under the linear model. After examining the CE transition in the technical and exterior textiles sector in the Netherlands, Hartley et al. (2022) conclude that, despite ongoing efforts, CE strategies have not yet achieved significant success. The authors identify several key barriers obstructing progress, including high production costs, low consumer awareness, and cultural challenges, among others. Furthermore, Reike et al. (2023) examine the CE transition in the textile sector within the framework of the Dutch “Circular Textile Mission.” They highlight the positive momentum generated in the secondhand clothing market and emphasize the significant technological advancements made possible through chemical recycling. Suárez-Visbal et al. (2023) highlight the fragmentation within the Spanish textile sector, where companies that implemented circular processes operate in isolation from one another. Wiegand and Wynn (2023) explore the role of digital technologies in supporting the transition of the German textile and clothing industry toward circularity. They conclude that companies are increasingly acknowledging the importance of adopting circular practices and the need for innovative business models, recognizing how digitalization can serve as a key enabler in meeting regulatory requirements and responding to evolving customer expectations. Ray and Nayak (2023) emphasize that the fashion industry is a major contributor to environmental degradation, driven by excessive consumption, substantial waste generation, and the unsustainable exploitation of natural resources. These challenges have far-reaching implications for ecological, social, and economic sustainability. They highlight the need for authentic marketing communication to support the advancement of sustainable fashion and identify several key areas for future research, including CE practices and sustainability-oriented innovation, particularly within emerging economies. Suárez-Visbal et al. (2024) emphasize the hyper-local vision of the circular companies in the Spanish textile sector, also noting that most of them adopt rental or recycling as their main circular strategies. Ramírez-Escamilla et al. (2024) analyze a range of strategies designed to reduce the rapid disposal of garments in the fashion industry. Among these, recycling, reuse, and repair were identified as the most effective approaches. However, none of these strategies have yet been fully successful due to various factors such as lack of key technology, supportive policies, or interest from consumers. Triguero and Córcoles (2025) explore the external influence of sustainability knowledge for Spanish companies in different stages of innovation toward circularity. They conclude that highly CE innovators typically prioritize collaboration with strategic actors in the production chain, particularly consumers and suppliers. In this context, vertical external knowledge proves to be the most valuable, whereas insights from competitors are of limited significance. Wynn and Wiegand (2025) provide a comparative, multi-country analysis of how sustainability, CE principles, and digitalization are being implemented across the European textile and clothing industry. Based on qualitative research conducted in nine countries (the United Kingdom, France, Turkey, Italy, Romania, Denmark, Portugal, Bulgaria, and Germany) and focusing primarily on small and medium-sized enterprises (SMEs), the authors examine the uneven progress in the CE adoption and the limited, yet emerging, role of digital technologies in enabling traceability, reverse logistics, and more sustainable supply chains. Their findings not only underscore the sector's capacity for adaptation but also emphasize the pivotal role of innovation, collaboration, and strategic foresight in shaping its future trajectory. Importantly, the study reveals that the pace and extent of transformation vary considerably across countries and firms, influenced by local market conditions, the availability of human and financial resources, and corporate culture.

Despite the growing body of literature on the CE, empirical research specifically addressing its application in the textile sector remains limited. Given this industry has traditionally followed a linear production model, there is a pressing need for a comprehensive framework to guide its transition toward circularity. This study aims to address this gap by providing a contemporary analysis of the textile industry, with special focus in Spain, alongside a strategic action plan to assist textile companies in transitioning into a circular production model. Additionally, the findings of this study may serve as a valuable resource for policymakers in formulating initiatives to encourage the adoption of circularity within the textile sector. Furthermore, this research contributes to overcoming a key barrier to the CE adoption among entrepreneurs by clarifying circular principles and outlining practical strategies for their implementation.

2.2 | Conceptual Framework

The concept of the CE originated in the 1970s as a response to rising energy costs and increasing unemployment. At that time, replacing energy-intensive processes with labor was proposed as a potential solution. The underlying principle of this approach was that manufacturing products from raw materials incur higher costs than remanufacturing, repairing, or recycling. Consequently, the CE encompasses two primary business models: those aimed at extending the useful life of products and those focused on reducing waste through recycling (Stahel 2016). In recent decades, numerous experts and institutions have attempted to define the concept of the CE. Kirchherr et al. (2017) analyzed different definitions from studies across various fields to develop a comprehensive and integrative definition. They proposed the following definition: "CE is an economic system that replaces the end-of-life concept with reduction, reuse, recycling, and recovery of materials in production, distribution, and consumption processes. It operates at the micro (products, companies, consumers), meso (eco-industrial parks), and macro (city, region, nation, and beyond) levels to achieve sustainable development that simultaneously promotes environmental quality, economic prosperity, and social equity, benefiting current and future generations. This is made possible through responsible business models and consumer behavior". The Ellen MacArthur Foundation (EMF 2024) describes the CE as a systemic framework aimed at addressing global challenges such as climate change, biodiversity loss, waste, and pollution. In the current linear economy, materials are extracted, products are manufactured and ultimately discarded as waste. By contrast, the CE seeks to eliminate waste from the outset. This philosophy is underpinned by three design-driven principles: eliminating waste and pollution, circulating products and materials at their highest value, and regenerating natural systems.

The CE seeks to achieve economic development without degrading the environment. The modern interpretation of circularity and its integration into economic systems and industrial processes has evolved to encompass various principles and concepts centered on the idea of closed cycles. Key theoretical influences include the cradle-to-cradle approach, loop and performance economics, regenerative design, industrial ecology, biomimicry, and the blue economy (Geissdoerfer et al. 2017). The CE is founded on the principles of "reduce, reuse, and recycle," which are implemented across five action areas: procurement, production, distribution, consumption, and recovery.

Successful adoption of these principles requires collaboration among small and medium-sized enterprises, larger corporations, and governmental institutions. At the micro level, smaller firms can create sustainable value through innovative products or services. At the meso level, industrial associations, clusters, or eco-industrial parks can facilitate the integration of circular practices and promote industrial symbiosis. At the macro level, institutions are responsible for developing and enforcing regulatory frameworks that support the effective adoption of the CE (Dey et al. 2020).

Institutions, aware of the need to promote a new production model, have enacted legislation to encourage the implementation of the CE. In 2020, the European Union created the Circular Economy Action Plan, which is part of the European Green Deal (EC 2020). In the same year, the Spanish government developed the Spanish Circular Economy Strategy, which identifies six key pillars. Among these is the textile sector (MITECO 2024a).

The CE also serves as a tool to help achieve the Sustainable Development Goals (SDGs) set by the 2030 Agenda adopted by the United Nations (UN 2024). They set goals and targets for both developing and industrialized countries, necessitating changes in their policies. The SDGs were defined with broad societal participation (Hickmann et al. 2023). Each SDG includes targets and implementation guidelines. Several SDGs share similarities with CE strategies, existing a direct relationship between 7 of the 17 goals: SDG 6: Clean water and sanitation; SDG 7: Affordable and clean energy; SDG 8: Decent work and economic growth; SDG 12: Responsible production and consumption; SDG 13: Climate action; SDG 14: Life below water; SDG 15: Life on land.

The International Organization for Standardization (ISO 2025) has established the ISO 59000 series of standards for the EC. This is a set of guidelines and frameworks aimed at promoting the adoption and implementation of circular practices. This series addresses various aspects of the CE, including terminology, business models, sustainability principles, and circularity metrics, providing businesses with comprehensive tools and best practices for transitioning to more sustainable and circular operations (Arana-Landin et al. 2024).

3 | Case Study: Textile Industrial Sector in Spain

The textile industry has become an essential part of people's lives. It is the third largest industry in the world, after the automotive and technology sectors. Textile production, which spans many countries and involves a long supply chain, is highly polluting. The manufacturing of fabrics and final products requires large amounts of water and energy, leading to high levels of waste and pollution (Jia et al. 2020). Due to its environmental and social relevance and impact, it is crucial to implement an environmentally friendly production model that ensures sustainable production and the industry's long-term viability in a world where resources are increasingly scarce, and consumers are demanding greater corporate responsibility.

The textile value chain consists of a series of steps to produce products primarily used in three areas: apparel, home textiles, and technical textiles (Alves et al. 2024). This chain is designed to support a wide distribution network. Additionally, it is characterized by a diversity of raw materials, technologies, and production methods (Raut et al. 2019). Focusing on the production process, the following activities stand out: raw material production, yarn production, fabric production, printing, dyeing and finishing, manufacturing, distribution, and sales (Alves et al. 2024). Of the entire value chain, 80% of activities are carried out in Asia. In Spain, the processes of yarn and fabric production, garment manufacturing, and sales and distribution are primarily carried out (Accenture 2022). In 2023, the industry employed more than 75 million people worldwide and had a market value of 1.75 trillion euros, accounting for 3.97% of the global market. The main exporter is China, and the leading importer is the USA. Moreover, exports have grown by an average of 7% per year since 2021 (OEC 2023).

