



## TRANSPARENCY IN TEXTILE & APPAREL SUPPLY CHAINS: A SYSTEMATIC REVIEW

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### ABSTRACT

*Consumers and suppliers demand transparency in the textile and apparel industry due to increasing complexity, volatility, and competition in the global market. While research communities acknowledge the scarcity of publications in this domain, the number of related papers has surged by 122%. Nonetheless, existing reviews have primarily refrained from offering a comprehensive exploration of transparency within the broader context of textile and apparel supply chains. Consequently, a gap in systematic reviews focusing on transparency within this domain is evident. To fill this gap, our study aims to synthesise existing research on transparency in apparel and textile supply chains. To this end, we have structured our study into four research clusters derived from author-generated keywords in a carefully curated Scopus dataset. Furthermore, our study explores how transparency has evolved in textile and apparel supply chains, supported by these four clusters, which cover the following themes: 1) Sustainable approaches for transparency, 2) Supply chain perspective in transparency, 3) Implementing traceability for transparency and 4) Information transparency. Considering the insights gleaned from this comprehensive review, our study offers valuable insights and delineates potential directions for future research endeavours. These avenues for exploration can improve transparency in textile and apparel supply chains towards greater advancement and scholarly innovation.*

**Keywords:** Textile & Apparel, Fashion, Supply chain, Transparency, Systematic literature review, Traceability

## 1. INTRODUCTION

The textile and apparel industry is one of the fastest-growing global markets and has a massive economic impact around the world. From fibre production to manufacturing garments, the textile and apparel industry creates essential articles for people across the globe. Following the challenges faced in 2020 due to the coronavirus pandemic, the industry faced a decline in sales. There is now an anticipated resurgence in global clothing demand. It is recorded that the revenue of the global apparel market reached 1.5 trillion U.S. dollars in 2021, and experts predict a further increase to approximately 2 trillion dollars by 2026 [1].

Thanks to the integration of automation and digitalisation in textile processes, production has reached unprecedented levels of effectiveness and efficiency. Consumers can access a wide array of product options through personalised mobile apps, ensuring convenient deliveries and hassle-free returns.

However, with the rising complexity of the textile and fashion industry, existing supply chain management systems encounter significant challenges. These include issues such as poor traceability, product tampering, unsustainable production practices, and lack of real-time information sharing [2].

Hence, transparency has emerged as one of the most prominent demands of consumers today. Numerous fashion brands actively respond to this demand by providing information when the product is being processed throughout the supply chain. Research indicates that transparency holds significant potential as a tool for fostering innovation in product development, process improvement, and even business model evolution. However, in the realm of fashion, there is limited understanding of the precise role transparency plays and how it impacts consumers' perceptions of a brand [3].

To thrive in an industry characterised by escalating competition, it is essential to ensure acceptable product quality with timely supplies in the presence of globally dispersed actors. Hence, it is important for a supply chain participant to diligently track each product and trace its history in the supply chain [4].

However, companies in the supply chain often rely on applications that were custom-built at different times, attained from third-party sources, or integrated with legacy systems. Moreover, they may operate across multiple tiers of manufacturing and information system platforms. As a result, the task of tracing items throughout the supply chain, encompassing different companies and spanning the entirety of the process scope, appears inherently complex [5]. To address these transparency issues, innovative tools and techniques have been explored that enhance traceability and

transparency. In this paper, we have focused on the scope of transparency in textile and apparel supply chains.

Based on available literature, it was discovered that there is a rising frequency of publishing studies on transparency and traceability. However, through the investigation of review studies, it has been revealed that textile and apparel supply chains have not been evaluated in terms of transparency. Therefore, considering identified research gaps, we have decided to conduct a systematic review. Our methodology and the bibliometric analysis are presented in this paper, followed by a comprehensive overview of the existing literature under a cluster analysis. Four research clusters were systematically derived: sustainable approaches for transparency, supply chain perspective in transparency, implementing traceability for transparency, and information transparency. The evolution of transparency has also been discussed based on the derived clusters. Finally, based on the findings and identified research gaps through literature, the review proposes potential future research directions.

