

**INNOVATION, COLLABORATION AND DESIGN AS TRANSITION STRATEGIES
TOWARD CIRCULARITY IN THE BRAZILIAN TEXTILE CHAIN**

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1. INTRODUCTION

The intensification of the socio-environmental impacts of the linear production and consumption model has exposed the limits of the current industrial logic. In the textile sector, this model is exacerbated by the fast fashion phenomenon, which accelerates product launch and disposal cycles, contributing to the increase in solid waste and the release of microplastics from synthetic fibres such as polyester, substances that pollute rivers, oceans, and harm aquatic ecosystems (Niinimäki et al., 2020). This is a resource-intensive, fragmented, and low-traceability value chain, making it a priority in the transition to more sustainable practices.

Over recent decades, the fashion industry has undergone unprecedented productive intensification, marked by accelerated cycles of consumption and disposal. Between 2000 and 2015, global clothing production doubled, while the average use of garments dropped by 36%, reflecting an unsustainable logic of planned obsolescence. In 2018, the sector was responsible for approximately 2.1 billion tonnes of greenhouse gas (GHG) emissions, equivalent to 4% of the global total (Ellen MacArthur Foundation, 2021). At the same time, the profit margins of major retailers fell by an average of 40% between 2016 and 2019 due to price declines, overstocking, supply chain disruptions, and product returns. The Covid-19 pandemic worsened this scenario, leading to profit drops of up to 90% across the industry. These data highlight the environmental and economic unsustainability of the prevailing model, underlining the urgency of transitioning to production structures aligned with circularity, impact reduction, and resource efficiency.

The circular economy has been consolidated as a strategic response to this scenario, driven by technological innovations, new business models, and bio-based solutions. International startups such as Circulose® and Resortecs have promoted material regeneration and design-for-disassembly approaches, while platforms like Worn Wear and Rent the Runway demonstrate the viability of service-based models rooted in use rather than ownership. However, such experiences arise in regulatory and industrial contexts that differ significantly from those of Brazil, and their replicability remains underexplored in the literature.

In Brazil, circularity is still incipient and faces structural, institutional, and cultural barriers. Although there are relevant textile waste recycling initiatives, such as Retalhar, Cotton Move, and Eurofios, the sector is characterised by informality, low traceability, resistance to collaborative innovation and a lack of integrated public policies (Colerato, 2021; EMF, 2017). In this context, the emergence of the bio-based economy has stood out as a promising alternative, combining technological innovation, renewable resources with lower environmental impact, and biodiversity valorisation. Startups such as Phycolabs (microalgae fibres), Muush (fungus-based materials), and Curauá (Amazonian plant fibres) exemplify a new innovation paradigm that aligns sustainability with local value generation, although they are still in early development and lack supportive policies.

Despite these punctual advances, the literature lacks studies that examine the national textile chain from a systemic perspective capable of articulating the various vectors of the circular transition. Research by Geissdoerfer et al. (2020) points out that although theoretical production on the circular economy is increasing, empirical investigations focused on its implementation

in complex supply chains of emerging countries remain scarce. The UNEP (2023) report reinforces that Global South countries, such as Brazil, face structural barriers to circularity, including productive informality, inadequate infrastructure, and a lack of reliable data. Within the Brazilian context, Colerato (2021) highlights the fragmentation of circular initiatives and the lack of articulation between design, technological innovation, and public policy.

To address this gap, this study proposes an integrated analysis of the opportunities and challenges for adopting circular economy strategies in the Brazilian textile value chain. The originality of the proposal lies in the articulation of circular business models, the bio-based economy, and traceability technologies, all understood within a systemic perspective of sustainable innovation. Rather than focusing on isolated solutions, the study seeks to map emerging practices, examine their feasibility conditions, and discuss their scalability within the context of a Global South country.

The research adopts a qualitative approach based on a literature review and analysis of national and international secondary sources. The results are expected to contribute on a theoretical level to advancing understanding of circular strategies in complex value chains in the Global South, particularly Brazil, and, on a practical level, to supporting the formulation of public policies and business strategies aligned with the Sustainable Development Goals, especially SDG 12 (United Nations, 2015), with a focus on the textile industry.

2. THEORETICAL FRAMEWORK

2.1. The crisis of the linear model and the urgency of transitioning to a circular economy

The textile and fashion value chain consists of a complex network of stages, ranging from agriculture and petrochemical production to manufacturing, logistics, and retail. Each of these stages generates significant environmental impacts, mainly due to the intensive use of natural resources, high energy consumption, and the application of harmful chemical substances (Niinimäki et al., 2020). The prevailing linear model, based on extraction, production, fast consumption and disposal, has led to severe economic and environmental consequences. It is estimated that over USD 500 billion are lost annually due to underutilisation of clothing and low recycling rates (Ellen MacArthur Foundation, 2017).

In response, the circular economy has been promoted as a systemic alternative capable of regenerating ecosystems, reducing value loss, and fostering more responsible production and consumption models. According to Kirchherr, Reike, and Hekkert (2017), this approach calls for a structural transformation of economic systems through the closing, narrowing, and slowing of resource loops. In the textile sector, this implies changes in business models, product design, and the way consumers interact with goods. Reports such as “Fios da Moda” (Colerato, 2021) and “Sustainability and Circularity in the Textile Value Chain” (UNEP, 2023) emphasise that circularity can generate interdependent environmental, social, and economic benefits, especially when combined with traceability strategies, circular design and innovations in the bioeconomy.