In the European Union, the textile sector is highly relevant, with more than 1.3 million jobs and a turnover of 147 billion euros in 2021 (EC 2023). The country that stands out the most is Italy, which is the largest job creator, exporter, and country with the highest turnover. It is followed by countries such as Germany, France, and Spain (Euratex 2022). The Spanish textile sector has a long history. Until the end of the 1970s, it was strongly protected and focused mainly on the domestic market. Subsidies, a high level of protectionism, and low wages fueled sectoral growth, which resulted in an industry characterized by low productivity and overcapacity. The crisis at the end of that decade, along with changes in economic policies during this period, triggered a deep crisis in the sector and its subsequent transformation. In the 1980s, the sector saw a rise in production, thanks to the creation of several firms such as Inditex and Mayoral. These firms, along with others, contributed to the advancement of the industry in Spain (Costa and Duch 2004).

The sector is divided into three categories: footwear and leather, textile industry, and apparel. This division reflects heterogeneity in the technologies required in each area. In terms of their relative importance within the industry, the three activities are balanced. However, in Spain, the category with the greatest weight is textile manufacturing. In 2023, Spain had 5953 companies in the textile industry subgroup, 8063 in the clothing manufacturing subgroup, and 3465 in the footwear and leather industry (INE 2023). The sector is composed of relatively small-sized companies. Less than 0.1% of companies employ more than 250 people, meaning that many firms lack the resources to invest in new technologies. This results in low productivity, estimated at around 32,000 euros in added value per person. In comparison, the pharmaceutical sector achieves 127,000 euros, highlighting the need for change in the textile industry (Medina et al. 2019).

Several factors influence the adoption of the CE in companies, including the current industrial landscape, the legislative framework, and the state of development of a collaborative economy. The Spanish textile sector is organized into clusters across various regions of the country, with a significant proportion of SMEs. While companies in Spain are generally familiar with the concept of the CE, only a few have successfully implemented it. Moreover, most SMEs are either unaware of circularity or perceive the substantial investments required

TABLE 1 | Examples of good practices in textile companies.

Renewable resources and optimization	*Environmental impact reduction* *Hydro Color*: Equipped with a Heat Recovery System (HRS) for gas filtration, capable of removing oils and paraffins from the vapors generated during its processes. *Regenerative agriculture and biomaterials* *Filippa K*: Imports wool from Sweden from meat industry waste; they obtain a product with greater traceability and reduce the amount of waste.
Product as a service	*Clothing rental* *Ecodicta*: Dedicated to clothing rental with maintenance and cleaning services, thereby extending the lifespan of garments and reducing waste
Product life extension	*Repair of parts* *Nudie Jeans*: Offers in-store jeans repair services, as well as repairs through partner locations or via a repair kit sent to customers. Produces durable garments using quality materials and processes. *Second-hand sales* *Percentil*: Sells second-hand clothing in Spain. Since 2012, their efforts have helped avoid the production of 1,383,000 new clothing items. *Micolet*: A Spanish brand committed to circularity that buys and sells second-hand clothes. *Long life products* *Sepiia*: A brand that produces in Portugal and Spain using recycled and recyclable materials. In addition to ensuring the highest quality, its anti-stain and breathable fabric technologies reduce the number of washes required, thereby prolonging the garment's useful life and reducing water consumption.

(Continues)

TABLE 1 | (Continued)

Waste recovery	*Recycling of textile materials* *Texlimca*: Manages pre- and post-consumer garments for recycling using innovative machinery. Processes include garment classification, removal of non-textile elements, production of secondary raw materials, and reintegration into manufacturing.

for its implementation as a barrier. Despite these challenges, there are examples within Spanish industry where circular practices have been adopted. Table 1 lists effective circularity strategies (Accenture 2022).

4 | Research Methodology

This research focuses on the exploration and analysis of the CE practices applied to the Spanish textile industry. To deepen understanding in this area, a methodology has been developed consisting of several research and analysis phases. Specifically, this study employs a survey as the primary tool for data collection. The survey method was chosen for its ability to capture accurate and relevant information regarding the perceptions, opinions, and behaviors of the target population, which in this case consists of Spanish companies operating in the textile industry and a sample of professional experts in the textile sector. Furthermore, the survey enables access to a representative sample that mirrors the diversity of perspectives within the research group.

4.1 | Research Design

The objective of this research is to analyze the current state of the CE practices and to establish a strategy enabling companies in the textile industrial sector to implement production systems aligned with this philosophy. Achieving this goal requires comprehensive information about these companies and their relationship with the CE. To gather this information, a questionnaire will be carried out. This questionnaire integrates both objective and subjective techniques to collect data on various aspects, including company characteristics (such as size and turnover among other factors), the degree of CE implementation, and broader perspectives on the potential advantages and disadvantages of adopting the CE. Additionally, the questionnaire includes a section exploring the relationship between the CE and the SDGs. The primary focus of the questionnaire will be quantitative, utilizing a Likert-type scale for responses. The insights gained from this questionnaire, combined with findings from prior bibliographic research, will facilitate the formulation of a new sustainability strategy for the Spanish textile industry.

TABLE 2 | Selection criteria of companies by main activity.

Main activity	Decision	Main activity	Decision
Garment manufacturing	Selected	Sun protection textiles	Not selected
Yarn and textile fabric preparation	Selected	Technical textiles	Not selected
Garment finishing processes	Selected	Automotive and vehicle textiles	Not selected
Finished home textile products	Selected	Clinical textiles	Not selected
Upholstery and decorative fabrics	Selected	Hospitality textiles	Not selected

4.2 | Sampling Procedure

The primary objective of a survey is to collect information about the target population. However, surveying the entire target population is often too extensive, costly, or impractical. As a result, the necessary information is typically gathered through a sample. A sample is defined as a subset of the target population, carefully selected to ensure that its composition and characteristics are representative of the overall population (Stoop and Harrison 2012).

In this study, the target population comprises textile companies specializing in the production of clothing and home textiles, with all or a significant portion of their manufacturing based in Spain. Due to the potential for low response rates from these companies, a secondary questionnaire with minor modifications will be distributed to experts in the sector. A voluntary or convenience sampling methodology has been employed for sample selection. This approach involves respondents being self-selected by the authors. Unlike random sampling, where each individual in the population has a known probability of being chosen, in this case, the probability of selection for each member is unknown (Rocco and Oliari 2007). While this type of sampling may introduce biases or errors, it is considered the most suitable method given the characteristics of the target population.

First, the sample of companies was determined. The SABI platform, a financial and analytical database containing information on over 2,900,000 Spanish companies and 900,000 Portuguese companies, was used for this purpose (SABI 2024). Filters were applied to narrow the search, focusing on the textile industry and garment manufacturing. This search yielded a total of 14,373 companies, which were ranked from highest to lowest based on their operating revenues for the most recent available year. The selected data were then exported to an Excel spreadsheet. The following data were obtained for each company: name, VAT number, location, country, consolidation code, last available year, and operating income. The population was further refined by including only companies with operating revenues exceeding 10,000 euros in the last year. This threshold was chosen under the assumption that larger companies are more likely to adopt sustainability-focused strategies in their production processes. This refinement resulted in a list of 279 companies. Subsequently, all companies that had not updated their information on SABI since 2015, as well as those marked as extinct or in liquidation, were excluded from the sample. This process reduced the list to 209 companies. Additional information was incorporated, including contact details, number of employees, and primary activities. These activities were categorized into clusters, from which companies focused on clothing and home textiles were selected (see Table 2).

The sample consists of 145 companies, of which 117 are focused on apparel and 28 on home textiles. The sampling process is shown in Figure 1.

The sample of professional experts in the textile sector was created using a different approach, as no specific database was available. The selection included key organizations and associations related to the textile sector in Spain, along with experts affiliated with professional journals, certification bodies, and consulting firms. Experts from the textile sector, with knowledge of or involvement in sustainability-related activities, particularly in the CE, were specifically sought. Furthermore, all participants possess a minimum of 2 years of experience within the textile industry. Table 3 presents the list of experts and their activity.

4.3 | Questionnaire Design

A questionnaire was designed to gather informed judgment from a panel of experts regarding key aspects of the CE implementation and to assess the degree of development of the CE in the Spanish textile industrial sector (INSST 2018). The questionnaire is tailored to the profile of the participating experts and consists of eight thematic sections, each containing various questions and focusing on a critical dimension relevant to the CE adoption in the textile sector: 1. Contextual information related to the experts' background and expertise; 2. General perceptions of the CE; 3. Knowledge of CE strategies; 4. Perceived barriers to the CE; 5. Enablers for the CE; 6. Alignment of the CE and the Sustainable Development Goals (SDGs); 7. Benefits of the CE; 8. Disadvantages of applying the CE. The selection of questions for each section of the questionnaire was based on a thorough review of existing scientific literature on the CE, particularly studies identifying key barriers, enablers, benefits, risks, and strategic implementation pathways (Kirchherr et al. 2017; Ritzén and Sandström 2017; Accenture 2022).

