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Exploring challenges in unlocking circular supply chains for fashion and textile: blockchain for strategic solutions

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Abstract

Purpose – The transition of the fashion and textile supply chain towards circularity faces persistent challenges, particularly in achieving traceability, transparency and accountability across complex global networks. This study investigates the key barriers to circular supply chain adoption and examines the potential role of blockchain as a trust-enabling technology to support circular practices.

Design/methodology/approach – This study adopts a mixed-method research design, combining survey data with in-depth semi-structured interviews involving fashion and textile industry stakeholders and technology experts. The data are analysed thematically to identify and categorise barriers across regulatory, economic, societal, informational, technological, organisational and market-related dimensions. To enhance the generalisability of the findings, results are also compared with barriers reported in other industries and geographical contexts.

Findings – The findings reveal that barriers to circular supply chains are highly interconnected rather than isolated, with governance, information quality and digital infrastructure emerging as critical enabling factors. Inadequate data standards, limited information sharing and weak accountability mechanisms restrict traceability and undermine sustainability efforts. Blockchain is identified as having strong potential to support trusted data frameworks, provided it is implemented strategically and aligned with governance structures, data standards and stakeholder incentives.

Originality/value – This study contributes to the limited empirical research on blockchain-enabled circular supply chains within the fashion and textile sector by offering stakeholder-informed insights into systemic adoption barriers. It positions immutable traceability as a foundational requirement for circularity and sustainability and frames blockchain not merely as a technical tool, but as part of a broader collaborative infrastructure necessary for industry-wide transformation.

Keywords Circular supply chains, Fashion and textile industry, Traceable technologies, Blockchain, Innovation and infrastructure

Paper type Research article

1. Introduction

The circular economy (CE) has long been positioned as a prominent framework for sustainable economic activity (Geissdoerfer *et al.*, 2017). Yet, despite its sustained presence in scholarly and policy discussions, its adoption in practice, particularly in complex industries such as Fashion and Textiles (F&T) (Heim and Hopper, 2021), remains nascent (Feldman *et al.*, 2024). It envisions a system where materials circulate perpetually, and ecosystems are revitalised. While CE principles are often articulated at a systems or ecosystem level, their practical implementation occurs within supply chains, where material flows, production decisions and value recovery are operationalised. In this context, circular supply chains (CSC) represent the mechanism through which CE principles are translated into actionable industry practices.

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Products and materials remain in use through maintenance, reuse, refurbishment, remanufacturing, recycling and composting (UNDP, 2023). A core principle is the recovery of value via shorter cycles such as reuse and refurbishment, rather than recycling or energy recovery (Mishra *et al.*, 2018). Building on these principles, CSC extend traditional linear supply chain models by integrating closed-loop and open-loop material flows, enabling the recovery, reuse and regeneration of resources across product lifecycles, particularly at end-of-life (EOL) (Lin, 2024). Closed-loop supply chains retain materials within the original value chain, preserving material quality and maximising value retention, while open-loop systems redirect materials into alternative value chains. The integration of both configurations is essential within CSC, enabling flexible value recovery across diverse material and economic conditions (Farooque *et al.*, 2019).

The F&T industry has drawn attention to CE for its potential to achieve prosperity within ecological limits. Despite its scale and economic contribution, the industry is still infamous for opaque supply chains and unethical practices, including sweatshops, modern slavery and unsafe working conditions (Badhwar *et al.*, 2024). These unsustainable practices, alongside the climate emergency and the United Nations (UN) sustainable development goals (SDGs) (UNDP, 2023), highlight the urgency of developing traceable and accountable systems as a pre-requisite for CSCs. Extending product lifecycles and reintegrating textiles waste as raw materials can help mitigate environmental and social impacts, aligning the industry with sustainable development (Ermini *et al.*, 2024; Schiaroli *et al.*, 2024).

While industry is interested in adopting sustainability and supply chain strategies, challenges persist in their effective implementation (Khan *et al.*, 2021). CSCs offer a pathway by embedding CE principles into supply chain management (SCM), enabling recovery of EOL products and reducing waste (Farooque *et al.*, 2019). However, research is still largely conceptual with practical solutions in pilot stages. Among many Industry 4.0 (I4.0) technologies, blockchain, commonly referred as "trust technology", has emerged in CSC discussions (Garcia-Buendia *et al.*, 2024; Montag, 2023) with limited empirical studies, particularly in exploring barriers to its adoption to enable CSC (Ayati *et al.*, 2022).

Blockchain is particularly relevant in this context, as its inherent ability to enhance traceability and transparency through its features like immutability of data, capacity to facilitate large networks and stakeholders and real-time data capturing with geo-time stamps (Badhwar *et al.*, 2023). These features show potential in addressing the opaque and fragmented nature of F&T supply chains (Liu and Liu, 2025). This study builds upon addressing the challenges hindering the Australian F&T industry's CSC transition and focuses on blockchain-enabled framework as a circular transition enabler.

Despite the growing interest in CSC, variations in CE definitions persist. A definition adopted for the purpose of this study suggests, "the foundation of the CSC is reuse, including reuse at the product level (such as "repair" or "refurbishment"), reuse at the component level (such as "remanufacturing"), and reuse at the material level (such as "recycling")" (De Angelis *et al.*, 2018). Regardless of definitional nuances, the aim remains to move beyond the linear model, which has prioritised profit at ecological cost (Nasir *et al.*, 2017).

The foundational challenge lies in the intersection of CSC and the current operations of the F&T industry, shaping a production system which has imbalanced economic and ecological priorities. Similarly, technology has aided F&T industry in taking data-driven decisions prioritising profit by transforming retail and fashion accessibility. However, technological advancements have also created opportunities for sustainable practices, including CSC innovation (Dzhengiz *et al.*, 2023; Kayikci *et al.*, 2024).

Existing literature calls for further investigation into barriers in shifting from linear to circular models (Ayati *et al.*, 2022). While the CE is sometimes criticised for not extending beyond theoretical principles and the challenges of practical implementation (De Angelis, 2021), this study seeks to bridge the gap by examining its application within F&T supply chains. It does so by addressing two primary research questions (RQ):

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Specifically, this study investigates:

RQ1. What are the major barriers preventing F&T supply chains' transition to CE?

RQ2. How can blockchain technology enable traceability and transparency within CSC in the F&T industry?

Recent literature also reflects the novelty of CSC, with publications increasing significantly only in the past six years (Rasi *et al.*, 2023). With CSCs' recognised potential to balance sustainability and competitiveness (Masi *et al.*, 2017), integration remains limited to a few industries in developed economies (Ayati *et al.*, 2022; Rasi *et al.*, 2023). Given the nascency of CSCs, this study also seeks to assess the awareness levels of the CSC within the Australian F&T industry professionals on the basis of the theoretical definition highlighted above.

RQ1 draws on two streams of data. The survey tests baseline awareness of CE and CSC, often a barrier to transition, and probes perceptions of technological integration, informing both RQ1 and RQ2. The interviews add depth by exploring barriers beyond awareness and validating survey insights, while also enriching understanding of how emerging technologies, such as blockchain, can support CSC transition. Together, the survey and interviews provide complementary perspectives, combining baseline awareness with strategic, in-depth insights.

2. Background

2.1 Fashion and textile industry overview: Australia's unique position

Australia is a major producer of natural fibres such as cotton and wool, but with less than 5% of onshore manufacturing, it relies heavily on imported F&T products (AFC, 2022). Australians purchase an average of 56 new items annually and discard around 23 kilograms of clothing per person, making the country one among the highest per capita consumers globally (Khan *et al.*, 2023; Retamal *et al.*, 2023). This reliance on imports against the backdrop of supply chain opacity, data gaps and accountability issues (Badhwar *et al.*, 2025), complicates the transition from linear to CSCs.

Australia plans to double its circularity by 2035, changing the way resources are used, reused and recovered nationwide (DCCEEW, 2024). Given that most F&T manufacturing is offshore, Australia's agriculture (Boersma *et al.*, 2025) and resource recovery sectors are crucial for transitioning the F&T sector onshore (Foley, 2024). The reliance on offshore manufacturing complicates CSC decision-making by dispersing key actors across global production networks (Feldman *et al.*, 2024).