## **2. LITERATURE REVIEW**

### **2.1. Transparency in textile and apparel supply chains**

The textile and apparel industry is an ever-growing global market that directly or indirectly affects every country in the world. It is expected to experience significant growth in value, from 1.5 trillion U.S. dollars in 2021 to approximately 2 trillion dollars by the year 2026 [1]. The fashion industry is marked by several factors, including escalating competition, high volatility, low predictability, short product lifecycles, and a tendency towards impulse purchases, etc., and as a result, the textile and apparel industry's supply chain is a complicated and fragmented network of entities involved in sourcing raw materials from various sources and operations [6]. This complexity has led to serious issues; industries face significant pressure from customers and governments to embrace sustainable production processes due to the prevalence of prominent illegal trades, unethical manufacturing practices, and fragile supply chains [7].

#### **2.1.1. Exploring technical solutions and benefits**

Assessing the performance of supply chains, especially beyond tier 1 of the buyer-supplier relationship, is significantly hindered by a lack of transparency [8]. The frequency of disasters within the apparel industry has led to a growing demand for an improved monitoring system and a method to trace garments throughout the supply chain [9].

Transparency is critical for tracing where and how items are manufactured as the first stage in assessing supply chain risks [10]. It promotes accountability within the apparel industry and enables its responsible growth, empowering consumers to make more informed purchasing decisions under a framework of trustworthy, sustainable communication [8],[11]. It maximises profitability while ensuring product quality and safety [12]. Enhanced traceability and real-time information sharing within the textile supply chain benefit stakeholders by fostering stronger relationships, increasing productivity, and mitigating risks associated with product recalls, counterfeiting, and unethical labour practices. To fill gaps in information flow, feasible technical tools should be examined in greater detail to evolve better communication to enable traceability.

### **2.1.2. Blockchain technology**

Blockchain technology is a promising tool to achieve sustainable supply chain transparency. Saberi et al., (2019) [13] reveal that the data collected through blockchains in sustainable supply chains facilitates reporting on the environmental and social sustainability aspects of supply chain partners.

Blockchain technology emerged as part of a movement associated with cryptocurrencies and the Internet of Things (IoT), offering features like traceability, authenticity, and security to sectors eager to use this technology [12]. Within the retail industry, blockchain technology empowers users with the capability to track information about the product's origin of raw materials, the quality of materials used in the manufacturing processes, the place of production, and information about the individuals or companies involved in it, etc. The apparel industry, particularly in ready-to-wear clothing, can leverage blockchain technology to effectively monitor suppliers and customers throughout the entire logistics chain [12]. However, Pérez et al., (2020) [12] reveal that the apparel industry has not been well studied even though blockchain-based studies have been published focusing on product traceability in agriculture or food supply chains in recent years.

In this regard, Pérez et al., (2020) [12] have introduced a contemporary traceability scheme for the apparel industry. Their framework utilizes blockchain technology specifically for ready-to-wear clothing, aiming to enhance supply chain transparency and validity of the retail products. Another case study has been conducted to investigate the characteristics of Distributed Ledger Technology (DLT) with the aim of utilising blockchain technology to enhance supply chain transparency and thereby attain reduced carbon emissions in the textile and apparel manufacturing process [14]. The case study by Agrawal et al., (2021) [15], based on the apparel industry, demonstrates a blockchain-related supply chain traceability framework, which is a simulation-based demonstration of network design and partner interaction protocol

in a complex multi-tier supply chain. The case study conducted by Ahmed & Maccarthy (2021) [16] examines the implementation of blockchain technology for supply chain traceability in the apparel industry. The study explores different levels of traceability throughout the supply chain, including digital identification, authentication, and the integration of blockchain solutions across the entire supply network.