Throughout the questionnaire development process, items were formulated to be concise, neutral, and unambiguous. Before full deployment, it was reviewed by a group of 20 experts to assess face validity, clarity, and coherence. Minor adjustments were made based on their feedback to ensure

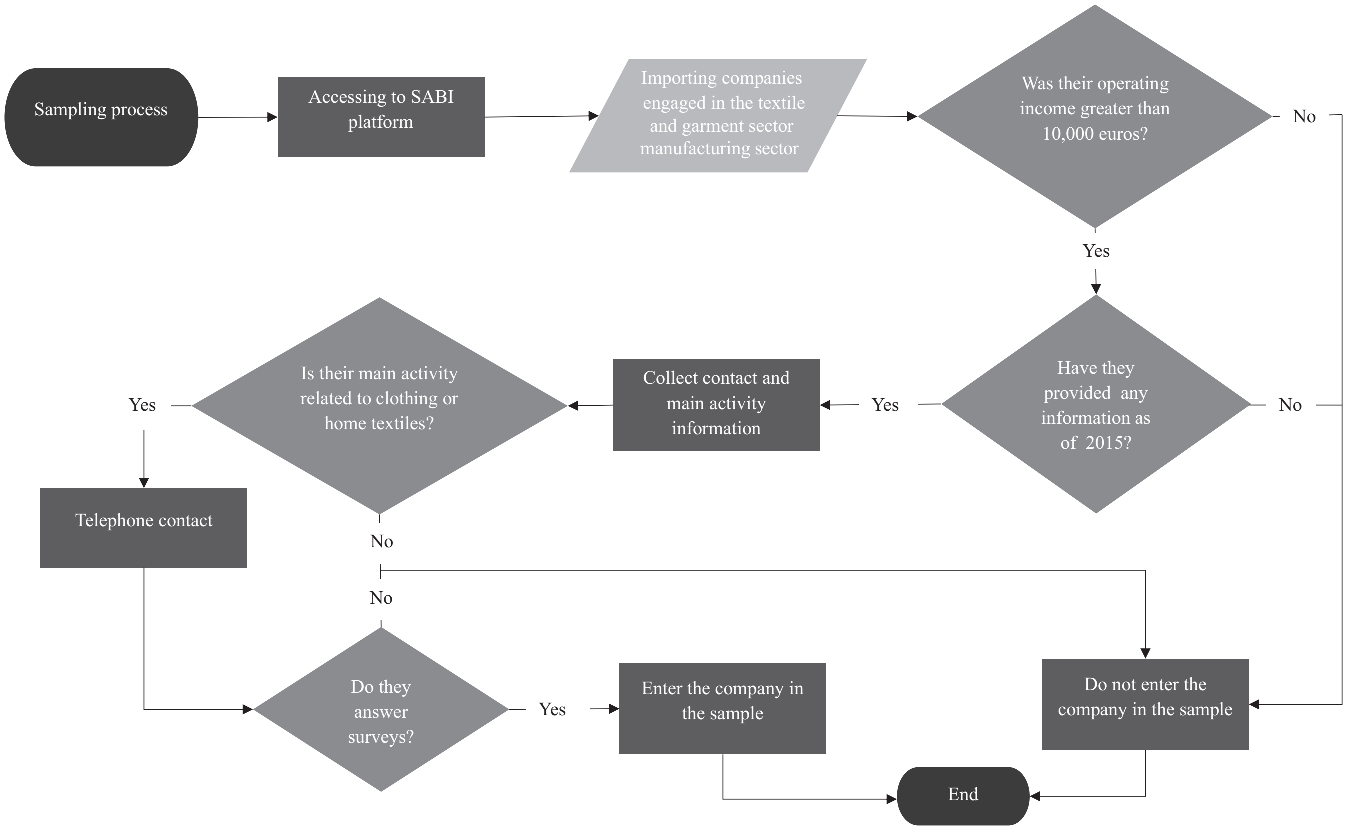

FIGURE 1 | Sampling process.

TABLE 3 | Distribution of professional experts by main activity.

Experts	Activity in the textile sector	Experts	Activity in the textile sector	Experts	Activity in the textile sector
1	Branding agency	23–36	Consulting firm	45–49	Foundation
2–7	Academic institution	37–41	Circular textile company	50–51	Government institution
8–19	Association	42–43	Certification body	52	Employer
20–22	Research center	44	Freelance	53–54	Professional journal

the instrument's relevance and comprehensibility. As a result, the final set of questions ensures alignment with both theoretical frameworks and practical knowledge of the CE implementation.

Each question on the questionnaire was formulated as a statement to be rated using a Likert-type scale from 1 to 5, where 1 represents the lowest level (strongly disagree, very low, not at all useful, not at all related), and 5 represents the highest (strongly agree, very high, very useful, very related). This scale was chosen due to its suitability for capturing degrees of expert consensus and divergence, a common practice in structured expert elicitation methods such as the Delphi technique (Hasson et al. 2000). The use of a Likert scale enables not only descriptive statistical analysis but also the identification of trends and priorities across expert groups.

Table 4 provides a detailed overview of the questionnaire's structure and content.

4.4 | Questionnaire Validation

Following the pilot phase of the questionnaire, specific parameters were established to ensure compliance with certain criteria (Rodríguez-Rodríguez and Reguant-Álvarez 2020). Subsequently, its reliability was assessed using Cronbach's Alpha coefficient, which evaluates the consistency of responses when the assessment process is repeated. In other words, it reflects the extent to which the questions accurately capture their intended content, regardless of the respondent or the timing. This coefficient is expressed as a positive decimal value ranging from 0 (no reliability) to 1 (perfect reliability). There is no universally accepted threshold for interpreting Cronbach's Alpha, as its evaluation depends on the context and potential errors inherent in its calculation. Generally, a value of 0.7 or higher is considered indicative of acceptable reliability, values above 0.8 reflect good reliability, and values exceeding 0.9 denote excellent reliability. For this questionnaire, a Cronbach's

Alpha of 0.914 was obtained, indicating a very high level of reliability.

4.5 | Survey Phase

The survey phase involved contacting experts, including companies and professionals associated with the textile sector. A representative sample of 145 companies and 54 professional experts was selected. Among the companies, 25 declined to participate due to privacy concerns, leaving 120 companies in the sample. Including the 54 professional experts, the total sample size amounted to 174 participants. The questionnaire was distributed via email through a web link. Responses were received from 37 participants: 24 from companies and 13 from individual professionals. This resulted in a response rate of 21.26%, notably higher than the typical rate of 10%–12% (Plaza et al. 2011).

4.6 | Methodoloy of Data Processing and Analysis

Principal Component Analysis (PCA) was employed to analyze the data collected in the survey. This statistical technique examines datasets where responses are described by multiple interrelated quantitative variables. Its primary objective is to extract relevant information, represent it through new variables called Principal Components (PCs), and reveal patterns of similarity between responses and variables. By reducing the dimensionality of large datasets using vector transformation, PCA allows the original dataset to be interpreted using a smaller set of variables, the PCs. This facilitates the identification of trends, patterns, and outliers (Abdi and Williams 2010). PCA involves three key steps. First, the available data are checked to ensure they meet the necessary requirements for analysis. Next, the main factors that group the analyzed variables are extracted. Finally, these extracted factors are interpreted following their rotation (Sarstedt and Mooi 2019). To conduct PCA, the number of initial variables must be reduced according to specific criteria. First, the questions deemed most important by the experts surveyed were selected. Additionally, variables identified as relevant through the descriptive statistical analysis were included. This process resulted in a list of 22 variables. Variables with low communalities (<0.5) or insufficient correlation with the rest were subsequently eliminated, reducing the set of questions to 19. After confirming the relevance of these questions with the experts, the procedure proceeded.

Once the final list of variables is established, all the data is analyzed using the SPSS software platform. The adequacy of those data is evaluated. The process begins by verifying the reliability of the variable set using Cronbach's Alpha coefficient. Next, the correlation among variables is analyzed, as PCA relies on sufficient intercorrelations. To assess this, the Kaiser–Meyer–Olkin (KMO) criterion and Bartlett's test of sphericity are applied. The KMO criterion measures sample adequacy and evaluates whether the partial correlations between variables are appropriate. Bartlett's test, on the other hand, checks whether the correlation matrix is significantly different from an identity matrix. A significant result indicates that the variables are interrelated and suitable for factor analysis (Sarstedt and Mooi 2019). For the data to meet the KMO criterion, its value must exceed 0.5 (Sarstedt and Mooi 2019). In Bartlett's test, a p-value below 0.001 leads to the rejection of the null hypothesis, confirming that the correlations are sufficiently strong to proceed with factor analysis (Rajput and Singh 2019). The data suitability study to initiate the PCA yielded these results: *Cronbach's alpha coefficient*: 0.814. This value indicates that the reliability of the variables is very good (Rodríguez-Rodríguez and Reguant-Álvarez 2020). *KMO criterion*: 0.681. Value higher than that required to perform the PCA (0.5), confirming sufficient correlation between the variables (Sarstedt and Mooi 2019). *Bartlett's test of sphericity*: 0.00. Value lower than the 0.001 required to consider the test as satisfactory (Rajput and Singh 2019).