With the responsibility of ordering, purchasing and importing products (Grégoire and Guay, 2023), Australia presents a significant opportunity to offer solutions for tracking the origin of the imported F&T items to advance towards CSC. Consequently, interoperable systems that enable transparent, credible information flows across stakeholders are critical for supporting Australia's CE transition.

2.2 Blockchain for circular fashion

Blockchain, often described as the "technology of trust", offers immutability that strengthens traceability and transparency across industries (Badhwar *et al.*, 2023). In F&T sector, luxury brands have adopted blockchain to combat counterfeiting, enhance consumer communication (Vieira, 2022) and creating digital fashion by NFTs (Zhang and Phang, 2024). However, in mass-produced fashion, applications remain limited to early research and pilot studies, with few scalable business cases (Chen, 2023).

CSC have become a strategic priority for organisations, shaping not only environmental but also economic and operational decisions (González-Sánchez *et al.*, 2020). I4.0 technologies, including blockchain, are viewed as enablers (Ghoreishi and Happonen, 2022) of this transition through improved data collection, information sharing and system integration in supply chains (Pal *et al.*, 2025). Blockchain has significant potential to enhance supply chain

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visibility by enabling real-time global stakeholder participation and streamlining communication (Philipp *et al.*, 2019). While blockchain's potential in CSCs is recognised, its role remains emergent and under-explored especially with navigating unique challenges of the F&T sector (Kayikci *et al*., 2024; Quayson *et al*., 2023).

Some scholars argue blockchain can significantly enhance traceability and strengthen SCM (Kouhizadeh *et al.*, 2020), making it a promising tool for advancing circularity in fashion (Cernansky, 2022). Others contend that evidence remains inconclusive, as large-scale applications are absent in mass-produced fashion, highlighting the paradoxical nature of the argument and need for further empirical research (Heim and Hopper, 2021) setting the context for this research. Notably, the European Union's Digital Product Passport (DPP) legislation reinforces the growing policy emphasis on traceability, with implications for shaping future regulatory approaches in contexts such as Australia.

2.3 Theoretical underpinning

The CE provides the theoretical foundation for CSC, shaping how industries conceptualise the transition from linear to circular models. Within this context, CSC operationalises CE principles by embedding resource recovery, reuse and regeneration into supply chain management. Despite this alignment, existing literature highlights a limited understanding of how CSC is practically implemented and, more critically, the barriers that constrain its adoption (Ayati *et al.*, 2022). Identifying bottlenecks remains critical to achieving scaled CSC adoption (Piila and Sarja, 2024).

Barriers to CSC transition have been conceptualised across multiple dimensions: Vermunt *et al.* (2019) distinguish between internal and external environmental factors; Saroha *et al.* (2018) identify societal, market, governmental, financial, technological, knowledge and managerial challenges; while Kirchherr *et al.* (2018) categorise them under culture, policy, economics and technology. Expanding on these perspectives, Ayati *et al.* (2022) classify barriers into seven dominant categories: economics, government, society, information, technology, organisation and market. This study adopts this classification as the analytical foundation for RQ1.

Effective CSC implementation requires several core characteristics, including traceability, transparency, stakeholder coordination and lifecycle visibility. However, achieving these characteristics remains challenging in the F&T industry due to fragmented supply chains, limited data integration and lack of accountability across actors. These limitations directly relate to the identified barriers and highlight the need for enabling mechanisms that can support CSC functionality.

Within this context, blockchain technology (as discussed in Section 2.2.) is increasingly proposed as a potential enabler due to its ability to provide immutable, decentralised and transparent data systems. Its capacity to support multi-stakeholder coordination and enhance data reliability positions it as a relevant technology for addressing information and traceability barriers within CSC (Khan *et al.*, 2021).

RQ2 builds on this premise by examining how blockchain can address the barriers identified in RQ1. In doing so, the study evaluates blockchain against key CSC characteristics, including value retention, system integration and lifecycle traceability. This provides the basis for developing a framework that integrates technological and governance-driven approaches to enable CSC transition.

3. Methodology

3.1 Research design

This study adopts a mixed-methods concurrent design (QUAL + quan) following Creswell and Clark (2017), where qualitative and quantitative data are collected in parallel and integrated during analysis. The design was selected to combine the depth of qualitative insights

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with the breadth of quantitative data, enabling a more comprehensive understanding of CSC transition in the Australian F&T industry. The qualitative interviews serve as the primary data source, while the survey provides supporting contextual evidence. An inductive-dominant approach guided the analysis, with themes emerging from qualitative data and quantitative results used for cross-verification. The overall design is summarised in Figure 1.

3.2 Sample selection and data collection

Participants were identified using purposive sampling through LinkedIn, professional networks and industry contacts, targeting individuals working within the Australian F&T

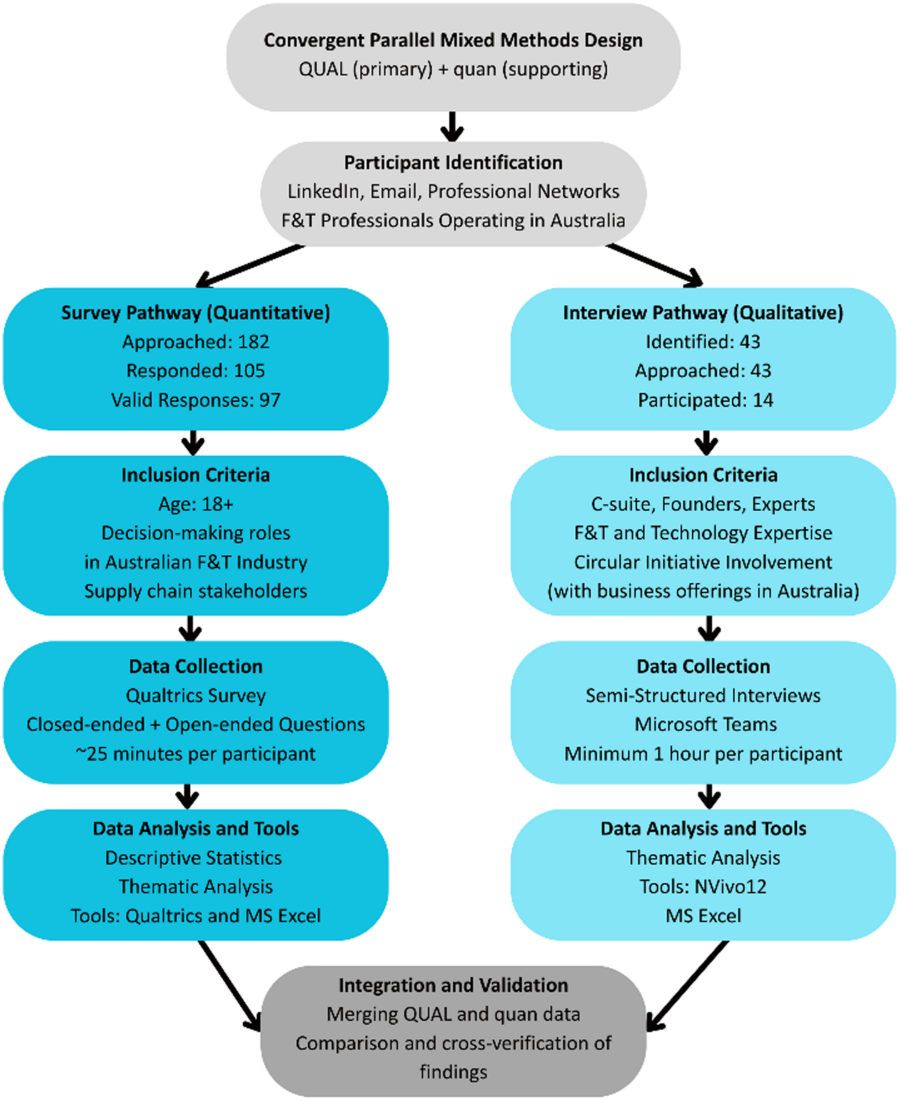

Figure 1. Convergent parallel mixed-methods design and sampling process. Source: Authors' own work

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sector. Initial outreach was conducted via direct messages and email invitations, resulting in 182 professionals being approached for the survey. Screening criteria included age (18+), professional involvement in the F&T industry and decision-making responsibility within their organisation. Of the 105 responses received, incomplete and ineligible responses were removed, resulting in a final sample of 97 valid participants.