In Brazil, the challenges to implementing circularity are even more acute. It is estimated that around 4 million tonnes of textile waste are discarded annually by Brazilian households, most of which ends up in landfills (Instituto C&A & BCG, 2021). The textile industry is also among the most polluting sectors, contributing approximately 2% to 8% of global greenhouse gas emissions (Mendes, 2025; UNEP, 2023). The Brazilian textile chain is characterised by

production fragmentation, informality, low traceability and a lack of incentives for innovation and green investment. Although relevant experiences exist, such as reverse logistics initiatives, circular design practices, and bio-based economy ventures, the transition at scale requires coordination among multiple actors and the establishment of structural public policies (Colerato, 2021; Ellen MacArthur Foundation, 2021).

Within this context of exhaustion of the linear model and growing pressure for sustainable transformation, this study adopts six structural dimensions as its theoretical framework to analyse the circular transition of the Brazilian textile chain: (1) innovation in circular business models; (2) collaborative ecosystems; (3) public policies and regulatory frameworks; (4) corporate strategies for circularity; (5) circular design; and (6) the bioeconomy based on the use of renewable, bio-based fibres. These dimensions, represented in Figure 1, provide the conceptual framework for analysing emerging initiatives in the sector, enabling an integrated approach to the factors that can facilitate a regenerative textile economy.

These six dimensions form the analytical lens adopted in this study to understand the potential pathways for the sustainable reconfiguration of the Brazilian textile chain. Their articulation is supported by authors who advocate for systemic approaches to sustainable transition, such as Kirchherr et al. (2017), Bocken and Geradts (2020), Niinimäki et al. (2020), and Lüdeke-Freund et al. (2019), who argue that circular strategies must simultaneously consider innovation, collaborative networks, cultural transformation, and institutional conditions.

2.2. Innovation in Circular Business Models: Circular Design and Traceability

Innovation in circular business models requires a profound reconfiguration of the traditional ways of producing, distributing, and consuming. In the textile sector, this transformation involves incorporating strategies that prioritize the closing and narrowing of production loops – reducing resource extraction and prolonging product lifespans (Bocken et al., 2016). These strategies go beyond just reverse logistics or recycling; they entail adopting new organizational models and leveraging emerging technologies (such as blockchain) alongside product R&D methods focused on circularity.

According to the Ellen MacArthur Foundation (2021), circular business models can be grouped into five main categories: resale, rental, repair, remanufacturing, and product-as-a-service. Each of these categories provides different pathways to extend product life and decouple economic growth from the extraction of virgin resources. Embracing such models, however, demands new operational and digital capabilities – for example, monitoring product usage, managing multiple reverse logistics streams, and integrating with data platforms to track products across their life cycle.

From this perspective, new business models built on circular design play a central role by embedding environmental, social, and functional criteria right from the product's conception. In practice, this means designing products for durability, modularity, ease of disassembly, and the reuse or recycling of materials at the end of their life (Bakker et al., 2014; Niinimäki et al., 2020). Design thus becomes a strategic element of innovation in circular models, as it directly influences the feasibility of future circularity. In fact, it is estimated that over 80% of a product's environmental impacts are determined at the design stage, underscoring how critical early design decisions are for sustainability UNEP (2023).

Implementing circular models also requires digital tools capable of integrating data and processes along the entire value chain. Product Lifecycle Management (PLM) systems – widely used in the textile industry to manage the pre-consumption phases of a product – illustrate both the potential and current gaps. Even the most up-to-date PLM platforms (e.g. Centric PLM) still do not integrally cover the use and end-of-life phases of products. Enabling true circularity will require moving toward a more comprehensive digital ecosystem, incorporating unique product identifiers, IoT sensors, and feedback systems that allow real-time tracking of product use and condition (Ellen MacArthur Foundation, 2021).

In this context, integrating PLM with technologies like blockchain and, above all, with Digital Product Passports (DPP) becomes pivotal. The DPP is considered a key instrument under the European Union’s sustainable products initiative (European Commission, 2022), as it enables the tracing of information about materials, processes, and circularity attributes throughout the product’s entire life cycle. Such integration creates a continuous “digital thread” linking design, production, use, and disposal – a connectivity essential for environmental monitoring and for enforcing policies like Extended Producer Responsibility (UNEP, 2023).

Finally, the viability of circular business models hinges on building collaborative networks among brands, suppliers, service providers, and digital platforms. As highlighted by the Ellen MacArthur Foundation (2021), it is necessary to develop “collective business cases” that allow secure data sharing and coordinated services for take-back, repair, redistribution, and recycling – operations that tend to be economically unviable if attempted by a single actor alone. In other words, scaling circular innovation in textiles will require stakeholders to collaborate and co-create the supportive infrastructure (both physical and digital) needed to keep products and materials circulating effectively.