Next, the table of communalities was generated (see Table 5). Communalities indicate the proportion of variance in each variable that is accounted for after factor extraction. For the extracted factors to be considered valid, they must explain at least 50% of the variance in the variables. In other words, the communalities should exceed 0.5 (Sarstedt and Mooi 2019).

All communalities exceed 0.5, so it is not necessary to eliminate any variables. The next step is the extraction of factors. To facilitate analysis, the components will be rotated using the Varimax method. While not mandatory, this approach simplifies the interpretation of the results and is particularly recommended when analyzing a large number of variables (Sarstedt and Mooi 2019). In this case, five factors were extracted, collectively explaining 70.68% of the total variance. The first factor (PC1) accounts for 17.60% of the variance, the second factor (PC2) explains 17.02%, and the third factor (PC3) contributes 14.89%. The fourth factor (PC4) accounts for 11.58% of the variance, while the fifth factor (PC5) explains 9.62%. The results are summarized in Table 6.

As a final step, the questions are grouped into the five factors identified. This is done by examining the table of rotated factors. Variables are assigned to factors based on their factor loadings, with the highest loading for each variable highlighted in bold in Table 7.

5 | Results and Discussion

After the previous grouping, each extracted component is discussed. Each principal component (PC) receives a name according to the variables it includes. Thus, the following can be observed:

5.1 | PC1: Essential Enablers for Undertaking the CE

This component accounts for 17.598% of the total variance and includes five variables that can be considered key enablers in the transition to the CE. According to Dissanayake and Weerasinghe (2022), five groups of actions are recognized for classifying the CE enablers. Variable 2.10, with a factor loading of 84.2%, falls under the enabler group "increase consumer participation". Variables 5.2 and 5.6, with factor loadings of 82.3% and 64.6% respectively, belong to the "technology and innovation" group. Variables 5.11 and 6.8, with factor loadings of

TABLE 4 | Questionnaire structure and content.

Section 1: General Information (Company Experts)
1.1. How many employees does your company currently have?
1.2. What has been the turnover of your company in the last year?
1.3. Do you recognize any application of the Circular Economy in your company?
1.4. Does your company have objectives and mechanisms to manage the Circular Economy?
1.5. Does your company have a direct responsible for Circular Economy/sustainability?
1.6. Does your company have any sustainability strategy currently under development?
Section 1: General Information (Other Experts)
1.1. What type of organization do you participate in related to the textile industry?
1.2. How many years have you been working in activities related to the textile industry?
Section 2: General Questions on the Circular Economy
2.1. Need for transition from the current linear model to the circular model.
2.2. Contributes to the protection of the environment.
2.3. It boosts R&D&I and the application of new technologies.
2.4. Stimulates the competitiveness of companies.
2.5. Benefits the economy, employment and local industry.
2.6. Extends the life cycle of products.
2.7. It is difficult to implement in the current economic model.
2.8. Government policies exist to facilitate its development.
2.9. Companies are motivated to move to the circular model.
2.10. There is a need for more sustainable and responsible consumption habits.
Section 3: Strategies Aligned with the Circular Economy in the Textile Company or Sector
3.1. Energy management and use of renewable energies.
3.2. Corporate social responsibility.
3.3. Elimination of inefficiencies in production.
3.4. Extension of the useful life of products, equipment and raw materials.
3.5. Integral waste management.
3.6. Use of sustainable materials.
3.7. Use of products as services through subscription or rental.
Section 4: Barriers to the Adoption of the Circular Economy in the Textile Sector
4.1. Lack of support from the administrations.
4.2. Unclear norms and regulations.
4.3. Low consumer awareness.
4.4. Unavailable or inadequate financing.
4.5. Key transition technologies not sufficiently developed.
4.6. Lack of collaborative culture among the different areas of the company.
4.7. High investment costs to modernize production systems.
4.8. High shareholder expectations.
4.9. Short-sightedness in setting the company's objectives.

(Continues)

TABLE 4 | (Continued)

4.10. Insufficient employee training.
Section 5: Enablers for the Adoption of the Circular Economy in the Textile Sector
5.1. Use of new textile materials.
5.2. Equipment for collection, separation, recycling and valuation of resources.
5.3. Platforms for shared use of resources or services.
5.4. New technologies.
5.5. Use of energy from renewable sources.
5.6. Extending the useful life of garments and materials.
5.7. Technologies for the reduction of water consumption.
5.8. Reduction in the use of harmful chemical substances.
5.9. Imposition of a green tax if materials are not recovered.
5.10. Extended Producer Responsibility.
5.11. Subsidies, aid and soft loans for investments in technologies for the transition to the CE.
Section 6: Circular Economy and Sustainable Development Goals (SDGS)
6.1. Are you aware of the Sustainable Development Goals proposed by the United Nations?
6.2. Do you consider the Circular Economy a valid tool to achieve these goals?
Evaluate the relationship between the following Sustainable Development Goals and the Circular Economy.
6.3. SDG 6: Clean water and sanitation.
6.4. SDG 7: Affordable and clean energy.
6.5. SDG 8: Decent work and economic growth.
6.6. SDG 9: Industry, innovation and infrastructure.
6.7. SDG 11: Sustainable cities and communities.
6.8. SDG 12: Responsible production and consumption.
6.9. SDG 13: Climate action.
6.10. SDG 14: Underwater life.
6.11. SDG 15: Life of terrestrial ecosystems.
Section 7: Benefits of the Circular Economy in the Textile Sector
7.1. Helps to meet strategic sustainability objectives.
7.2. Establishes a guideline for better resource utilization.
7.3. Increased customer satisfaction.
7.4. Increased profitability and competitive advantage.
7.5. Implies greater employee commitment.
7.6. Reduced greenhouse gas emissions.
7.7. Reduced dependence on suppliers.
7.8. Savings in production costs in the medium and long term.
7.9. Improved collaboration between companies in the sector.
7.10. Improved market share.
Section 8: Disadvantages of Applying the Circular Economy in the Textile Sector
8.1. Loss of competitive advantage with respect to less sustainable competitors.

(Continues)

8.2. Loss of customers and suppliers due to lack of environmental awareness.
8.3. Reduction of profits due to the need to invest in sustainability.
8.4. Impossibility of using certain raw materials because they are difficult to recycle.
8.5. Difficulty in collaborating with other companies in the textile sector.
8.6. Higher production costs.

72.4% and 68.9% respectively, align with the "policy implementation" group. These enablers can be linked to the stakeholders' needs, identified by De Felice et al. (2025). They highlight how consumers are increasingly demanding a more sustainable approach to textile production, favoring recycled and upcycled products, which are reflected in variables 2.10, 5.6, and 6.8. Textile companies also seek stronger government support through policies, regulations, and economic incentives, which corresponds to the enabler identified in variable 5.11. This component leads to two more considerations. Firstly, the responses show the presence of actions classified as enablers in Sections 2 and 5 of the survey. Secondly, out of the five key action groups identified in the literature, only three are represented in the extracted components. Notably absent are enablers related to education and awareness and the creation of efficient reverse logistics processes.

5.2 | PC2: Business Model and Its Objectives

This component accounts for 17.019% of the total variance and includes the following variables: 3.7, with a factor loading of 68.5%; 7.4, with a factor loading of 82.6%; 7.8, with a factor loading of 75.6%; 7.9, with a factor loading of 59.2%; and 7.10, with a factor loading of 80.9%. This second component highlights Variable 3.7, which relates to a potential business model based on the CE principles, such as offering products as services through subscription or rental models. Additionally, it incorporates four variables that represent key objectives for companies adopting such a business model. Schwanholz and Leipold (2020) describe how clothing rental platforms aim to achieve several goals: improving resource efficiency, uncovering new business opportunities, promoting sustainability, and fostering social cohesion. These objectives align with Variables 7.8, 7.9, and 7.10. Wynn and Wiegand (2025) highlight the importance of innovative and collaborative approaches within the textile industry and with academic institutions, exemplified by the case of Italy or Portugal. This observation aligns with Variable 7.9.