A survey of 97 professionals captured awareness of CE and CSC, with respondents representing businesses of varying sizes by business origin, type (Fashion Pyramid classification) (SanMiguel and Sádaba, 2020), size and supply chain ownership (refer Table 1 for the sample description). Awareness of CE and CSC remains limited in Australia, hindered by inadequate related educational initiatives (Ayati *et al*., 2022; Cole *et al*., 2019; Frei *et al*., 2020).

Effective CE implementation requires coordination, transparency and stakeholder collaboration, with traceability as a critical enabler (Santana and Ribeiro, 2022; Zhou *et al*., 2023). To examine these issues, a Qualtrics survey (refer to Table 2 for the survey design) was distributed via LinkedIn, professional networks and email.

For the interview phase, a subset of 43 professionals was identified using similar purposive criteria, with an emphasis on seniority (C-suite, founders and domain experts) and involvement in circular or traceability-related initiatives. Following recruitment via LinkedIn, company websites and email, 14 participants agreed to participate and met the inclusion criteria. This staged approach ensured that participants possessed the required expertise while maintaining an Australia-centric focus.

Participants were identified through associations and media (AFC, Vogue Australia, The Guardian) and contacted via email and LinkedIn. Collecting data from decision-makers provided depth on organisational priorities and strategic challenges (Caldarelli *et al*., 2021; Ziolkowski *et al*., 2019).

The interviews engaged senior leaders from two groups: (A) fashion businesses recognised for circular initiatives, and (B) blockchain and supply chain technology specialists supplying F&T brands in Australia. Participants included C-suite executives, directors and business owners, ensuring top-level strategic perspectives on CSC transition (refer Table 3 for the sample description).

Each protocol consisted of the following sections: (1) An introduction to the interviewee's role and area of expertise. (2) Questions regarding the current state of CE in the Australian F&T industry, as well as the transition of existing supply chain operations to a CSC. (3) An exploration of the challenges hindering the transition (Nyffenegger *et al*., 2024) of F&T supply chains to CSC.

Table 1. Description of survey respondents based on business' origin, type, size and supply chain ownership

Analysed sample (97 responses)					
Origin of business operating in Australia	Australian business operating in Australia		Global business operating in several countries including Australia		Other (services and consultation)
Count (%)	48		42		10
Type of business based on the fashion Pyramid	Luxury and Premium		Mass Market		Other (services and consultation)
Count (%)	49		18		10
Business size based on number of employees	Small (0–19)		Medium (20–199)		Large (Over 200)
Count (%)	11		28		61
Business' supply chain	Locally Owned	Locally Outsourced	Globally Owned	Globally Outsourced	Other
Count (%)	21	8	22	39	10

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Table 2. Survey design with details of the responses

Questions	Context of the questions	Requirement of response	Modification of response	Respondents (*n*)
2	Screening: age and role	Mandatory	Allowed	97
4	*Type: Business and supply chain*	Mandatory	Allowed	97
1	*CE and CSC awareness level*	Mandatory	Allowed	97
Definitions of CE and CSC provided for clarity				
1	*Traceability in CSC awareness level*	Mandatory	Finalised responses without modification	97
1	*Descriptive elaboration of traceability in context of CSC*	Mandatory	Finalised responses without modification	75
1	*Transparency in CSC awareness level*	Mandatory	Finalised responses without modification	97
1	*Descriptive elaboration of transparency in context of CSC*	Mandatory	Finalised responses without modification	86
1	*Potential of technological integration to advance CSC*	Mandatory	Finalised responses without modification	97

Table 3. Categorisation of the sample profile from the F&T industry and technology sector

Group A Criteria	Fashion and textile industry Category	Participants codes
Supply chain operations	Local	GA1, GA3, GA5
	Global	GA2, GA4, GA6, GA7
Retailing location	Local	GA1, GA2, GA3, GA5, GA6
	Global	GA4
Emerging technology	Users	GA2, GA6, GA7
	Non-users	GA1, GA3, GA4, GA5
Primary initiative focus	Circularity	GA3, GA5, GA7
	Sustainability	GA1, GA2, GA4, GA6

Group B Criteria	Technology sector Category	Participants codes
Business origin	Local	GB2, GB3, GB5, GB6
	Global	GB1, GB4, GB7
Availability of technology services	Local	GB5, GB6
	Global	GB1, GB2, GB3, GB4, GB7
F&T centric services	Exclusive	GB1, GB3, GB4, GB7
	Inclusive	GB2, GB5, GB6
Primary initiative focus	Circularity	GB2

3.3 Data analysis

A two-stage cross-analysis (Hill, 2012) assessed awareness of the CE and CSC using data collection and analysis tools such as Qualtrics and Microsoft Excel. First, respondents were categorised into four groups based on their self-assessment: *Experts* (complete understanding), *Name-Droppers* (partial understanding), *Fence-Sitters* (uncertain) and *Newcomers* (unfamiliar). Descriptive statistics (%) summarised awareness levels, deliberately limited to simple descriptors in line with prior awareness-testing studies using binary or categorical measures (Bahtiyar *et al*., 2020; Radanovic *et al*., 2018).

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In the second stage, only *Experts* and *Name-Droppers* were retained, provided with standardised CE and CSC definitions, and asked to describe traceability and transparency in this context. These responses were thematically analysed to extract key insights. This approach deepened understanding of awareness levels and enabled comparison with interview findings, enhancing analytical rigour. The findings from the survey are presented in Section 4.1.

Qualitative data from the interviews were analysed using thematic and content analysis (Humble and Mozelius, 2022), identifying keywords as nodes and discerning patterns (Neuendorf, 2018; Roberts *et al*., 2019). NVivo 12 software supported coding (Allsop *et al.*, 2022), guided by the six-step thematic analysis framework (Braun and Clarke, 2006; Oguntegbe *et al*., 2022) as shown in Table 4. Within-group analysis of Groups A and B was followed by cross-group comparison, ensuring a comprehensive perspective. Transcriptions were coded to reveal themes, ultimately categorised based on Ayati *et al*. (2022) classification: economics, government, society, information, technology, organisation and market.

4. Findings

4.1 Survey findings

In the first stage of self-assessment, most respondents demonstrated complete awareness of the CE and CSC, placing them in the Expert category as shown in Table 5. A similar pattern was observed in their understanding of traceability and transparency within CSC. Name-Droppers and Newcomers accounted for comparable proportions, while Fence-Sitters represented the smallest share. Although Experts expressed optimism about technology's role in advancing CSC, they comprised less than half of total responses. More than half of respondents reported only partial confidence, uncertainty, or unfamiliarity regarding technology adoption in CSC within the F&T industry.

In Stage 2, Experts contributed most descriptive responses on traceability and transparency, followed by Name-Droppers. However, the most notable change was a rise in Fence-Sitters, with 17% expressing uncertainty about traceability and 15% about transparency, which shifted the overall distribution of respondent category. This increased their overall share to 20.4%

Table 4. Thematic analytical approach adopted for RQ1 and RQ2

Qualitative data gathering process (utilising interviews and descriptive survey responses)				
Step 1	Familiarising with the dataset by reading the literature analysis conducted for the purpose of research			Data Analysis
Step 2	*Organising the data to generate initial codes*			
RQs and data gathering tools	RQ1 (Awareness Survey)	RQ1 (Interview)	RQ2 (Interview)	
Number of initial codes	8	64	8	
Step 3	Classifying similar codes into the overarching themes			
RQs and data gathering tools	RQ1 (Awareness Survey)	RQ1 (Interview)	RQ2 (Interview)	
Number of overarching themes	2	7	3	
Step 4	*Reviewing the themes by comparing with dataset*			
RQs and data gathering tools	RQ1 (Awareness Survey)	RQ1 (Interview)	RQ2 (Interview)	
Number of reviewed themes	2	7	3	
Step 5	*Renaming the emergent themes*			
RQs and data gathering tools	RQ1 (Awareness Survey)	RQ1 (Interview)	RQ2 (Interview)	
Number of themes	2	3	3	
Step 6	Data Reporting			

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Table 5. Survey findings from stage 1

Context	Experts (%)	Name-droppers (%)	Fence-sitters (%)	Newcomers (%)
CE and CSC awareness	74	10	7	10
Definitions of CE and CSC provided for clarity				
Traceability awareness in CSC	61	16	7	16
Descriptive responses	*Data collected from Experts and Name-Droppers (n = 75) to include and analyse in Stage 2*			
Transparency awareness in CSC	76	12.5	5	6
Descriptive responses	*Data collected from Experts and Name-Droppers (n = 86) to include and analyse in Stage 2*			
Positive scope of technological integration for CSC transition	42	18	31	9

from 7% for traceability and 18.5% from 5% for transparency and reducing the proportion of respondents with complete or partial understanding compared to Stage 1.