2.3. Circular Design

Circular design is one of the pillars of the transition to a circular economy in the textile sector, since it is during the product development phase that more than 80% of its environmental impacts are determined (UNEP, 2023). Unlike traditional design, which focuses on aesthetics, functionality, or cost, circular design incorporates from the outset criteria such as disassemblability, modularity, repairability, recyclability, and traceability (Bakker et al., 2014; Niinimäki et al., 2020).

In the fashion industry, this entails developing garments with extended life cycles, composed of mono-materials with reduced fibre blending, and designed to facilitate upcycling or mechanical and chemical recycling processes. Brands such as Flávia Aranha, which employ eco-design practices and natural dyeing, exemplify initiatives aimed at embedding circularity from the creative process onward.

Furthermore, circular design should be understood as a strategy that directly aligns with circular business models (Bocken et al., 2016). It does not operate in isolation: it is embedded within an ecosystem in which products are designed for multiple-use flows—such as rental, resale, or buy-back—and requires the support of technological and logistical systems that enable the reintegration of post-consumer products or materials into the production system.

Thus, circular design plays a dual role: as a conceptual driver, by structuring circular logic from the origin, and as an operational tool, by guiding the material and technical innovation of products within sustainable business models.

2.4. Bio-based Bioeconomy

The bio-based bioeconomy represents a strand of the circular economy centred on the valorisation of renewable biological resources, aiming to replace fossil-based raw materials with natural alternatives that have low environmental impact and high regenerative potential. This concept integrates principles from biotechnology, regenerative agriculture, and sustainable innovation, promoting a more balanced relationship between productive systems and natural ecosystems (Brunori & Raffaelli, 2014; Ellen MacArthur Foundation, 2021).

In the textile sector, the bioeconomy has led to the emergence of new materials derived from plant-based or microbial sources, often developed by startups focused on achieving a positive environmental impact. In Brazil, notable examples include Muush, which creates alternatives to leather using fungi; Phycolabs, specialized in biomaterials extracted from microalgae; and Curauá, which explores the use of Amazonian plant fibres as potential substitutes for cotton and polyester. These materials not only reduce greenhouse gas emissions and water use but also support local value chains and the sustainable use of biodiversity.

Such innovations contribute particularly to the narrowing strategy (reducing resource consumption) and align with closing strategies (reintegration) when biomaterials are biodegradable or easily recyclable (Bocken et al., 2016). Alongside circular design and innovation in business models, the bio-based bioeconomy constitutes a strategic driver of circularity, offering material alternatives that are better aligned with climate goals and ecological restoration efforts.

Despite its potential, these solutions still face scalability challenges, such as high initial costs, lack of fiscal incentives, and absence of regulatory frameworks for new materials. Nevertheless, they represent a promising pathway for transitioning toward more resilient and regenerative supply chains.

2.5. Integration between circular business models, circular design and the bio-based bioeconomy

This study adopts the circular economy as a theoretical lens, understood as a systemic economic model aimed at keeping resources in use for as long as possible, regenerating cycles, and minimizing negative externalities (Geissdoerfer et al., 2020). The conceptual framework adopted here is anchored in the typology proposed by Bocken et al. (2016), which organizes circular strategies into four complementary categories: *narrowing* (resource efficiency), *slowing* (product life extension), *closing* (reintegration of materials into production cycles), and *managing* (coordination, traceability, and systemic support).

These pillars are aligned with the Ellen MacArthur Foundation's (2021) proposal, which defines circular models as ways of redefining economic growth by prioritizing product use value over ownership. This redefinition implies the adoption of new performance metrics, such as resale rate, effective use, and environmental and social impact indicators, which complement or replace traditional financial indicators.

Based on this framework, this study articulates six interdependent analytical dimensions as key drivers for the adoption of circular strategies in the textile sector: (1) innovation in circular business models, (2) circular design, (3) bio-based bioeconomy, (4) public policies, (5) collaborative ecosystems, and (6) corporate strategies oriented toward circularity. These

dimensions were selected for reflecting the main challenges and opportunities highlighted in the recent literature on circular economy (Geissdoerfer et al., 2020; Kirchherr et al., 2017; Niinimäki et al., 2020), and for being present in emerging practices observed in the sector. They support the study’s theoretical framework, enabling a comprehensive analysis of the circular transition from multiple levels of transformation, from the micro level (design and innovation) to the macro level (policy and regulation), encompassing organizational strategies and collaborative networks.

The articulation among these six drivers forms a strategic core for the systemic transition of the textile value chain. This approach not only enhances transparency and enables the traceability of design decisions throughout the entire product lifecycle but also allows for environmental impact control, reduction of textile waste, and measurement of the carbon footprint associated with each product. In doing so, it becomes possible to align industrial innovation with the principles of the circular economy and with global climate commitments.

Grounded in the literature on circular economy and sustainable innovation, this study structures its analytical lens around six interdependent dimensions that influence the adoption of circular strategies in the Brazilian textile sector. These dimensions represent both internal and external enabling conditions, as well as strategic drivers related to the transformation of products, processes, organizational culture, and intersectoral relationships. Figure 1 presents the conceptual model guiding the analysis, linking the main constructs to the theoretical propositions investigated.