5.3 | PC3: Barriers to the CE Implementation

This component, accounting for 14.889% of the total variance, consolidates four variables from section four of the questionnaire: Variable 4.1, with a factor loading of 71.4%; 4.2, with a factor loading of 69.8%; 4.4, with a factor loading of 80%; and 4.7, with a factor loading of 56.4%. These difficulties have been identified in the implementation of the CE in the textile sector. Wynn and Wiegand (2025) provide empirically grounded, policy-relevant insights into the barriers and enabling factors shaping circular and digital transitions within the textile and clothing sector, one of Europe's most resource-intensive industries. Although digital technologies play a pivotal role in facilitating this transformation, their adoption remains constrained by the complexity and substantial costs associated with implementing innovative business models. This challenge is evident in countries such as Germany, Denmark, and the United Kingdom, among other European nations. Akash et al. (2025) identify similar barriers, including structural limitations, regulatory gaps, and financial constraints, in the textile sector in Bangladesh. The previous variables correspond to a set of barriers frequently identified in studies on the implementation of the CE systems across various contexts, not limited to the textile industry. For instance, Rizos et al. (2016) analyzed 52 European SMEs that had successfully adopted circular systems, and similar barriers were observed. Over half of the sample cited a lack of financing as one of the most significant challenges. This finding aligns with variables 4.4 and 4.7. Additionally, a quarter of the SMEs reported that insufficient government support, such as ineffective legislation and inadequate collaboration with local authorities, posed a major obstacle to the CE. This issue corresponds to variables 4.1 and 4.2. Araujo-Galvão et al. (2018) conducted a literature review of 195 articles on the implementation of the CE and categorized the potential barriers into seven groups. According to this classification, variables 4.1 and 4.2 are categorized as "policy and regulatory" barriers, while variables 4.4 and 4.7 are classified as "financial and economic" barriers. These barriers, identified in the textile sector, are observed to hinder the CE across various industries. Thus, four key barriers have been identified as particularly relevant.

5.4 | PC4: Most Relevant Challenges for Developing the CE

This component accounts for 11.557% of the total variance and includes the following variables: 2.1, with a factor loading of 72.2%; 4.3, with a factor loading of 68.1%; and 8.6, with a factor loading of 58.8%. Research conducted in the textile industry in the Netherlands highlights several significant barriers to its transition toward the CE. These include the high costs of producing and selling circular products, a lack of consumer awareness and interest, and cultural challenges tied to the enduring dominance of a linear system (Hartley et al. 2022; Saha et al. 2021). These three challenges align closely with those represented in this component. The primary conclusion is the striking similarity between the key barriers or challenges faced by industries in different countries. This underscores the essential importance of establishing regulations and action plans at an international level, such as those adopted by the European Union.

TABLE 5 | Communalities obtained after the extraction of principal components.

Variable	Initial	Extraction
2.1. Need for a transition from the current linear model to the circular model.	1.000	0.779
2.10. There is a need for more sustainable and responsible consumption habits.	1.000	0.864
3.4. Extension of the useful life of products, equipment and raw materials.	1.000	0.805
3.7. Use of products as services through subscription or rental.	1.000	0.598
4.1. Lack of support from the administrations.	1.000	0.582
4.2. Unclear rules and regulations.	1.000	0.758
4.3. Low consumer awareness.	1.000	0.627
4.4. Unavailable or inadequate financing.	1.000	0.679
4.7. High investment costs to modernize production systems.	1.000	0.681
5.2. Equipment for collection, separation, recycling and valuation of resources and materials.	1.000	0.813
5.6. Extending the useful life of garments and materials.	1.000	0.655
5.11. Subsidies, aid and soft loans for investments in technologies for the transition to the CE.	1.000	0.653
6.8. SDG 12: Responsible production and consumption.	1.000	0.568
7.4. Increased profitability and competitive advantage.	1.000	0.735
7.8. Savings in production costs in the medium and long term.	1.000	0.589
7.9. Improved collaboration between companies in the sector.	1.000	0.777
7.10. Improved market share.	1.000	0.777
8.5. Impossibility of using certain raw materials because they are difficult to recycle.	1.000	0.813
8.6. Higher production costs.	1.000	0.678

5.5 | PC5: Problem-Solution Relationship

This component, accounting for 9.619% of the total variance, includes variable 3.4, with a factor loading of 83.7%, and variable 8.4, with a factor loading of 60.9%. In a production system, challenges often arise when recycling materials. Huether et al. (2022) categorize these challenges into three groups: the impossibility of closed cycles due to dissipation, the impracticability of fully recycling composite materials, and the inability to achieve a holistic life cycle assessment. PC5 is closely associated with the second group mentioned. Recycling composite materials is particularly challenging due to their composition. During production, two or more materials are combined, and separating them at the end of the product's life cycle becomes impossible. These composites are primarily valued for enhancing physical properties such as durability. Variable 8.4 pertains to these challenges and highlights the need to create durable products with alternative materials. The use of composite materials should be limited to cases where they are absolutely necessary. This proposed solution also aligns with variable 3.4, which is included in this component. Finally, it is worth mentioning that these two practices cannot be considered mutually exclusive. In some textile industries, such as the Japanese one, recycling (to close the loops) and durable products (to slow down the loop) are considered key approaches to circularity (Herrado and Imanishi 2025).

Table 8 gives a summary of the previous results.

6 | Proposal for Action

The proposed action plan includes five strategic activities to address the issues identified with the PCA for implementing the CE practices in textile companies: (i) Setting sustainability objectives; (ii) Ecodesign; (iii) Analyzing costs and financing options; (iv) Implementing a circular model within the value chain; and (v) Awareness raising. These activities will be explained in this section.

6.1 | Justification

The transition to the CE requires a multifaceted approach to address the diverse challenges and opportunities faced by industries. The analysis of five key components, PC1 through PC5, provides a framework for understanding the critical activities, strategies, and barriers involved in adopting circularity practices and promoting sustainable development, particularly in the textile sector. PC1 emphasizes the activities of ecodesign, setting sustainability objectives, and analyzing costs and financing options. These elements are essential for integrating circular technologies, improving corporate environmental responsibility, and securing the resources needed. PC2 focuses on implementing a circular model within the value chain, particularly through innovative platforms that enable the use of products as services, such as rental or subscription models. PC3 addresses the significant barriers companies face in initiating circular projects. It highlights the importance of raising consumer awareness and analyzing financial options as key activities to overcome these obstacles. PC4 identifies additional challenges, including low consumer awareness and the financial burdens of circularity. To combat these issues, it recommends a combination of awareness raising, cost analysis, and

TABLE 6 | Total variance explained and extraction of principal components.

Component	Initial eigenvalues			Sums of squared extraction charges			Sums of loads squared by rotation		
	Total	% of variance	% accumulated	Total	% of variance	% accumulated	Total	% of variance	% accumulated
PC1	5.463	28.751	28.751	5.463	28.751	28.751	3.344	17.598	17.598
PC2	3.154	16.602	45.354	3.154	16.602	45.354	3.234	17.019	34.617
PC3	2.025	10.659	56.012	2.025	10.659	56.012	2.829	14.889	49.505
PC4	1.592	8.381	64.393	1.592	8.381	64.393	2.196	11.557	61.063
PC5	1.195	6.288	70.682	1.195	6.288	70.682	1.828	9.619	70.682
PC6	0.925	4.868	75.550						
PC7	0.800	4.209	79.758						
PC8	0.716	3.768	83.526						
PC9	0.601	3.164	86.690						
PC10	0.517	2.721	89.411						
PC11	0.478	2.513	91.924						
PC12	0.365	1.918	93.843						
PC13	0.286	1.506	95.348						
PC14	0.234	1.230	96.578						
PC15	0.198	1.041	97.619						
PC16	0.150	0.792	98.411						
PC17	0.143	0.753	99.164						
PC18	0.092	0.483	99.647						
PC19	0.067	0.353	100.000						

a circular model in the value chain as practical solutions. PC5 highlights the role of ecodesign as a critical tool for extending the lifespan of products made from materials that are difficult or impossible to recycle. By focusing on this activity, companies can improve sustainability while addressing material-related challenges. Together, these five components provide a comprehensive roadmap for facilitating the CE in the textile industry. In particular:

6.1.1 | PC1: Key Activities

This component is related to ecodesign, the establishment of sustainability objectives, and the analysis of costs and financing options. Ecodesign serves as a crucial tool for integrating more circular technologies into production processes, such as extending the useful life of garments. Setting sustainability targets helps create a corporate image that is strongly aligned with environmental responsibility. This, in turn, positively influences consumer engagement by conveying a clear message about the company's strategic direction. Analyzing costs and financing options provides companies with the necessary resources to initiate the transition to the EC.

6.1.2 | PC2: Circular Model in the Value Chain

For this component, the strategy focuses on implementing the CE model in the value chain. This involves creating platforms that facilitate the use of products as services, such as through rental or subscription-based models.

6.1.3 | PC3: Overcoming Barriers

This component identifies the primary challenges companies face when initiating circular projects. Raising consumer awareness and conducting an analysis of costs and financing options are regarded as the two critical activities for overcoming these obstacles.

6.1.4 | PC4: Addressing Key Challenges

This component emphasizes the importance of transitioning to a circular model while identifying low consumer awareness and the high costs associated with implementing circularity as significant challenges. To address these issues, the proposed strategies include awareness-raising initiatives, cost and financing

TABLE 7 | Rotated component matrix with Varimax procedure.