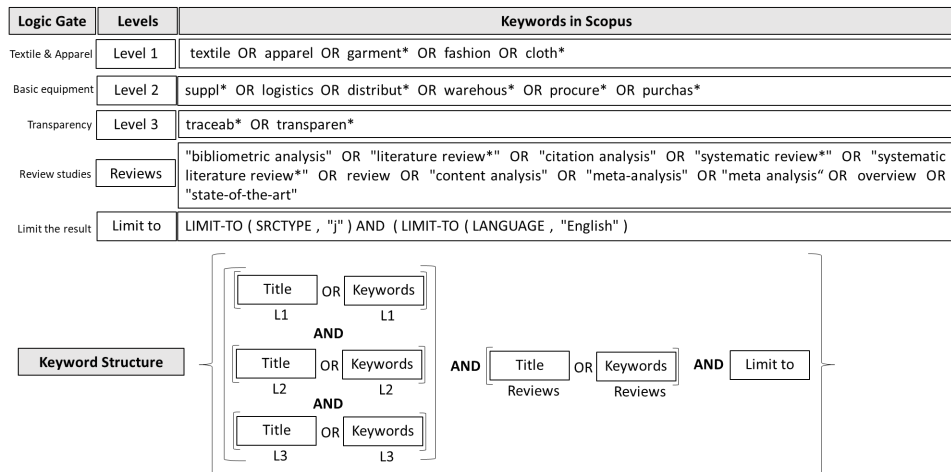
However, these studies reveal that there is a deficiency in effectively conveying information about sustainability to consumers in a straightforward and clear way, which can help them make informed choices about the most sustainable products [8]. The literature available on the practical implementation of blockchain technology in industries is still scarce. Thus, insights into its success and failures are limited. Hence, more empirical research is required to explore the significance of potential obstacles, discover the causal relationships between them and focus on the real-world applications of research to determine practical constraints.

The textile and apparel industry, projected to grow substantially in the coming years, faces multifaceted challenges, including intense competition, volatility, and ethical concerns in its supply chain. Transparency emerges as a critical solution, enabling traceability and accountability throughout the supply chain, empowering informed consumer choices, ensuring product quality and safety, and fostering stronger stakeholder relationships. Blockchain technology, initially associated with cryptocurrencies and IoT, holds promise in achieving sustainable supply chain transparency. However, research in this area is still nascent, with limited studies focusing on the apparel industry. Recent work has introduced traceability frameworks utilising blockchain to enhance supply chain transparency and reduce carbon emissions in textile and apparel manufacturing. Nonetheless, a deficiency exists in effectively conveying sustainability information to consumers, and more empirical research is needed to explore practical obstacles and real-world applications of blockchain technology in the industry.

## **2.2. Review studies in transparency in textile and apparel supply chains**

### **2.2.1. Structure for searching review studies**

First, we gathered previously published reviews focusing on transparency in textile and apparel supply chains. We employ the following Keyword Structure (KS) in Scopus and search for review studies on transparency in textile and apparel supply chains (Figure 1).



**Figure 1: Keyword structure for identifying review studies within the scope**

We ended up with only three peer-reviewed journal papers that have been published as review studies within the scope (Updated on 31<sup>st</sup> Dec 2022). These three studies have also been published very recently in 2019, 2021, and 2022 respectively; Kamann, Alfaro, and Sebrek, (2019) [17], Gonçalves and Silva, (2021) [8], and Alves et al., (2022) [18]. Kamann, Alfaro, and Sebrek, (2019) [17] discuss traceability management exploring publications within the period of 1970 – 2017. However, it does not consider textile and apparel supply chains as the key focus, while the review touches on the overall areas within supply chain management and Information Technology (IT).

### 2.2.2. Scope of previous review studies

Gonçalves and Silva, (2021) [8] have conducted a review study considering environmental footprint, social impacts, and transparency aiming for sustainability. Their full focus is on the apparel industry; while sustainability is specifically addressed, transparency is not. Alves et al. (2022) [18] have highlighted the circular economy within textiles and clothing value chains. Further, Alves et al., (2022) [18] have discussed how the applications of blockchain technology and IoT have evolved in developing circular economy concepts.

None of the review studies already published have focused specifically on transparency in apparel and textile supply chains. Further, transparency is a requirement for each tier of the textile and apparel supply chains. Moreover, any of the systematic review studies have not been found under the scope. Transparency is directly related to sustainability and procurement, while transparency must be investigated from a broader perspective to introduce research agendas for future studies.