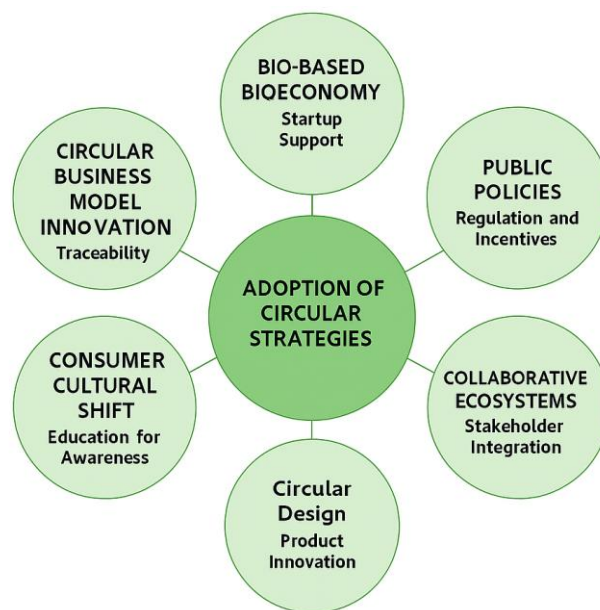


Figure 1. Analytical dimensions and theoretical propositions for the adoption of circular strategies in the textile sector. *Source: Elaborated by the author (2025), based on Kirchherr et al. (2017), Niinimäki et al. (2020), Bocken & Geradts (2020), and Lüdeke-Freund et al. (2019).*

3. Methodology

This study adopts a qualitative, exploratory approach, focusing on documentary analysis. Given the exclusively documentary nature of the research, we employed qualitative content analysis as proposed by Mayring (2014), due to its ability to combine methodological rigour with contextualized interpretation. This approach allowed for the integration of deductive categories,

grounded in the theoretical constructs of the study, with emergent categories identified during the document analysis.

The initial categories were defined based on the literature on circular economy and circular strategies in the textile industry, as represented in Figure 1. Six main analytical axes were considered: innovation in circular business models, collaborative ecosystems, public policies, corporate strategies for circularity, bio-based bioeconomy, and circular design. These dimensions reflect both technical and organizational or institutional factors that influence the adoption of circular strategies.

The coding procedure followed systematic criteria, respecting the context of the texts and ensuring coherence between theory, data, and interpretation. Based on the content analysis, theoretical propositions were developed through an inductive process, integrating empirical findings with the concepts presented in the theoretical framework.

This methodology proves appropriate for investigating complex and interdisciplinary phenomena, such as the transition to circularity in the Brazilian textile chain, especially in Global South contexts where practices are still in the process of consolidation.

3.1. Documentary Sources

Data collection was carried out between March and June 2024, based on secondary sources selected according to thematic relevance, recency, and diversity of perspectives. The documentary sample comprised different types of sources, as shown in Table 1.

Table 1 – Documentary sources used in the analysis, organized by type

Source Type	Documentary Sources Analysed in the Research
International Reports	Ellen MacArthur Foundation (2017 - 2021); UNEP (2023); European Commission (2022); Joint Research Centre (2021).
National Reports	Instituto C&A & BCG (2021); Colerato (2021); ABIT (2024); Mendes (2025).
Sectoral Organizations	Textile Exchange (2023); BSR (2020); McKinsey & Company and Global Fashion Agenda (2020); PACE - Platform for Accelerating the Circular Economy (2021); Mower (2024)
Scientific Articles	Bocken et al. (2016); Geissdoerfer et al. (2020); Niinimäki et al. (2020); Kirchherr, Reike e Hekkert (2017); Lüdeke-Freund et al. (2019); Bakker et al. (2014) ; Brunori & Raffaelli (2014); Pieroni et al. (2021); Sauerwein et al. (2019); Goldsworthy (2014).
Institutional Websites	Muush, Phycolabs, Curauá, Retalhar, Cotton Move, Keel Labs, Resortecs, Rent the Runway, Circulose®.

Source: Compiled by the author (2025). The selection included institutional reports, academic publications, and websites of startups and initiatives applying circular models to the textile value chain.

In addition to institutional and sectoral sources, the selection of scientific articles and academic publications was conducted through systematic searches in the Web of Science, Scopus, Google Scholar, and ResearchGate databases, using the keywords “*circular economy*”, “*textile industry*”, “*business model innovation*”, “*bio-based economy*”, “*circular design*”, and “*traceability*”. Priority was given to the most cited studies published in high-impact

journals, with an emphasis on key authors from both international and Brazilian literature. The inclusion criteria considered thematic relevance to the research constructs and pertinence to the Global South context.

3.2. Analytical Procedures

Data analysis was conducted using a deductive-inductive approach. Initially, analytical categories were defined based on the existing literature, particularly the circularity strategies proposed by Bocken et al. (2016): narrowing (resource use efficiency), slowing (product lifespan extension), closing (material reintegration), and managing (systemic coordination and traceability). These categories guided the preliminary reading and structured the document coding process.