Thematic analysis identified four traceability themes outlined in Table 6: (1) tracking products from raw materials to consumers, (2) demand for data-driven solutions, (3) accountability through reliable data, and (4) overlap with transparency. Transparency reflected similar themes: (1) stakeholder information sharing, (2) ethics and workers' rights, (3) product lifecycle and waste management and (4) overlap with traceability.

A key Stage 2 finding was the absence of references to circular practices such as R-imperatives or closed-loop systems. While stakeholders viewed credible information as essential, their focus remained on linear supply chains, revealing both limited envisioning of CSC in practice and a gap in understanding CE and CSC principles.

4.2 Interview findings

RQ1 of study focuses on the categorisation of challenges presented in three themes in Table 7 based upon Ayati *et al.* (2022) classification: economics, government, society, information, technology, organisation and market. All interview quotations referenced in this section are provided in Table A1 in Appendix; each is cited using the interviewee code and quotation (Q#) number for ease of reference.

4.2.1 Fashion accelerates depreciation: the current nature of fashion. Participants consistently described the current F&T industry as being driven by cost efficiency and profit maximisation, often at the expense of transparency and ethical considerations. Both mass-market and luxury segments were perceived to operate with limited visibility across their supply chains, although through different structural approaches.

Luxury brands were described as maintaining greater control over their supply chains, often through vertically integrated operations. However, this control was also associated with strategic opacity, where limited disclosure was seen as a means of protecting competitive advantage. In contrast, high-volume F&T businesses were characterised by complex, multi-tiered supply chains, which participants noted make traceability difficult to achieve and monitor (GB4, see Q1).

Participants highlighted that cost pressures begin at the raw material sourcing stage, where low-cost procurement strategies often result in the use of substandard materials. This was widely acknowledged to contribute to the production of lower-quality garments with reduced

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Table 6. Stage 2 of descriptive thematic analysis performed on the survey data obtained from experts and name-droppers of stage 1

Themes		Representative responses	(n = 75) Count (%)
Traceability for CSC	Tracking of product from raw material to consumer	Product details and impact at each level in SC The ability to track the details of the product's origin The ability to trace back to the roots of how and where a garment is made	48%
	Data focused solution	A system in supply chain to find out the problems efficiently Analytical verification of the product, live tracing The ability to see all the steps of the supply chain using technology for reliable data	11%
	Transparency focused overlaps	Customer knows how their products are produced Knowing how your products are made and communicating that openly, communicating product knowledge both to internal and external stakeholders, including customers Letting the stakeholders know about the operations such as sourcing, supplier details, logistics, production, shipment to build trust in relationship	16%
	Accountability	Being accountable for each tier of the supply chain Auditing the transparency Proving the credibility of supply chain and taking responsibility of the information	8%
	Added to Fence-Sitters	*Respondents indicated uncertainty, as they were unable to edit their previous response and thus could not provide a descriptive answer*	*17%*
Transparency for CSC	Information sharing focused	Essentially being open and honest about all business operations or at the least being open and honest about the fact that you don't have access to all information Sharing information about the supply chain within the organisation and consumers Any customer can access the traceability information anytime	37%
	Ethics and worker rights focused	Ethical supply chain, ethical sourcing and fair wages for the labour Responsible production with safe working conditions End to end Ethical practices in supply chain	12%
	Traceability focused overlaps	Any process in the supply chain (suppliers, manufacturers, brand itself etc.) are very clear and able to be tracked Business is aware of all the materials and stakeholders involved in making the final product within the supply chain Evidence and clarity about all the involved tiers, their geographical location as well as social and environmental standards and their partners. Transparency in data regarding the fibres and their original resource, manufacturing processes and human assets involved	35%
	Product life cycle focused	Providing information about the waste management system	1%
	Added to Fence-Sitters	*Respondents indicated uncertainty, as they were unable to edit their previous response and thus could not provide a descriptive answer*	*15%*

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Table 7. Thematic analysis and categorisation of challenges in transitioning to CSC identified by groups A and B in Australian fashion and textile industry's context during interviews

Challenges	Theme 1 Nature of fashion	Theme 2 Knowledge gaps	Theme 3 Foundational flaws
Economics and finance	Capitalism, prioritising profit, high volume business, overproduction, lack of manufacturing and remanufacturing infrastructure, low value of material recovery and recycling practices, landfilling is cheaper and more accessible than recycling	Lack of scaling recovery, remanufacturing and recycling practices, lack of interest and initiatives in scaling innovative material for circulation	Disposal of economic and financial resources in aftermath inquires over preventive frameworks
Government and regulations	Weak regulations, conservative levy, slow policy reform	Lack of regulations to transition to CE, lack of clear action plan and targets for CE	Loose regulations, delayed action, disproportionate punishment
Society and culture	Accepts low quality products for cheaper products, overconsumption	Lack of awareness towards impact of overconsumption, lack of knowledge towards circular practices	Prioritises aspirations over acknowledging fashion's environmental and social impact
Information	Selective information or misinformation sharing practices, lack of transparency in take-back initiatives, fake audits and compliance, lack of post-consumption information	Lack of EoL management databases, subjective nature of sustainability, lack of information on recycling blended fabrics	Lack of garment detailed labelling standards for F&T products
Technology	Hesitation towards technology, material innovation lacks scaling	Lack of use of technological advancements to reduce production impact, promotion f overconsumption using advance technology	Lack of manufacturing capabilities, education and training of local stakeholder for material circulation
Organisation	Capitalistic business model, profit over people and planet, secretive supply chain operations, lack of accountability, greenwashing	Lack objectivity towards data collection and its applicability other than increasing sales	Voluntary circular initiatives
Market	Trend-driven, flooded with low quality materials, depreciated second-hand value of products	Lack of information about products afterlife	Four-cent levy on F&T waste has minimal retail pricing impact, complicating market's reaction and effectiveness assessment

durability. Several participants noted that such practices have led to a market saturated with products that depreciate quickly in value.

This issue was further reinforced by the rapid pace of trend cycles within the industry. Participants described how the frequent introduction of new styles encourages short-term consumption patterns, leading to increased product turnover and overproduction. As a result, garments are often discarded before the end of their functional life.

The depreciation of product value was identified as a critical barrier to circularity. Participants noted that low-quality materials reduce the feasibility of reuse, resale and

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recycling, as the economic return from recovering such products is often insufficient. This limits the effectiveness of circular initiatives and discourages investment in recovery systems.

Transparency and traceability were identified as key challenges across two primary dimensions. First, at the manufacturing level, participants highlighted limited visibility due to the use of undisclosed subcontractors and third-party production facilities. This was seen to weaken accountability and allow brands to bypass compliance mechanisms (GB1, see Q2).

Second, traceability was described as significantly constrained beyond the point of sale. Participants noted the absence of systems to track garments through their use and EOL stages, which contributes to difficulties in managing disposal, recovery and recycling processes (GA6, see Q3). This lack of post-consumer visibility was seen as a major obstacle to enabling effective CSC practices.

4.2.2 Blind spots: the knowledge gap in circular fashion. Five key gaps emerged from the data, highlighting limitations in the F&T industry's preparedness for transitioning to CSC. These include challenges related to data collection practices, EOL management, recycling processes, material innovation and the absence of actionable circular strategies.

Participants consistently expressed concern that the industry lacks a clear and actionable roadmap for circular transition. While CE concepts are widely referenced, they were often described as remaining at a conceptual level rather than being operationalised. Several participants noted that terms such as "sustainability" and "circularity" are frequently used without clear definitions or measurable outcomes, creating ambiguity and enabling their misuse (GB3, see Q4).