Variable	Component				
	1	2	3	4	5
2.1. Need for a transition from the current linear model to the circular model.	0.376	0.268	−0.209	**0.722**	−0.010
2.10. There is a need for more sustainable and responsible consumption habits.	**0.842**	−0.086	−0.066	0.376	0.046
3.4. Extension of the useful life of products, equipment and raw materials.	0.060	0.236	−0.193	0.091	**0.837**
3.7. Use of products as services through subscription or rental.	0.052	**0.685**	0.165	0.021	0.314
4.1. Lack of support from the administrations.	0.192	0.152	**0.714**	0.089	−0.065
4.2. Unclear rules and regulations.	0.083	0.323	**0.698**	0.392	0.074
4.3. Low consumer awareness.	0.207	−0.243	0.246	**0.681**	0.019
4.4. Unavailable or inadequate financing.	0.128	0.151	**0.800**	0.001	0.005
4.7. High investment costs to modernize production systems.	0.231	−0.025	**0.564**	−0.073	0.551
5.2. Equipment for collection, separation, recycling and valuation of resources and materials.	**0.823**	0.090	0.284	0.107	−0.186
5.6. Extending the useful life of garments and materials.	**0.646**	0.072	0.061	0.461	0.130
5.11. Subsidies, aid and soft loans for investments in technologies for the transition to the CE.	**0.724**	0.105	0.236	−0.129	0.213
6.8. SDG 12: Responsible production and consumption.	**0.689**	0.186	0.138	0.158	0.118
7.4. Increased profitability and competitive advantage.	0.029	**0.826**	0.063	0.062	−0.211
7.8. Savings in production costs in the medium and long term.	0.045	**0.756**	0.120	0.006	−0.036
7.9. Improved collaboration between companies in the sector.	0.449	**0.592**	0.405	−0.225	−0.105
7.10. Improved market share.	0.154	**0.809**	0.033	−0.193	0.245
8.5. Impossibility of using certain raw materials because they are difficult to recycle.	0.079	−0.250	0.429	0.435	**0.609**
8.6. Higher production costs.	0.044	−0.202	0.418	**0.588**	0.338

analyses, and the implementation of circularity in the value chain. These measures aim to equip companies with the necessary tools to overcome these barriers effectively.

6.1.5 | PC5: Role of Ecodesign

This component identifies ecodesign as the sole activity, highlighting its crucial role in extending the useful life of products made from materials that are extremely difficult or impossible to recycle.

Table 9 summarizes the proposed actions for each principal component.

6.2 | Analysis of Proposed Actions

The following is a description of the different actions included in the action proposal for the process of transition to the CE in the Spanish textile industry.

6.2.1 | Setting Sustainability Objectives

The establishment of goals involves collaboration between customers and individuals connected to the company. These targets enable the measurement of progress in actions taken and facilitate the communication of achievements in the transition toward circularity to stakeholders. Integrating the SDGs can serve as a critical component of the company's decision-making process. The attainment of certain SDGs may align with the implementation of the CE principles (Schröder and Barrie 2024). Goals specific to the textile sector are detailed in Section 2. Moreover, ISO 59004 (*Circular economy—Vocabulary, principles and guidance for implementation*) aims to support organizations in contributing to the United Nations 2030 Agenda for Sustainable Development by facilitating the transition to a circular use of resources (ISO 2025).

6.2.2 | Ecodesign

Ecodesign is essential to adapt the textile sector to circularity. Products must be designed from the source. Certain

TABLE 8 | Representativeness and variables of principal components.

PC1	*Essential enablers for undertaking the CE*	Variance (%)	17,598
	2.10. There is a need for more sustainable and responsible consumption habits.	Factor loading (%)	84,2
	5.2. Equipment for collection, separation, recycling and valuation of resources and materials.		82,3
	5.6. Extending the useful life of garments and materials.		64,6
	5.11. Subsidies, aid and soft loans for investments in technologies for the transition to the CE.		72,4
	6.8. SDG 12: Responsible production and consumption.		68,9
PC2	*Business model and its objectives*	Variance (%)	17,019
	3.7. Use of products as services through subscription or rental.	Factor loading (%)	68,5
	7.4. Increased profitability and competitive advantage.		82,6
	7.8. Savings in production costs in the medium and long term.		75,6
	7.9. Improved collaboration between companies in the sector.		59,2
	7.10. Improved market share.		80,9
PC3	*Barriers for the CE implementation*	Variance (%)	14,889
	4.1. Lack of support from the administrations.	Factor loading (%)	71,4
	4.2. Unclear rules and regulations.		69,8
	4.4. Unavailable or inadequate financing.		80,0
	4.7. High investment costs to modernize production systems.		56,4
PC4	*Most relevant challenges for developing the CE*	Variance (%)	11,557
	2.1. Need for a transition from the current linear model to the circular model.	Factor loading (%)	72,2
	4.3. Low consumer awareness.		68,1
	8.6. Higher production costs.		58,8
PC5	*Problem-solution relationship*	Variance (%)	9,619
	3.4. Extension of the useful life of products, equipment and raw materials.	Factor loading (%)	83,7
	8.5. Impossibility of using certain raw materials because they are difficult to recycle.		60,9

companies will only have to introduce small modifications to their creative and productive processes to be classified as ecodesign, while others will require major changes and may employ techniques such as Business Process Reengineering (Fasna and Guanatilake 2019). Furthermore, ecodesign has become an increasingly important strategy for European textile companies. The European Commission (EC 2025) has identified textiles as a priority product group within the Ecodesign for Sustainable Products Regulation (ESPR). Although the work plan suggests 2027 as a potential adoption timeline, it is crucial that companies begin preparing for the upcoming requirements. The regulation will assess various aspects of a product's sustainability, many of which directly influence its circularity (recyclability, potential for remanufacturing, reparability, and possibility of maintenance and refurbishment). The ESPR will be supported by the introduction of a Digital Product Passport (DPP), which will act as a digital identity for products, components, and materials. This passport will store essential information to improve product sustainability, promote circular practices, and ensure compliance with legal standards.

An example of ecodesign can be the creation of products that follow the technical cycle of the butterfly diagram (EMF 2021). The sequence to follow would be:

6.2.2.1 | **Choosing the Material.** Selecting the right material is crucial for designing a sustainable product. Three key factors are considered:

- *Footprint*. It is essential to determine the origin of the material chosen for the product and understand its environmental

TABLE 9 | Principal components and proposed actions.

Principal components	Proposed actions
PC1: Essential enablers for undertaking the CE	• Ecodesign • Setting sustainable objectives • Analyzing costs and financing options
PC2. Business model and its objectives	Implementing a circular model within the value chain
PC3. Barriers to the CE implementation	• Awareness raising • Analyzing costs and financing options
PC4. Most relevant challenges for develoving the CE	• Implementing a circular model within the value chain • Awareness raising • Analyzing costs and financing options
PC5. Problem-solution relationship	Ecodesign

impact. After identifying potential issues, circular solutions are sought. For instance, options like natural or recycled fibers can be prioritized.

- *Durability*. Durability plays a vital role in extending the useful life of products, ensuring they do not break easily. High-quality materials selected for repeated use contribute significantly to sustainable design.
- *Recyclability*. Circular products aim to avoid becoming waste. Once their useful life ends, every effort is made to reintegrate their components into the technical cycle.

6.2.2.2 | Choosing the Design Strategy. The company will adopt the most appropriate design strategy for its circular product project. Possible approaches include:

- *Creating a durable garment*. Durable clothing requires the use of long-lasting materials. The design will prioritize durability by minimizing and reinforcing stress points, thereby reducing the likelihood of component failure. High-quality manufacturing techniques will be employed to ensure optimal results, and detailed care instructions will be provided to customers. In the fashion industry, customer choices are often influenced by trends; therefore, companies will aim to create timeless designs that can be worn for many years.
- *Enhancing wearability*. The versatility of the garment can be increased to allow a single customer to use it more frequently or to facilitate its use by multiple customers. Services such as garment-sharing or leasing programs can also support extended use.
- *Designing repairable garments*. The design should facilitate easy maintenance and repair. Additional components, such as spare buttons, threads, or fabric pieces (e.g., obtained through over-cutting), can be included with the product or offered on demand. Detailed information on repair and maintenance processes should also be provided to empower customers to prolong the garment's lifecycle.
- *Facilitating garment recycling*. Recycling garments by separating their components is an inefficient process that can damage materials and require significant effort. A key solution lies in the careful selection of materials. Using recyclable materials can simplify the recycling process. However, this alone is insufficient. For recycling to be truly efficient, at least 90% of the garment should consist of the same type of fiber.