Subsequently, inductive analysis enabled the identification of empirical evidence that confirmed, expanded, or challenged these theoretical categories, revealing emerging patterns within the data. This process led to the formulation of analytical propositions structured around five interdependent axes: innovation in business models, collaborative ecosystems, public policies and regulatory frameworks, corporate strategies for circularity, and circular design, with an emphasis on the role of the bio-based bioeconomy as a driver of sustainable innovation.

The articulation between theoretical dimensions and empirical findings was essential for constructing the conceptual model presented in the results section, allowing for a systemic understanding of the challenges and solutions related to the adoption of circular economy practices in the Brazilian textile value chain.

3.3. Interpretative Synthesis

Table 2 presents the analytical categories used in the documentary analysis, organized according to the circular strategies previously defined in the theoretical framework (Figure 1). The categorization followed a deductive approach as proposed by Mayring (2014), and the examples provided represent recurring excerpts from the documents analysed that illustrate the presence of each subcategory.

Table 2, in conjunction with Table 1, represents a synthesis constructed from documentary analysis, reorganizing concepts and categories in light of empirical evidence. This systematization highlights the specific challenges, opportunities, and contextual enablers within the Brazilian textile value chain.

Due to the exclusively documentary nature of the data, this research did not employ open or axial coding, nor did it make use of qualitative data analysis software, thus diverging from the approach proposed by Gioia et al. (2013). Instead, qualitative content analysis was adopted, following Mayring (2014), which is more suitable for identifying thematic patterns in non-standardized secondary sources.

Table 2: Analytical categories deductively defined based on the circular strategies from Figure 1, according to the content analysis method by Mayring (2014).

The examples represent documentary evidence extracted from national and international reports on circularity in the textile value chain as mentioned in Table 1.

Analytical Category (Circular Strategy)	Subcategory or Focus	Example of Documentary Evidence
Circular Design	Modular, recyclable, and zero-waste design	"Products designed for recycling"; "Zero-waste product design"; "Planned end-of-life of product"
Circular Design	Material innovation and low impact finishing	"Use of biodegradable fabrics made from bio-based or recycled yarns"
Innovation in Circular Business Models	Transparency and traceability	"Tracking product origin through blockchain and use of digital product passport"
Innovation in Circular Business Models	Reverse logistics and recommerce	"Buy-back, repair, recycling programs and resale platforms"
Innovation in Circular Business Models	Use of AI-enabled technologies	"Demand forecasting software, digital design, trend analysis, and circular practice tracking"
Governance and Regulation	Certifications and compliance	"Certification of recycled fibres and sustainable raw materials"
<i>Bio-Based Bioeconomy</i>	Replacement of fossil-based inputs	"Use of renewable raw materials such as algae, fungi, and food waste"
Collaborative Ecosystems	Multi-stakeholder platforms and coalitions	"Collaboration among companies, institutions, suppliers, and consumers"
Culture and Social Participation	Consumer education and engagement	"Consumer campaigns promoting circular habits".

Source: Developed by the author (2025).

4. RESULTS AND DISCUSSION

4.1. Conceptual Model of Solutions for the Adoption of Circular Economy in the Textile Sector

Figure 2 presents the conceptual model developed based on the documentary analysis conducted in this study. The central concept is the adoption of circular strategies in the textile sector, grounded in the articulation of six main dimensions: innovation in circular business models; collaborative ecosystems; public policies and regulatory frameworks; corporate strategies for circularity; circular design; and the bioeconomy or the use of bio-based fibres.

The documentary analysis was guided by the principles of qualitative content analysis (Mayring, 2014), allowing the identification of patterns and thematic recurrences in the secondary sources examined. As a result, a conceptual model was proposed, composed of five theoretical propositions, each representing a critical axis for the adoption of circularity. These propositions derive from the six analytical dimensions previously grounded in the literature (see Figure 1), functioning as interpretive systematizations of the empirical findings.

To present the results, the SQC structure (Setup, Quote, Comment) was adopted, as suggested by Graff and Birkenstein (2014), in which each proposition is discussed through: (i) an introductory statement (setup); (ii) direct evidence extracted from the documents (quote); and (iii) a critical interpretation (comment) that connects the finding to the theoretical framework. This methodological strategy aims to ensure transparency of the analytical process and strengthen the alignment between theory and data.