Data collection was identified as a critical limitation in enabling circular practices. Participants from the technology sector highlighted that while tools such as blockchain are being adopted, their application is largely confined to customer engagement and product authentication. There was limited evidence of their use in capturing comprehensive supply chain data. As a result, participants noted that the absence of reliable and objective data across different stages of the supply chain restricts the ability to assess product lifecycles and limits the implementation of circular strategies.

EoL management emerged as a significant challenge. Participants highlighted a lack of accountability and ownership over products once they reach the post-consumer stage. The absence of systems to track garments after purchase was identified as a key barrier to collecting meaningful data on product disposal, reuse, or recycling. This lack of visibility was seen to limit the development of effective recovery systems and hinder the transition towards circularity.

Participants also raised concerns about the effectiveness of existing take-back and recycling initiatives. While many brands promote programs aimed at extending product life, participants noted a lack of transparency regarding their outcomes. These initiatives were often perceived as lacking measurable impact, with limited clarity on how collected garments are processed or reintegrated into the supply chain (GA5, see Q5).

Recycling practices were described as economically and technically constrained. Participants highlighted that the high volume of low-quality garments, often made from blended fibres, presents significant challenges for sorting and recycling. The complexity and cost associated with separating these materials were identified as key barriers, reducing the feasibility of large-scale recycling efforts (GA5, see Q6).

Material innovation was recognised as an important enabler of circularity; however, participants noted that progress in this area remains slow. While there is growing interest in developing circular materials, the scale of innovation was described as insufficient to meet the demands of current production levels. This mismatch between production volume and material innovation was identified as a critical limitation (GA6, see Q7).

Overall, participants emphasised that the combination of low product quality, limited recycling infrastructure and insufficient material innovation creates a systemic imbalance. The volume of products entering the market significantly exceeds the capacity of current circular systems to manage them. This imbalance contributes to inefficiencies in collection, sorting and

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recycling processes, further limiting knowledge development and the scalability of circular practices (GB2, see Q8).

4.2.3 Foundational flaws: infrastructural barriers in the fashion and textile industry's path to circularity. Participants consistently described the global F&T industry as operating within relatively weak regulatory environments, a condition they noted is reflected in the Australian context. This regulatory setting was perceived to shape the nature of circular initiatives, which were described as largely voluntary and lacking enforcement.

Several participants highlighted that, despite the presence of regulatory bodies, enforcement mechanisms were seen as insufficient to drive meaningful behavioural change. In particular, the scale of retail operations was described as enabling businesses to absorb financial penalties without fundamentally altering their practices. Concerns were also raised regarding garment labelling standards, with participants noting that current requirements provide limited information beyond basic details such as origin and care instructions, restricting visibility into material composition (GA5, see Q9).

The absence of detailed labelling was identified as a significant barrier to circularity, particularly in the context of recycling. Participants noted that second-hand garments are not subject to the same labelling requirements, further limiting the ability to identify material composition during sorting and processing stages. This lack of information was described as complicating the management of blended and chemically treated materials, reducing the efficiency of recycling systems (GA3, see Q10).

Participants acknowledged recent government efforts aimed at supporting CE initiatives; however, these were generally perceived as fragmented and insufficient relative to the scale of the challenge. Funding allocations and national initiatives were described as early-stage developments that involve multiple stakeholders but lack the depth and coordination required to address industry-specific needs.

A recurring concern was the lack of infrastructure tailored to the F&T sector. Participants noted that while CE initiatives exist across related industries, targeted approaches addressing the specific characteristics of fashion production and consumption remain limited. This gap was seen as particularly significant given the high volume of consumption within the Australian market (GB7, see Q11).

Policy measures aimed at reducing textile waste were also viewed as limited in impact. Participants referred to existing levy-based approaches as symbolic rather than transformative, noting that the financial burden imposed on producers and consumers is minimal as illustrated in Figure 2, and unlikely to influence behaviour at scale. As a result, such measures were perceived as insufficient to shift current consumption and production patterns (GA2, see Q12).

Some participants suggested the need to re-establish manufacturing capabilities within Australia, highlighting the potential benefits of increased control over production processes and improved understanding of material flows. However, this was widely acknowledged as a highly challenging and long-term undertaking, requiring substantial investment in infrastructure, skills development and industry transformation (GA5, see Q13).

Overall, participants emphasised that the transition to CSCs is constrained by limited regulatory enforcement, insufficient infrastructure and a lack of comprehensive systems for tracking materials across their lifecycle. The absence of end-to-end visibility, from raw material sourcing through to EOL stages, was identified as a key barrier to achieving circularity in the F&T industry.

4.3 Blockchain unveiled: strategic approach for circular supply chains in fashion and textiles

The survey findings indicate that the Australian F&T industry has limited awareness of CE and CSC, with readiness for a circular transition hindered by a lack of traceability and transparency in supply chains focused on linear models. Insights from stakeholder interviews reveal deeper systemic challenges. Based on the identified challenges, a strategic framework is proposed,

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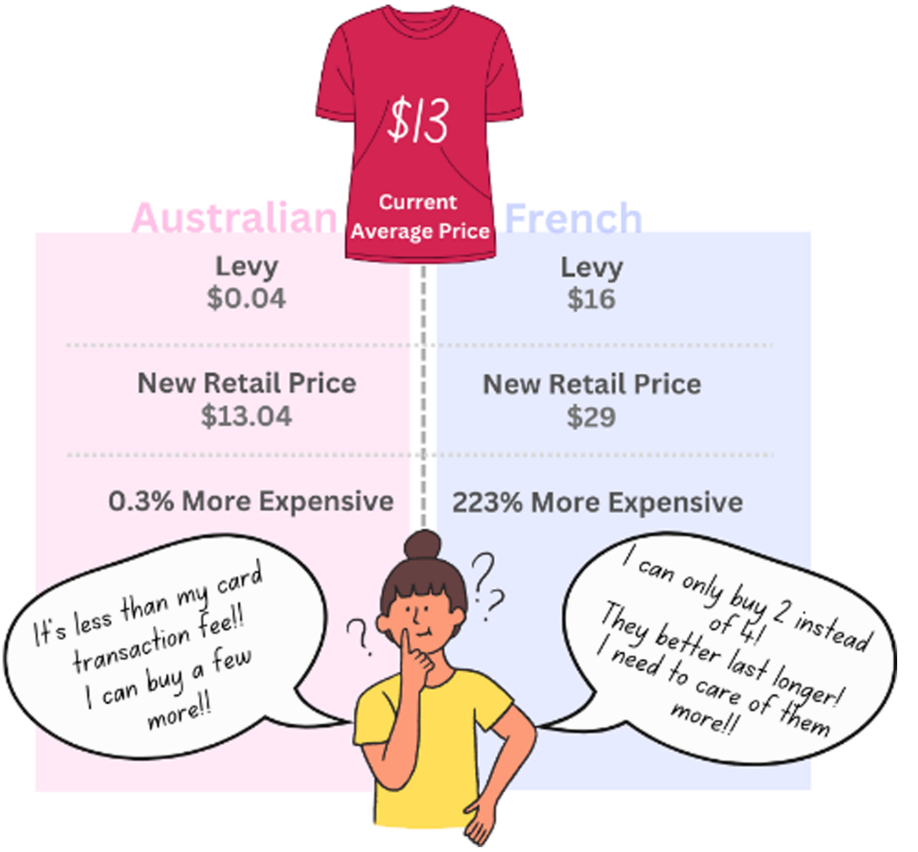

Figure 2. Comparison between the expected consumer behaviour towards the increased price of F&T items based on Australia's and France's proposed levy. Source: Authors' own work

combining literature and empirical findings. The study introduces two key perspectives from the Australian context: a regulation-driven approach and a technology-focused solution for effective CSC adoption.

4.3.1 Regulation-driven perspective. Participants identified challenges in transitioning from linear to CSCs, particularly due to limited regulatory integration and infrastructure. A key theme was the lack of embedding traceability technologies within existing systems.

Several participants suggested that governments could strengthen this transition by integrating such technologies into import and export processes and official record-keeping systems. This was seen as a way to improve supply chain visibility, auditing and compliance (GA1, see Q14).