6.2.2.3 | Eliminating Waste. Design plays a pivotal role in minimizing waste and reusing generated waste by reintegrating it at the beginning of the value chain. Two main approaches can be considered:

- *Reduction*. Efficient pattern designs can minimize leftover fabric during production. Advanced technologies, such as artificial intelligence and 3D digital prototyping, can further reduce waste by eliminating the need for physical samples.
- *Recycling*. Waste can arise at various stages, including during production (e.g., pattern cutting), before the product reaches the customer, or after consumption. The varying qualities and technical properties of these materials may render them unsuitable for use in new garments. However, such unusable materials can be sold to other companies for alternative applications, reducing overall waste.

6.2.3 | Implementing a Circular Model Within the Value Chain

The textile value chain is highly interconnected, meaning that unsustainable practices in one segment can adversely affect the entire system. While isolated circular solutions can enhance sustainability to some extent, significant and lasting change can only be achieved by redesigning the entire chain in a circular manner. In this context, Business Process Reengineering proves to be a valuable approach, rethinking processes from the ground up (Silva de Oliveira et al. 2021). A circular value chain necessitates sustainable practices that minimize resource consumption in textile production, such as water and energy. Findings from the questionnaire highlight that the use of renewable energy sources (Farhana et al. 2022) and the adoption of technologies to optimize water usage (Shaikh 2009) are critical enablers in the transition to the CE. Wynn and Wiegand (2025) account for upstream and downstream activities, including supply chain integration, reverse logistics, and traceability mechanisms. They emphasize the nuanced roles that digital technologies, such as Internet of Things (IoT), blockchain, Industry 4.0 tools, and Artificial Intelligence (AI) can play in enabling the CE, while cautioning that these technologies are not yet widely adopted, particularly among SMEs. Rather than being primary drivers of change, digital tools are often secondary enablers, whose effectiveness depends on regulatory frameworks, firm capabilities, and sectoral dynamics. Digital technologies play a vital role in advancing sustainability in the textile industry. Beyond improving traceability, facilitating reuse, and supporting innovation in distribution, they enable virtual product design, optimize supply chains through real-time data, and enhance demand forecasting using AI. These technologies also support product lifecycle management and foster transparency by providing consumers with verifiable information on ethical practices and material sourcing. Together, these applications contribute to reducing waste, improving resource efficiency, and aligning production with sustainable goals. Another pressing issue is the use of environmentally harmful chemicals, which often contaminate soil and water, posing severe risks to ecosystems and human health (Nimkar 2018). Experts indicate a correlation between reducing the use of polluting chemicals and conserving water, underscoring the importance of addressing these interrelated risks. Two key actions inherent to the technical cycle of the Butterfly Diagram are proposed to enhance circularity: sharing and remanufacturing (EMF 2021). Specifically, a circular value chain integrates the following elements:

6.2.3.1 | Reducing the Use of Non-Renewable Energy. Textile production requires electricity for lighting, ventilation, and mechanical processes such as weaving, spinning, and wet processing. Additionally, thermal energy is essential for processes like dyeing, bleaching, dampening, and garment finishing. Addressing these diverse energy demands calls for multiple strategies:

- *Use of renewable energy.* The most viable option for renewable energy in textile production is solar energy, given its abundance. Spain, for instance, enjoys one of the highest annual sunshine hours in Europe, making it an ideal candidate for solar energy solutions. Two main types of solar energy can be utilized: thermal solar energy and photovoltaic solar energy. Biomass is another alternative, offering a way to replace fossil fuels required in energy-intensive processes such as dyeing.
- *Increasing energy efficiency.* Improving energy efficiency can significantly reduce costs and greenhouse gas emissions. For example, poor insulation systems often result in substantial thermal energy losses. Techniques to recover and reuse lost heat can mitigate this issue. Further measures to enhance energy efficiency include optimizing lighting systems, upgrading motors, implementing advanced control systems, and improving refrigeration systems. Moreover, eliminating non-value-adding activities in production processes can have a positive impact on energy conservation.

6.2.3.2 | Reducing Water Consumption. The activities with the highest water demand are concentrated at the end of the value chain. Processes such as garment dyeing and finishing are typically performed in water baths, while desizing and bleaching occur in aqueous systems. Implementing techniques that minimize water usage and prevent the discharge of polluted water is crucial. Several techniques can contribute to this goal:

- *Employing good practices.* Simple measures can result in significant water savings. Examples include ensuring faucets are not left open, conducting preventive maintenance on supply and drainage systems, reviewing operations to identify excessive water usage, and raising employee awareness about the importance of water conservation.
- *Reusing water.* Reusing water reduces both consumption and wastewater generation. For instance, water from jet weaving processes, bleach baths, soapy water, dyeing solutions, or cooling and washing processes can be recycled and reused effectively. Another approach is to treat used water through biological, physical, or chemical processes. However, when applied individually, these methods may not always achieve the desired results. As a result, some producers opt to combine different treatment techniques to enhance effectiveness. For instance, K. Ayedi et al. (2023) analyzed the integration of membrane processes with hydrodynamic cavitation for the treatment of industrial wastewater containing dyes. Their study concluded that this combined method effectively produces clean water, suitable for reuse or safe discharge.
- *Installing valves.* Automatic shut-off valves that operate based on time, flow, or temperature can help control water consumption. Additionally, flow control valves can reduce water flow rates. Both options are highly effective in managing water use.
- *Using low liquid-to-material ratio systems.* Dyeing equipment varies in water consumption. Systems with low liquid-to-material ratios can significantly reduce water and chemical usage while improving fixing efficiency.

6.2.3.3 | Reducing the Use of Chemicals. Chemicals used in garment dyeing and finishing often pose significant environmental challenges due to their harmful effects, including contamination through atmospheric emissions and liquid effluents. Ventilation systems may release solvent vapors, particulates, and metal compounds, while wastewater contamination from unfixed dyes exacerbates environmental issues. The following strategies are proposed:

- *Ecological alternatives.* One option is to replace starch with polyvinyl alcohol (PVA), a recoverable fiber, for sizing cotton. Unlike starch, which increases oxygen demand for oxidation in wastewater, PVA is less harmful and recoverable. Additionally, the use of organic substances can eliminate the need for wastewater treatment, further reducing environmental impact.

- *Alternatives that eliminate water use*. Processes that eliminate water use also avoid generating polluting liquid waste. For example, dyeing polyester with supercritical CO_2 is an innovative method that replaces water-based dyeing techniques.
- *Creating lists of "positive" chemicals*. Developing lists of approved chemicals serves as a guide to ensure compliance with restricted substance limits in garments. These lists also provide transparency and valuable information for consumers.
- *Use of digital printing*. Digital printing is a sustainable technique for fabric design that eliminates the need for harmful chemicals and reduces water pollution. This method also offers greater flexibility, enabling customers to personalize designs according to their preferences.

6.2.3.4 | Remanufacturing. Remanufacturing extends product life and reduces waste by conserving resources such as raw materials, energy, and water, leading to significant economic savings. The process involves taking a used garment, disassembling it into components, and using these to manufacture a new garment that retains or even improves upon the former quality and functionality. To implement remanufacturing, reverse logistics are required to transport products from customers back to the factory. Once received, the garments undergo a series of steps, including inspection, cleaning, repair, and the replacement of worn or damaged parts. The outcome is a new garment, which may either replicate or differ from the original, produced with reduced material and energy costs. On the negative side, studies such as the one by Nohra et al. (2022) indicate that remanufacturing is three to five times more labor intensive than conventional manufacturing. This increased labor demand stems from additional tasks such as disassembly and cleaning. To improve the efficiency of remanufacturing, there is a growing need for automation. However, standardizing remanufacturing processes is challenging due to the variability in the condition of returned products, which often requires workers to make real-time decisions. In this context, collaborative robots (cobots) offer an optimal solution for effective process automation. These tools support operators by enhancing precision, consistency, and accuracy, while preserving the flexibility and human decision-making essential to remanufacturing workflows.

6.2.3.5 | Sharing. This strategy improves the efficiency of operations, reduces costs and minimizes their environmental impact, promoting a more efficient use of resources. It encourages the creation of collaborative networks and industrial symbiosis, generating additional benefits of mutual learning and the development of strong business relationships. There are several ways:

- *Sharing production facilities*. This allows textile companies to maximize production capacity and reduce infrastructure or maintenance costs.
- *Sharing equipment and machinery*. Some specialized equipment and machinery, such as looms, dyeing machines or finishing systems, can be shared among several companies. This helps to optimize the utilization factor and reduce investments.
- *Sharing raw materials*. Textile companies can collaborate to purchase raw materials in large volumes and share them as needed. This can reduce purchasing costs and minimize waste by avoiding excess inventory.
- *Sharing knowledge and technologies*. R&D collaboration between companies can drive innovation and the adoption of technologies that promote circularity.