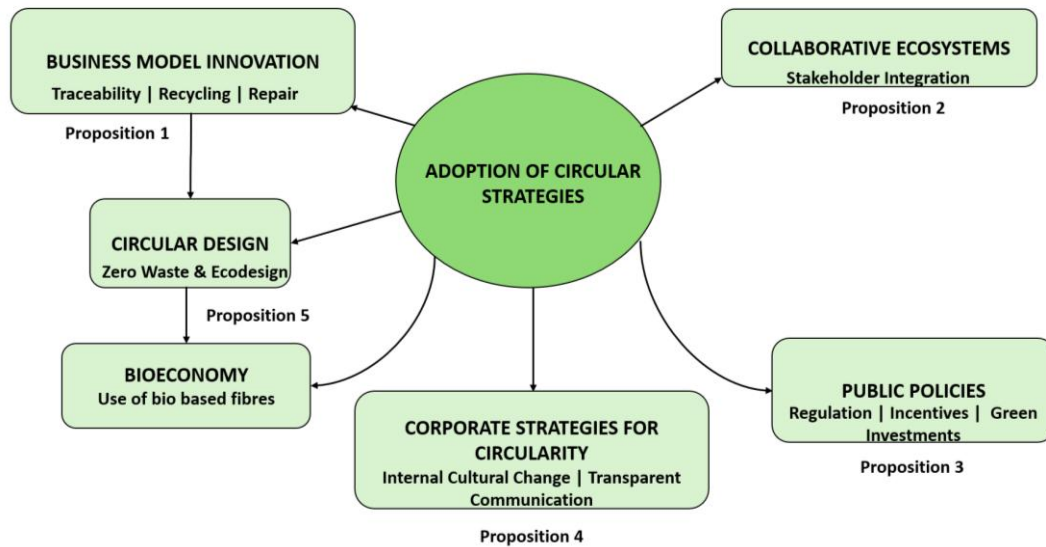


Figure 2: Conceptual model for the adoption of circular strategies in the textile value chain
Source: Elaborated by the author.

These dimensions unfold into five theoretical propositions that express causal relationships and activation mechanisms identified in the documentary sources analysed. Each proposition is grounded in evidence that indicates how emerging practices, policies, and technologies can act synergistically to enable circularity. The model highlights elements such as traceability, stakeholder integration, regulation and incentives, cultural change, both organizational and in consumer behaviour, and innovation in product and material design. In this way, the model not only synthesizes the research findings but also proposes an integrative analytical framework that can guide future investigations and strategic formulations aimed at the circular transition of the Brazilian textile value chain.

The five propositions thus function as analytical syntheses of the results, consolidating empirical evidence in light of the literature and serving as interpretive guides for understanding the challenges and opportunities associated with the circular transition in the Brazilian context. Dimensions such as traceability, product innovation, sectoral integration, and consumer cultural change are transversal to the propositions and reinforce their interdependence.

The analysis revealed that the transition toward a circular textile value chain cannot rely on isolated solutions but instead requires coordinated transformations across multiple fronts. In this sense, Proposition 1 emphasizes the central role of innovation in business models as a driver of systemic transformation, being interdependent with the other propositions.

Proposition 1: Business model innovation as a driver of systemic transition

Setup: The literature recognizes innovation as a central element of the circular economy, extending beyond technology to include cultural and organizational transformations (Geissdoerfer et al., 2020). In the textile sector, innovation is essential given the complexity of the value chain and the volume of waste generated.

Quote: According to the report *Fios da Moda* (Colerato, 2021), “startups are responsible for a significant share of circular innovation, operating in niches such as recycling, reverse logistics, and traceability.”

Comment: Cases such as the brand Flávia Aranha (eco-design and regenerative processes) and the cooperative Justa Trama (solidarity-based organization with social traceability) demonstrate how innovation can be driven by diverse actors. Moreover, digital technologies such as blockchain (FibreTrace, Adetex.ID) expand traceability and trust across the value chain (Lozano et al., 2022). However, as Pieroni et al. (2021) point out, isolated innovations tend not to scale without articulation within collaborative ecosystems.

In addition, several documents analysed emphasize the role of emerging digital technologies in enabling circular business models. There is growing adoption of artificial intelligence (AI) solutions applied at different stages of the value chain. According to Techpacker (2024), AI has been used in trend analysis, generative design (automated creation of designs based on predefined parameters), demand forecasting, and sustainable product development. It also supports lifecycle management (PLM), quality control, logistics, supplier management, and customer services. These tools are complemented by visual search engines, virtual fitting rooms, and content management systems for social media, promoting customer engagement and personalization. Together with blockchain and the emerging Digital Product Passport (DPP), these technologies enhance traceability and lifecycle monitoring capabilities, enabling new business models based on use, sharing, and circularity.

Such technologies allow for fluid communication between companies and service providers in essential circular processes such as collection, cleaning, repair, and distribution. Examples like Circular ID (Eon), the Zoa system (Hirestreet + ACS), the Lizee platform, and the Save Your Wardrobe app demonstrate how technology can generate shared value between brands and consumers through non-financial data, customized experiences, extended product lifespan, and use-oriented innovation. These models may inspire applications tailored to the Brazilian context, particularly in developing integrated solutions for traceability, reverse logistics, and consumer engagement.

Although innovation is an essential starting point, its effectiveness depends on coordination with other actors in the value chain. Proposition 2 therefore highlights the importance of collaborative ecosystems to integrate solutions and amplify impact. The documentary analysis reveals how multi-sectoral networks and territorial coalitions are emerging as key strategies to enable circularity in fragmented contexts such as Brazil.

Proposition 2: Collaborative ecosystems as enablers of circularity

Setup: Circular transition requires synergies among multiple stakeholders, as no single organization holds all the necessary resources (Lüdeke-Freund et al., 2019). (Lüdeke-Freund et al., 2019).

Quote: The Ellen MacArthur Foundation (2017) emphasizes that “circularity demands joint action in business model design, infrastructure, and consumer engagement.”