Improved data capture was also linked to better measurement of ethical practices, increased producer accountability and more effective recycling and second-hand market processes. Participants noted that enhanced traceability could support more efficient material identification and recovery.

Overall, participants viewed the integration of traceability technologies within government systems as a critical enabler for improving transparency and supporting the transition to CSC (GB5, see Q15).

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4.3.2 Technology-driven perspective. Technological solutions emerged as a key theme, particularly in addressing the lack of visibility in tracking the EOL of the F&T items. Participants identified limited availability of traceability data as a major barrier to CSCs implementation.

Technology providers highlighted this gap as an opportunity, noting the importance of engaging all actors across the value chain, especially consumers, to improve data collection and traceability (GB6, see Q16).

However, participants also emphasised challenges related to data reliability. Several noted that combining multiple tracking approaches with digital systems could improve the accuracy of information across the supply chain. This was seen as particularly relevant for verifying recycled content and ensuring that material flows are accurately tracked without contamination from mixed inputs (GB4, see Q17).

5. Discussion

5.1 Bridging practice and theory: structural gaps in circular fashion

The findings indicate that the transition to CSC in the F&T industry is constrained by structural, informational and regulatory limitations rather than a lack of awareness or intent. Participants consistently highlighted that cost-driven production models, rapid trend cycles and low product durability accelerate depreciation, reducing the feasibility of reuse, resale and recycling. This reinforces existing literature on the dominance of profit maximisation and short product lifecycles as key barriers to sustainability in fashion (Badhwar *et al*., 2023; Khorsand *et al*., 2023). A key contribution of this study is the identification of a value-based barrier to circularity, where low-quality materials undermine the economic viability of recovery systems, extending prior work on circular inefficiencies (Dainelli *et al*., 2024).

The findings also reveal a gap between the conceptual adoption of CE principles and their practical implementation. Circularity was described as remaining largely aspirational, with limited actionable strategies and measurable outcomes. This reflects broader concerns regarding the ambiguity of sustainability-related terminology and its susceptibility to misuse (Siderius and Zink, 2023). In particular, initiatives such as take-back schemes were perceived as lacking transparency, raising the risk that CE practices may replicate earlier patterns of greenwashing (ChangingMarketsFoundation, 2022; Trunk *et al*., 2023). This is further compounded by a systemic imbalance between production volume and circular system capacity, where the scale of low-quality, blended-material output exceeds the technical and economic limits of recycling systems (Casciani & D'Itria, 2024; Quicker *et al*., 2020).

Regulatory limitations were identified as a key factor shaping this transition. In the Australian context, circular initiatives remain largely voluntary, reflecting broader global patterns of weak enforcement in the F&T sector (Grégoire and Guay, 2023). While regulatory bodies such as the ACCC have taken steps to address greenwashing, participants noted that enforcement remains insufficient to drive systemic change (Badhwar *et al*., 2024). A critical insight from this study is the role of garment labelling as a structural barrier, where the absence of detailed material composition data limits the effectiveness of sorting and recycling processes, particularly in second-hand markets (Casciani and D'Itria, 2024). Comparatively, emerging international policies such as the European Union's DPP signal a shift towards mandatory traceability, highlighting a potential pathway for regulatory development in Australia.

Data availability and reliability emerged as central enablers of CSC. The findings highlight a lack of end-to-end visibility across product lifecycles, reinforcing existing research on the importance of data integration in supply chain transformation (Ghoreishi and Happonen, 2022). While technologies such as blockchain are often positioned as solutions, their current application remains limited, primarily focused on authentication rather than comprehensive traceability (Chen, 2023; Vieira, 2022). This supports the view that the role of such technologies in circular systems remains emergent (Kayikci *et al*., 2024; Quayson *et al*., 2023).

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Importantly, the study finds that technology alone is insufficient without system-level integration, particularly in ensuring data reliability across material flows.

Building on this, the study identifies government-led integration of traceability technologies as a strategic pathway for enabling CSC. Embedding such systems within import and export processes and official record-keeping could enhance auditing, compliance and data standardisation. This aligns with calls for stronger regulatory involvement in supporting circular transitions (Ayati *et al*., 2022). By improving measurability in areas such as ethical production, producer accountability and EOL tracking, such integration directly addresses the data and transparency gaps identified in this research. Overall, the findings suggest that effective transition to CSC requires coordinated system-level change, combining regulatory enforcement, infrastructure development and integrated data systems rather than isolated technological or voluntary initiatives.

5.2 Blockchain enabled innovation-governance alignment pathway

The implementation of technology within policy is already underway through initiatives such as the European Union's DPP, which is poised to establish a global benchmark for supply chain traceability and shape future regulatory frameworks, including in Australia.

The innovation-governance alignment pathway to CSC is grounded in CE principles, emphasising waste reduction, material retention, cross-industry collaboration (Lee *et al.*, 2024), policy alignment (Kazancoglu *et al.*, 2021) and technological integration to advance circularity (Abideen *et al*., 2021). This framework developed based on the findings presented in this research, leverages blockchain's immutability and information-sharing capabilities. The framework for RQ2 will be developed based on key characteristics of CSC, including (1) R-imperatives, (2) restorative and regenerative cycles, (3) a sustainability framework, (4) value focus, (5) holistic system-thinking and (6) paradigm shift (Montag, 2023; Sudusinghe *et al*., 2024).

Its goal is to create a comprehensive system that connects key stakeholders within traditional supply chains while integrating regulatory bodies and policymakers. This approach is based on incorporating and sharing critical data, such as import regulations, levies and incentive structures, identified as key discussion points during data analysis. The proposed pathway offers a solution to tackle the key challenges of "economics and finance," "government and regulations," and "society and culture," which hinder early-stage adoption and prevent large-scale implementation of CSC (Ayati *et al.*, 2022).

The proposed approach utilises additional technological advancements from I4.0 (Bui *et al.*, 2023), including RFID (George *et al.*, 2023), DNA tagging and traceability markers (Iezzi *et al.*, 2024), to record and amplify data at every stage of the CSC. This includes manufacturing, importing, retail, consumption, usage, recycling and reintegration into production, as outlined in Figure 3. Notably, this system would support the collection of product life cycle assessment data, incorporating customer participation as active stakeholders who are incentivised (Gelhaar *et al.*, 2021) for sharing user-phase information. By integrating insights from all stages, production, retail, consumption, disposal, recycling and remanufacturing, in addition to importing stage (with regulatory bodies as stakeholders) this approach enables a more inclusive and data-driven decision-making process, strengthening sustainability efforts across the CSC.

While material selection and design play a crucial role (Moktadir *et al.*, 2025) in ensuring high-quality, long-lasting products suitable for reintegration into the cycle through restoration (Sudusinghe *et al.*, 2024), the absence of such considerations should carry financial penalties under extended producer responsibility (Maitre-Ekern, 2021). This is reflected in Figure 2, where the discarding stage serves as a critical intervention point and provides the data recording implementation roadmap for each stage. A comprehensive database of non-recyclable materials would enable regulatory bodies to impose financial penalties on importers, producers and retailers, ultimately leading to the phasing out and eventual ban of

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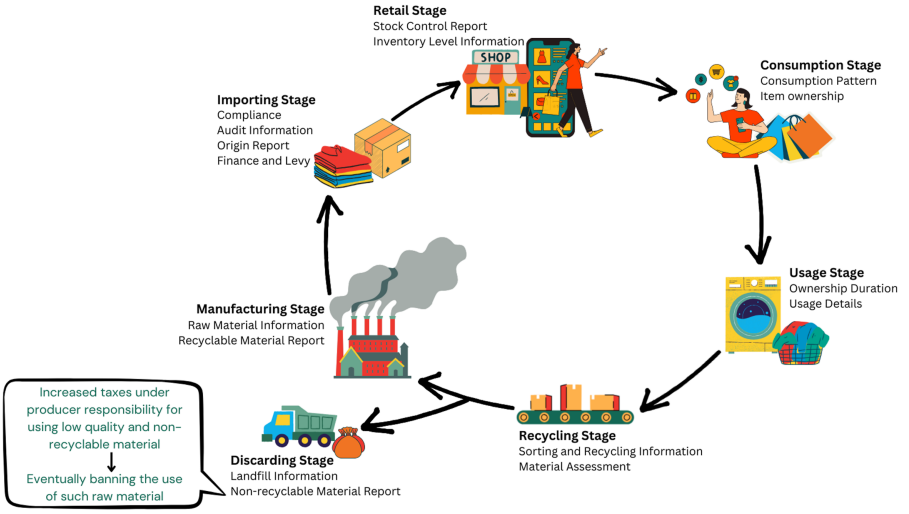

Figure 3. Collaborative approach of regulation and technology-driven pathways to create a blockchain-powered database for circular transition of the Australian F&T industry. Source: Authors' own work

linear materials to promote zero-waste future (Salehi *et al.*, 2024). Alternatively, this intervention at this stage can lead to avenues to explore, EoL products returning to another supply chain as a resource focusing on the regenerative approach (Hussain *et al.*, 2023; Sudusinghe *et al.*, 2024; Tseng *et al.*, 2022).