6.2.4 | Analyzing Costs and Financing Options

In a circular project, the economic benefits for companies are not always immediately evident. The *Pacto Mundial* organization in Spain analyzed the relationship between economic profitability and the adoption of SDGs (PM 2023), concluding that a commitment to sustainability generates positive impacts on financial performance. However, it is acknowledged that implementing sustainable strategies does not inherently lead to economic growth, though it positively influences indicators such as productivity, economic risk, and profitability. Consequently, the CE should be viewed not as an expense but as an investment. Antonioli et al. (2022) affirm the positive relationship between process innovations and revenue growth, while noting that increased revenues may be accompanied by higher production costs. Similarly, Gonçalves et al. (2022) argue that economic profitability depends on factors such as company size, initial investment costs, organizational structure, and exposure to risk. Potential cost factors impacted by the CE include:

- *Raw materials and resources*. Costs for raw materials and resources are expected to decrease due to improved efficiency in processes. Dependence on finite resources can be minimized by opting for more sustainable and readily accessible alternatives. The circularity of the production process allows greater value to be extracted from previously used and recovered raw materials, transforming waste into resources.
- *Logistics*: If a company uses its own infrastructure to recover and repurpose waste at the end of the value chain, logistical costs may rise. However, recovering waste to convert it into raw materials can reduce costs earlier in the production process. In global supply chains, sourcing raw materials locally in the country of production can reduce costs, prevent information loss, and shorten waiting times.
- *Investment*. Initial investment costs may be substantial, depending on the project's scope. These costs, typically one-time expenses, and subsidies from various institutions can help offset them.
- *Human capital*. A circular model increases costs related to human capital. At the project's inception, skilled personnel will be required to develop the strategy. Over time, the system's effectiveness will rely on well-designed products that serve their purpose at every stage of the process. Trained personnel must be available to ensure appropriate decision-making.
- *R&D*. Investments in research and development represent strategic fixed costs for circular companies. These are

critical for ensuring survival and long-term success, as continuous innovation equips companies with the adaptability and resilience needed to thrive in rapidly changing markets.

- *Manufacturing*. The adoption of new technologies to enhance production systems will lead to their optimization. Key benefits include cost reductions stemming from fewer defective products, decreased workplace accidents, and improved compliance with legal standards.

In contrast, several potential revenue streams emerge with the adoption of the CE:

- *Increased sales*. Optimizing processes allows circular companies to offer products of higher quality, superior durability, enhanced functionality, and a stronger sustainability profile. These attributes increase consumer utility and promote greater satisfaction, loyalty, and brand advocacy. As a result, circular companies are better positioned to justify premium pricing and address objections from price-sensitive consumers.
- *New business opportunities*. The adoption of circularity, particularly through strategies that emphasize providing a circular customer experience, opens avenues for expanding business operations. Initiatives such as platforms for recycling, maintenance, or the alteration of products can evolve into significant revenue sources for the organization.

The benefits consumers derive when companies implement the CE enhance the social profitability of the project. The potential benefits include the following (EMF 2024):

- *Increased disposable income*. The implementation of effective circularity practices can lead to reduced prices for certain products and services, resulting in a rise in average disposable income for consumers.
- *Increased product utility*. Enhanced product flexibility and functionality provide customers with greater versatility and utility in the products they use.
- *Reduced obsolescence*. Mitigating obsolescence increases convenience for customers by minimizing the need for returns and repairs, while also reducing associated monetary costs.
- *Health benefits*. The CE contributes to lower greenhouse gas emissions, reduced microplastic spills, and decreased ecosystem pollution by toxic substances, leading to positive health outcomes for the population.

To finance a CE project in Spanish textile companies, grants are available from both the Spanish government and the European Union. One notable example is the *Fundación Biodiversidad*, an organization under the Spanish Ministry for Ecological Transition and the Demographic Challenge. This foundation offers grants specifically aimed at promoting the CE in the textile, fashion, clothing, and footwear sectors. Supported financially by the European Union, this initiative enhances its impact and significance. The total funding available amounts to 97.5 million euros, designated to support innovative and sustainable projects (MITECO 2024b).

6.2.5 | Awareness Raising

The research highlights a lack of motivation among both companies and consumers. To address this issue, companies aiming to transition toward circularity must focus on raising awareness among their customers. It is recommended that companies collaborate with consumers by offering services that support circular actions (Jiménez Fernández et al. 2023; Van Langen et al. 2021). The following options are proposed:

- *Offer services*: Establish new business branches where the company provides complementary assistance to customers. This approach represents a promising new business opportunity.
- *Provide information*: Equip customers with practical guidance on maintaining garments, altering them for renewal, or responsibly disposing of them. Such initiatives enhance customer satisfaction with the brand and foster greater loyalty for future purchases.
- *Form partnerships*: Collaborate with external companies offering these services through pre-arranged agreements. This strategy improves customer satisfaction while mitigating the financial risk of launching a new business line.

Despite notable national disparities and persistent challenges, the textile industry demonstrates a growing collective recognition of its substantial impact on sustainable development. As a result, it is increasingly engaged in the pursuit of innovative strategies and solutions to address and fulfill this responsibility (Wynn and Wiegand 2025). Institutions must raise awareness among both consumers and companies regarding the importance of adopting the CE in the textile sector. Training initiatives, such as seminars, workshops, and courses, play a crucial role in achieving this goal. Similarly, efforts to promote awareness through information campaigns, recognition programs, awards, and the establishment of collaboration networks between companies can significantly facilitate circular practices. However, two major barriers to implementing the CE have been identified: insufficient or inadequate financing and unclear regulatory frameworks. To overcome these challenges, it is essential to provide financial incentives to companies while simultaneously developing clear regulations that promote the CE and impose penalties on unsustainable practices.

7 | Conclusions, Limitations and Future Lines of Work

The current climate crisis necessitates a shift from traditional production models. The textile industry, known for its significant environmental and social impacts, urgently requires a transition toward more sustainable practices, with the CE emerging as a viable alternative. Although some major textile and fashion companies have adopted measures to align their processes with circularity principles, these efforts remain insufficient. In an industry dominated by fast fashion and excessive consumerism, a fundamental structural change is imperative.

This study examines the global textile sector, with Spain serving as a case study. The data were collected through a purpose-designed questionnaire administered to a panel of experts. The analysis employed PCA, which identified key aspects of the CE model within the sector. CE enablers have been identified through PC1. These include the adoption of new technologies, increased consumer engagement, and the development of policies aligned with business needs. A new business model promoting circularity, detailed in PC2, is essential. There is a strong connection between these actions and several critical barriers outlined in PC3, such as lack of financing, insufficient support from administrative bodies, ambiguous regulations, and unclear rules. PC4 highlights significant challenges for the CE. Economic factors are recognized as the primary barrier to progress. Major concerns include higher production costs, limited or unsuitable financing options, and substantial investment requirements for modernizing production systems. Addressing these issues necessitates the development of financing mechanisms tailored to the needs of businesses, facilitating the funding required for circular projects. Simultaneously, new regulations must be designed to reflect the current realities of the textile industry. These should aim to educate companies and emphasize the importance of an effective transition to the CE. Consumer awareness will play a crucial role in moving away from the linear model, which is centered on resource exploitation, production, and disposal. Promoting responsible consumption habits among customers is essential. PC5 focuses on recycling and using sustainable materials to extend the useful life of products and minimize the consumption of raw materials.

The analyzed framework has informed the development of a comprehensive action plan designed to effectively support the textile industry's transition toward the CE. The proposed plan serves as a valuable tool not only for companies seeking to implement sustainable practices, but also for policymakers aiming to align regulatory frameworks with industry transformation.

The proposal is built on strategic pillars, including ecodesign, the establishment of sustainability objectives, cost and financing analysis, the integration of a circular model throughout the value chain, and awareness-raising initiatives. By addressing these five activities in a cohesive and purposeful manner, the proposed action plan offers a comprehensive roadmap for overcoming challenges and embedding the CE model into the textile sector. This approach not only reduces the environmental footprint of the industry but also promotes innovation, resilience, and economic growth through sustainable practices.

In response to the two central research questions, this study has delivered a comprehensive assessment of the current state of the CE in the textile industry, grounded in the Spanish context, and put forward a strategic framework to facilitate the transition toward circular-based production systems.

Finally, several limitations of this research should be acknowledged. First, despite extensive preliminary efforts to establish contact, the response rate from experts to the questionnaire was relatively low. To mitigate potential bias, a representative sample was carefully selected. Additionally, the limited number of observations compared to the number of variables in the questionnaire precluded the application of PCA to all questions. In light of these limitations, the following avenues for future research are proposed:

- Increase the number of expert responses, particularly from companies within the textile sector.
- Expand the number of variables analyzed in the PCA to enhance the precision and robustness of the results.
- Include additional activities within the textile sector, such as the production of technical textiles.
- Broaden the scope of the study to encompass other countries where the textile sector plays a significant role in the economy.
- Incorporate related industries, such as leather and footwear, to provide a more comprehensive understanding of the sector.

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Conflicts of Interest

The authors declare no conflicts of interest.

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