Comment: The documentary analysis revealed the existence of regional coalitions and consortia in São Paulo, as well as networks such as Fashion Revolution and Justa Trama, which exemplify network-based collaboration. In the international context, initiatives such as ReFashion (France) and Textiles 2030, promoted by WRAP (2021) in the United Kingdom, demonstrate how multisectoral platforms foster systemic solutions. These experiences reinforce the importance of ecosystems as infrastructures for innovation and institutional alignment.

However, even in contexts of intra-organizational cooperation, institutional barriers and regulatory gaps continue to limit the advancement of circular practices. Proposition 3 specifically addresses the role of public policies and regulatory frameworks in creating an enabling environment for transition. The analysed documents show that, in the absence of fiscal incentives, legal targets, and effective regulatory instruments, circularity tends to remain confined to isolated and small-scale initiatives.

Proposition 3: The role of public policies in the circular transition

Setup: The absence of structuring public policies and adapted regulatory frameworks limits the scalability of the circular economy in Brazil.

Quote: he *Panorama Têxtil Brasil* (ABIT, 2023) observes that “the lack of tax incentives and the classification of textile waste as reject prevent the development of circular production chains.”

Comment: Policies such as Extended Producer Responsibility and Digital Product Passports, implemented in the European Union (European Commission, 2022), offer potential pathways. The CVM Resolution nº 193/2023, by requiring ISSB-aligned sustainability reporting standards, represents a significant regulatory advance. However, more specific instruments tailored to the textile sector are still needed.

Beyond external regulation, circular transformation also requires internal change within organizations, both in terms of culture and consumer engagement practices. Proposition 4 explores how corporate strategies focused on transparency, engagement, and impact marketing are essential to build legitimacy, foster new consumption habits, and consolidate business models based on circularity.

Proposition 4: Organisational culture and marketing as educational tools for cultural transformation

Setup: The circular transition entails internal cultural change and transparent communication with consumers.

Quote: According to Mol (2015), “environmental transparency is an emerging regulatory mechanism that can generate pressure for internal changes.”

Comment: Startups such as Retalhar and Cotton Move exemplify how traceability and the communication of positive impact can engage consumers and generate value. However, greenwashing practices are still common (Delmas & Burbano, 2011), highlighting the need for greater coherence between discourse and action. Strategic marketing, when aligned with genuine circular values, becomes a powerful tool for cultural and educational transformation. Finally, the evidence indicates that circular design acts as an integrative link between innovation, strategy, and sustainability.

Proposition 5 explores how circular design, eco-design, and zero waste design, along with the use of bio-based materials, can contribute to the closing of production loops from the product conception phase, while also demanding changes in professional training and in how companies structure their supply chains.

Proposition 5: Circular design and innovation in sustainable materials

Setup: Circular design and the bioeconomy based on renewable and bio-based fibres act complementarily in the initial phase of the product life cycle, guiding the creation of recyclable solutions with lower environmental impact. Both concepts are foundational pillars in designing products for circularity from the outset, integrating technical, aesthetic, and environmental innovation.

Quote: According to Niinimäki et al. (2020), “designing products with a focus on disassembly and recyclability is essential to closing production loops within the logic of the circular economy.”

Comment: Initiatives such as the Oricla project (ORICLA, 2023) demonstrate how waste can be reintegrated into valuable products. In terms of design strategies, the use of mono-materials—fabrics composed of a single fibre type, such as 100% cotton or 100% recycled polyester—has been widely discussed in the literature as a way to facilitate disassembly, sorting, and recyclability in post-consumption stages (Goldsworthy, 2014; Karell & Niinimäki, 2019; Sauerwein et al., 2019). Modular design has also been explored by brands such as Botter, Coperni, Peter Do, and Courrèges, which create transformable, adaptable, and multifunctional garments, such as blouses that turn into skirts or jackets with removable elements. These products extend their useful life while promoting circular experiences with aesthetic and playful appeal (Mower, 2024).

The bioeconomy based on Brazilian natural fibres and emerging biotechnological solutions, as developed by startups like Muush, Curauá, and Phycolabs, reinforces this pathway by introducing raw materials with lower environmental impact and high reintegration potential in production cycles. This convergence of material innovation and design strategies outlines a promising direction for the circular transition of the Brazilian textile value chain.

4.2. Discussion

The analysis of results demonstrates that the transition to a circular textile economy in Brazil is conditioned by a combination of interdependent factors, synthesised in the five theoretical propositions developed. In response to the questions raised in the introduction, the study showed that circularity in the textile value chain cannot be understood as a mere technological or sectoral change, but rather as a systemic transformation that requires innovation in business models, cooperation among stakeholders, appropriate sectoral regulation, cultural change, and integrated product development strategies.

These findings are aligned with the international literature: Geissdoerfer et al. (2020) propose replacing the linear model with circular approaches based on systemic sustainability; Niinimäki et al. (2020) emphasise the strategic role of circular design; and Porter and Kramer (2011) highlight the logic of shared value as a way to integrate purpose and economic performance. When applying these frameworks to the Brazilian context, the study reveals critical specificities of the Global South. Unlike countries in the Global North, which have outsourced production stages, Brazil, like China and India, maintains a relatively complete supply chain, from fibre production to garment manufacturing (UNIDO, 2021; IEMI, 2022). This structure offers greater intervention capacity over industrial and logistical flows, enabling the redesign of business models more aligned with circularity (Colerato, 2021; Ellen MacArthur Foundation, 2021).