During this transition, financial penalties could be redirected to support educational initiatives aimed at increasing consumer awareness of the environmental and social impacts of the industry. By aligning technological advancements with regulatory oversight, this approach seeks to establish a comprehensive, enforceable CSC framework, ensuring both accountability and long-term sustainability. Given the urgency of the current environmental crisis, relying solely on voluntary actions is no longer sufficient; bold, unconventional measures are required to drive systemic change and enforce true circularity (Blomsma *et al.*, 2023).

6. Implications

6.1 Empirical

Given that only a few studies have explored the implementation of CE in relation to supply chain activities (Montag, 2023), and the low frequency of empirical research on identifying barriers to these approaches (Ayati *et al.*, 2022), this study makes a significant contribution to the empirical body of research in the domain. Interestingly, research by Nyffenegger *et al.* (2024) in Switzerland, examining multiple industries including F&T, identified similar CSC barriers to those found in this Australian-focused study. This notable overlap indicates that challenges in transitioning to circularity, whether conceptual, organisational, technological, innovative or cultural, are consistent across industries, enhancing the theoretical contribution of this research.

This study recognises the critical role of governance and regulatory bodies as active facilitators of CSC furthering Tura *et al.* (2019) contribution to the subject matter by proposing a strategic pathway with government as an active stakeholder. It enriches the SCM domain by emphasising traceable technologies, such as blockchain, to enhance circularity and improve financial efficiency by reducing long-term operational costs (Gu *et al.*, 2024). A key finding is the pivotal role of regulatory bodies, which have historically set lenient guidelines and targets

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for CSC. These bodies hold the greatest potential to catalyse rapid and meaningful change (Khan *et al.*, 2024), underlining the urgency of decisive action to meet CE targets by 2030 (Parker, 2023), to prevent circularity from becoming an empty promise.

Building on Ayati *et al.* (2022) categorisation of challenges, this research brings a fresh perspective with its empirical findings, particularly in the Australian context, where government regulations and information-related challenges emerged as the most frequently quoted barriers, followed by other issues. This highlights that significant progress also requires robust infrastructural support and mandated governance. This research furthers the idea of current lack of effort in of defining indicators and evaluation systems by legislative bodies proposed by Mura *et al.* (2020) and Ayati *et al.* (2022).

6.2 Managerial

The study advocates for the Australian government to implement a higher levy to not only address F&T waste but also to fund educational initiatives that raise consumer awareness about the industry's environmental and social impacts. Relocating F&T manufacturing to Australia will take time. In the interim, prioritising CE-driven initiatives in countries that produce goods for Australian consumption offers a more immediate pathway. This approach could provide valuable insights for policymakers and businesses, from local startups to multinational corporations, ultimately strengthening the broader CSC framework.

Current practices within the F&T industry often lack ethics and transparency, making traceability vital for both ethical accountability and circularity. Integrating solutions such as blockchain can ensure material traceability across the value chain. However, the challenge lies in how businesses adopt and implement this technology (Hastig and Sodhi, 2020; Oke and Nair, 2023). Stakeholders should view blockchain not just as a compliance tool (Vinayavekhin *et al.*, 2024), but as a means to foster shared responsibility for innovation and sustainable development. A strategic commitment to traceability will strengthen ethical practices, transparency and the industry's transition to CSC.

The EU's DPP legislation aims to enhance transparency across value chains (EU, 2024), but incidents such as Dior's alleged use of sweatshops in Italy (Kent, 2024) show that simply adopting DPPs (Bain, 2023), does not guarantee ethical supply chains. Such cases highlight the need for a holistic approach to CSC, ensuring traceability and accountability across all stages. This research proposes an interconnected framework that integrates technological solutions, supporting trust among stakeholders (Silvestri *et al.*, 2024) and enhancing CSC effectiveness.

To avoid the exploitation of CE initiatives (Trunk *et al.*, 2023), F&T industry leaders should integrate immutable technologies such as blockchain within a circularity-driven framework (Schmidt and Wagner, 2019). The effectiveness of these technologies depends on aligning them with CE initiatives and technological progress. Managers should support regulation- and technology-driven pathways to enhance traceability and governance (Schmidt and Wagner, 2019). By establishing a scalable, government-backed platform (Ayati *et al.*, 2022) enabled by traceable technologies, leaders can contribute to an informational database, essential for an efficient transition to CSC.

6.3 Limitations and future recommendation

This study offers a thorough examination of the F&T industry's scope of transition to a CSC using traceable technologies such as blockchain, however, with its limitations. As an exploratory study, it focuses on identifying the barriers specific to transitioning the F&T industry to CE within the Australian context. The identified challenges have shaped the strategic approaches to integrate blockchain aiding the circular transition which are identified in this research. Future research should aim for a more detailed analysis of these technologies' practical applications utilising existing circular business examples.

The consumer knowledge and acceptance of circular transition should be further researched to design incentive programs for responsible consumer and producers based on traceable technological platforms. Such platforms can channel the information to the

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government databases which can shape collaborations between the policymakers and the stakeholders from the F&T industry. Additionally, the role of regulatory and governance bodies emerged as a crucial factor in shaping the industry's transition, which should be investigated further.

While the interview sample is relatively modest due to the limited accessibility and availability of C-suite executives and founders, this constraint is offset by the depth, quality and strategic insight provided by these high-level participants. The findings need further empirical validation to confirm their generalisability and assess their impact in various industrial settings. Lastly, the findings are specific to the Australian F&T industry and may not be universally applicable. Comparative research across different regions is essential to advance global CSC efforts.

7. Conclusion

This mixed-method study contributes significantly to the literature on CSC, focusing on the Australian F&T industry. It identifies key challenges in transitioning to CSC, highlighting the slower-than-needed pace of embedding CE within economic systems. The study examines the roles of producers and consumers, exploring factors that could accelerate this transition.

A key contribution of this study is the identification of recurring themes from the perspectives of both technology providers and F&T industry stakeholders, which helps clarify the challenges on the path to circularity. The research presents strategic approaches for integrating traceable technologies, such as blockchain, to facilitate the transition to CSC. It also emphasises the importance of setting clear, actionable objectives for the implementation of these technologies.

Beyond its academic contributions, the study offers practical insights for stakeholders, including technology providers, fashion businesses, regulatory bodies and policymakers. These insights are vital for developing a robust infrastructure that supports the transition to a CE. The research underscores the need for strategic reforms to drive transformative change within the F&T sector, contributing to a more sustainable and circular future for the industry.

While this study provides valuable insights into the transition towards CSCs, within the Australian F&T industry, its exploratory scope and context-specific focus highlight the need for further empirical validation and cross-regional analysis.