On the other hand, the country faces structural obstacles such as informality, fragmentation of the value chain, and the lack of consistent public policies, which limits the scalability of circular

practices and reinforces the importance of locally adapted solutions. The articulation of the five concepts, innovation, stakeholder collaboration, regulation, organisational culture, and circular design, enabled the formulation of an integrative conceptual model that goes beyond fragmented approaches focused solely on technology or consumption. This model provides both a theoretical and methodological contribution to understanding circularity in complex production systems and emerging market contexts.

Analytically, the proposed model advances by incorporating structural dimensions that are often overlooked in circular economy studies, such as the role of regulation, traceability gaps, and the need for coordination among multiple agents in collaborative ecosystems. Practically, the results highlight several pathways for companies, startups, and policymakers: developing regional collaborative arrangements; fostering innovation programmes based on circular design and the bio-based bioeconomy; revising legal frameworks that hinder waste reuse; and promoting conscious consumption through marketing strategies oriented by socio-environmental value.

Moreover, this study contributes to expanding the understanding of the feasibility conditions and activation mechanisms for a circular textile value chain in Brazil by highlighting the potential of communities of practice and collaborative networks as catalysts for transition. As proposed by Wenger, McDermott, and Snyder (2002), communities of practice are formed by actors who share a common domain and learn collectively through continuous interaction, the construction of shared repertoires, and the resolution of practical problems. In the textile sector, these communities can play a strategic role in consolidating socio-environmental innovation ecosystems and inducing institutional change by promoting knowledge exchange, articulating demands for regulation, and encouraging the formation of public–private partnerships. This process finds parallels in the European Union, with policies such as the Green Deal and the EU Strategy for Sustainable Textiles (European Commission, 2022), which highlight the role of collaborative coalitions in shaping circular economy agendas.

Finally, the results indicate that an effective circular transition depends on the combination of three levels of transformation: **micro**, involving innovation in products and business models; **meso**, through the consolidation of territorial ecosystems, collaborative arrangements anchored in regional contexts that integrate companies, policymakers, scientific institutions, and civil society to foster sustainable innovations; and **macro**, with public policies and regulatory structures that promote institutional coherence and economic incentives for circularity (Truffer & Coenen, 2012).

5. Final Considerations

The findings of this study indicate that the transition to circularity in the Brazilian textile value chain depends on multiple interdependent factors, including innovation in business models, the development of traceability technologies such as blockchain and Digital Product Passports (DPPs), the use of bio-based or recycled raw materials, and the strengthening of circular design as both a corporate and educational strategy.

The documentary analysis allowed for the identification of emerging practices such as the use of mono-materials, the valorisation of waste through upcycling and industrial recycling processes, as well as the adoption of environmental certifications. These practices offer concrete pathways for closing and narrowing material loops in the textile sector.

However, the data also reveal significant barriers, such as the absence of structured public policies, the lack of incentives for collaborative innovation, and the challenges related to training professionals capable of operating in circular ecosystems. These obstacles constrain the scalability of the identified solutions, requiring stronger integration among government, the private sector, educational institutions, and civil society.

From a theoretical standpoint, this study advances the understanding of circular strategy adoption in complex value chains by proposing an integrative conceptual model that articulates innovation, collaborative ecosystems, public policies, organizational culture, and circular design.

This contribution aligns with the propositions of Geissdoerfer et al. (2020), who advocate for systemic approaches in the transition to circularity; with Bocken et al. (2016), who emphasize the relevance of circular business models; and with Niinimäki et al. (2020), who assign a central role to design in structuring circular value chains. By applying these frameworks to the context of the Global South, the study also addresses research gaps identified by authors such as Colerato (2021) and Sauerwein et al. (2019), who stress the need for solutions tailored to productive realities marked by informality, low traceability, and institutional fragmentation.

In practical terms, the findings offer insights to support the formulation of public policies and corporate strategies aligned with the Sustainable Development Goals, particularly SDG 12, which promotes responsible production and consumption patterns. Furthermore, the proposed conceptual model may serve as a reference for companies and startups aiming to align innovation with social impact and environmental regeneration.

Future research should pursue the following four main directions:

- a)** Investigate how Brazilian and international biotechnology-based startups associated with the bioeconomy (e.g., Muush, Curauá, Phycolabs, Re-Root-TEX, Keel Labs, and BioPuff®) can contribute to circular strategies in the textile sector, with emphasis on the use of textile raw materials made from plant-based fibres and their potential for future scaling.
- b)** Analyse circular design, eco-design, and zero-waste design practices in the Global North to assess their applicability and adaptation potential to the Brazilian textile industry.
- c)** Map the main regulatory, cultural, and structural barriers faced by startups in implementing circular models in the Brazilian context.
- d)** Examine the enabling role of emerging digital technologies such as artificial intelligence, blockchain, Digital Product Passports, and Product Lifecycle Management (PLM) systems in facilitating decentralized circular networks.

Additionally, future studies should incorporate qualitative data through interviews with representatives of startups, companies, and industry associations to deepen the understanding of success factors and practical limitations of the circular transition.

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