(The Appendix follows overleaf)

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Appendix

Table A1. Interviewee codes and illustrative quotations

Quote (Q) #	Descriptive quote
Q1	*GB4: "Businesses need to realise they can't keep churning out massive amounts of clothing every year. But for big fashion brands, scaling back feels like business suicide. The industry is still led by people who don't truly believe in circularity. Everyone talks about sustainability and the CE, but at the end of the day, it's all about keeping shareholders happy. You can see it in global sourcing, companies chase the lowest costs, and the moment a factory improves conditions and pays workers better, they move somewhere cheaper. Profit always comes first, even over people's lives, which is primarily wrong"*
Q2	*GB1: "CSC impacts all industries, including fashion, as its fundamentally about resource efficiency, keeping materials in the value chain. Yet, F&T products still end up in landfills, with increasing consumption driven by declining durability. True circularity means extending product use, making circular materials essential. I believe, innovation in this area is crucial, but fashion brands focus more on selling than sustainability. With better-quality products, repairs and recovery would hold real value, proving profitability and circularity can go hand in hand"*
Q3	*GA6: "I don't think the CE really exists in practice yet, it's still in its early stages. Less than 1% of textiles are actually recycled, and CSC solutions aren't keeping pace with new clothing production. There's a huge disconnect between brands talking about circularity and ensuring their products can be recycled. Unless a brand has a system to take back its own products and repurpose them without a massive carbon footprint, it can't truly claim to be circular. Right now, the energy, water, and logistics needed to deal with textile waste are overwhelming, and innovation just isn't keeping up. So, in reality, CSC doesn't exist yet"*
Q4	*GB3: "When I think about circularity in fashion, it feels like there's a battle over recyclables. Take a plastic bottle: it can be recycled multiple times into new bottles, creating a continuous loop. But once you turn that bottle into a garment, it's done, it's either heading to the landfill or getting incinerated. So, why is the apparel industry competing for PET that could stay in the plastics loop? If the material quality is poor or if it's blended with different fibres, there's no potential for reuse or redesign. It's just waste. If we know this, why doesn't the fashion industry take a step back and understand its impact instead of chasing big profits? This approach is misleading the future of the CE"*
Q5	*GA5: "Many businesses have take-back programs and spend a lot on storytelling, but they often just create a pile of waste. Let's be real: there's no safe EoL solution for these products; we're just delaying the issue. Sure, if we displace some virgin material demand, that's a positive step, but in my experience, this mush is becoming a bigger problem, leading to initiatives that were doomed from the start. It raises questions about the credibility of these efforts. For instance, the quality of circular materials isn't consistent enough to support the entire industry's supply chain, while credible innovations like Renewcell struggle due to a lack of demand from fashion brands. What happened to genuine circularity? It feels like a smoke screen covering up a much larger problem."*
Q6	*GA5: "Some things fall out of the circular system, but if they can safely return to the ground, that's still part of the process. Biological circularity is easier to understand; for example, high-quality cotton can have an extended life and compost at end-of-life, returning nutrients without wasting energy on short-lived recycling. Yet, no one discusses the importance of total quality management, like we did 30 years ago, making well-crafted products and producing less. Is that approach actually more impactful than all this talk about circularity? We seem clumsy in defining financial or CSC success, and these successes won't always be reflected in GDP"*
Q7	*GA6: "The issue isn't a lack of solutions; it's scale. Many businesses won't switch from cheap viscose to circulose, which is currently more expensive, until prices are on par. Brands want to maintain their margins, and to make a profit on low-priced products, they need to produce millions. This creates a cyclical problem: brands must be willing to invest in these materials and possibly sell at higher prices to support the solution. Otherwise, the solution disappears, leaving us with no recycled materials to create new products, and we just continue down the same path. There's a significant disconnect; solutions exist, but brands aren't compelled to adopt them. Plus, investors are hesitant to invest substantial money to support these solutions, leading to a lack of interest from brands"*

(*continued*)

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Table A1. Continued

Quote (Q) #	Descriptive quote
Q8	*GB2: "... a brand mentioned that if they can trace products already in circulation and the materials are valuable enough, they're willing to buy them back, reproduce them, and create new products. But first, they need to know where those products are! This approach allows them to recycle and reuse materials rather than relying on new resources. CE isn't just about landfilling or recycling; recycling is energy-intensive, and logistics have their own environmental footprint. You can't have a CSC while consuming resources, where does the energy come from? The fashion industry accounts for about 10% of global emissions"*
Q9	*GA5: "Australia has no real Product Safety laws for textiles imported, we do have laws for bringing chemicals in in a barrel, but not for a fabric dipped in chemicals, we kind of go, just declare it. It's like a sort of pamphlet of guidelines requiring voluntary actions. When everybody's pushing for margins and somebody subcontracts, it comes back to the whole traceability thing, right? Now the question becomes, if the declared information is true?"*
Q10	*GA3: "I don't see many brands focusing on circular fashion products. You can't be a circular business while engaging in mass production and promoting mass consumption; those concepts just don't align with CSC. In the Australian fashion industry, there's limited activity, only a handful of businesses are truly committed to circularity. The infrastructure to support it is lacking, and resources are scarce. Additionally, how can customers verify that circular products are legitimate when ultra-fast fashion brands claim to be circular? Education and awareness are major challenges. How long will consumers be expected to seek out the truth? It would be more effective to have regulations to address misleading claims"*
Q11	*GB7: "Infrastructure is a major blockage, preventing us from progressing rapidly in the CE; it remains just a concept. Achieving circularity requires a cultural shift in attitudes. Much of the responsibility falls on technology providers to find solutions, but the guidelines are vague. From a CSC perspective, this relates to business operations, including consumption in Australia, where infrastructure is lacking. We need more sorting facilities and factories, and government support is crucial; otherwise, there's little incentive for businesses to view this as a viable opportunity"*
Q12	*GA2: "I think we're significantly lagging behind the EU, especially countries like the Netherlands and France, in terms of education and willingness to embrace the CE. While government support could help accelerate this process, there's still a lot more to be done regarding innovation and infrastructure. That's why I'm working on creating a facility to enhance recycling and repurposing, aiming to push the envelope further. Collaboration is also essential; it's a shared project between our brand and a few others in the country"*
Q13	*GA5: "We don't invest enough in practical applications for the CE. I envision a factory dedicated to circular production, bustling with scientists, researchers, and innovators working with cutting-edge machines. Circularity thrives where creativity and manufacturing coexist. If they aim for circularity by 2030, they need to develop a strong local manufacturing industry. I urge the government to prioritise the voices of manufacturers over finance professionals; you can't have remanufacturing without manufacturing. Ultimately, there can be no CSC without robust local manufacturing infrastructure"*
Q14	*GA1: "We know that the Australian government has strict regulations around importing products, so if technology can be embedded as part of those processes, it will be easier to get traceability across the chain. It is always hard to create new infrastructure, so we should use what we have and improve on it. Brands can save money on auditing and compliance checks, while the government will be able to have credible records too. Eventually, the data around waste and landfill can be collected and accessed easily, because the government is spending a lot of money on these initiatives already"*
Q15	*GB5: "The main challenge is the lack of local knowledge about product whereabouts, whether they're still in use or heading to landfills. This is where blockchain technology comes into play for CSC. If governments mandate traceability, it can encourage brands to adopt technology that ultimately saves them money and time. Additionally, there needs to be better coordination among all stakeholders. CE initiatives require widespread change, and regulations can facilitate this. But will the fashion industry ever engage in traceability voluntarily? For instance, what standards exist for an organic t-shirt versus a regular one, especially in the face of greenwashing? While governments set standards for commodities, fashion is more complex. Can we even regulate fashion in the same way as commodities?"*

(*continued*)

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Table A1. Continued

Quote (Q) #	Descriptive quote
Q16	*GB6: "For a real business opportunity, consider an application that gathers data from various actors in the value chain and incentivises them for sharing that information. As a business, you might wonder if this data can be monetised to cover the costs of integrating the technology into your operations. The key is establishing an infrastructure that allows for trusted data sharing among distributed parties. While this approach can help achieve CE goals, it also opens the door to fulfilling other objectives. By leveraging the collected data, you can uncover insights that benefit multiple stakeholders and create additional value beyond just circularity"*
Q17	*GB4: "So, with CSC, visibility of products is crucial. Without knowing the journey of a T-shirt; from production through its lifecycle to recycling; it's impossible to determine if it has achieved circularity. Implementing traceability solutions is essential for this.* *For instance, using technologies that imprint a luminescent pigment onto the yarn could allow scanning during the recycling process to track the material's origin and identify recycling methods. However, this requires implementing such traceability measures right at the raw material stage. It's challenging to assess materials and collect data at every product stage without this level of traceability. So, I believe traceability is vital for the successful existence of CSC"*

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