### 2.3. Research gaps and objectives

Upon examination of the literature through the lens of three review studies, lacunae in research become evident. The review of scholarly works delves into potential areas warranting investigation concerning transparency in the textile and apparel supply chains. Notably, an uptick in the publication of papers within this domain has been observed in recent times, a development with positive connotations. Nonetheless, there is an imperative to recognising and scrutinising ongoing research endeavours remains paramount because these lay the foundation for the seamless execution of future inquiries. Notably, no prior review studies have undertaken an exploration of transparency management with a focused purview on the textile and apparel supply chains. Similarly, the literature fails to pay attention to broader facets of transparency, distinct from the prevailing emphasis on supply chain sustainability in the context of textile and apparel supply chains. Furthermore, review studies have not investigated the utilisation of traceability-enhancing tools within the textile and apparel industry from a transparency-centric perspective, as opposed to a focus on circular economy considerations. In addition, it is discerned that a systematic review encompassing the theme of transparency in textile and apparel supply chains remains conspicuously absent.

Considering the above research gaps, our main objective of the study can be introduced as follows: Conducting a systematic literature review to discuss ongoing research and reveal potential areas for future research within the scope of transparency in textile and apparel supply chains.

## 3. METHODOLOGY

According to Perera, Fahimnia, and Tokar (2020) [19], Perera et al. (2019) [20], Weerasinghe et al. (2023) [21] and Davarzani et al. (2016) [22], a systematic process can be outlined into nine steps: 1) Develop a Keyword Structure (KS) to guide the search, 2) Search in a selected database, 3) Narrow down the result based on the subject area, 4) Extract relevant publications using inclusion words, 5) Exclude irrelevant publications using exclusion words, 6) Cross-check with reference lists of selected significant studies, 7) Finalize the paper pool with the selected studies, 8) Conduct bibliometric analysis 9) Conduct further analysis including clustering to reveal trends.

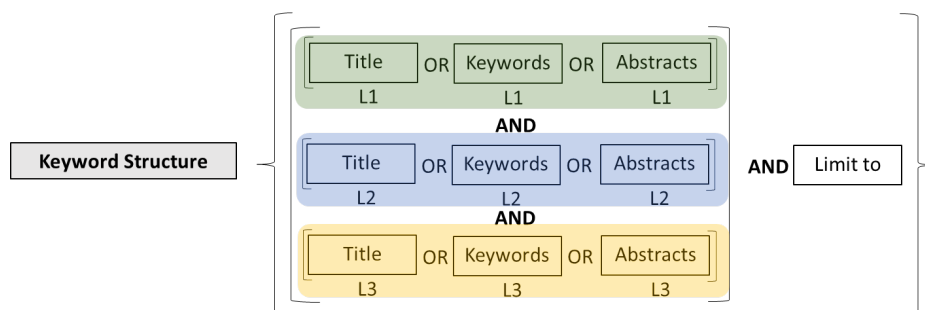
Generating the KS plays a pivotal role in shaping the direction in which the study flows. Defining a proper KS usually takes time and it is not an easy task when few keywords are applied and obtain a result. Initially, an extensive background search was conducted on the most significant papers following their contributions and

timelines. The KS was then formulated by assimilating the concepts and terms following Bhaduri and Ha-Brookshire, (2011) [23], Cheng et al. (2013) [24], Ma, Lee, and Goerlitz, (2016) [25], Pérez et al., (2020) [12], Brun, Karaosman, and Barresi, (2020) [11], Gonçalves and Silva, (2021) [8].

Our structured KS (Figure 2) includes three levels: 1) Textile and apparel industry, 2) Supply chain and logistics and 3) Transparency. Simply, at least one keyword from each level should be included in a paper to appear in our search results. Search is applicable for titles, keywords and abstracts of papers in Scopus.

As the second step, the Scopus database is used to conduct a search for relevant papers, employing the predefined KS. Subsequently, the search result is refined, focusing specifically on journal publications that are published in the English language. The third step is to narrow down the search results based on the subject area. It should be filtered carefully since some of the relevant papers might come under irrelevant subject areas as the papers have been indexed in Scopus.

Logic Gate	Levels	Keywords in Scopus
Textile & Apparel	Level 1	textile OR apparel OR garment* OR fashion OR cloth*
Supply chain & logistics	Level 2	suppl* OR logistics OR distribut* OR warehous* OR procure* OR purchas*
Transparency	Level 3	traceab* OR transparen*
Limit the result	Limit to	LIMIT-TO ( SRCTYPE , "j" ) AND ( LIMIT-TO ( LANGUAGE , "English" )



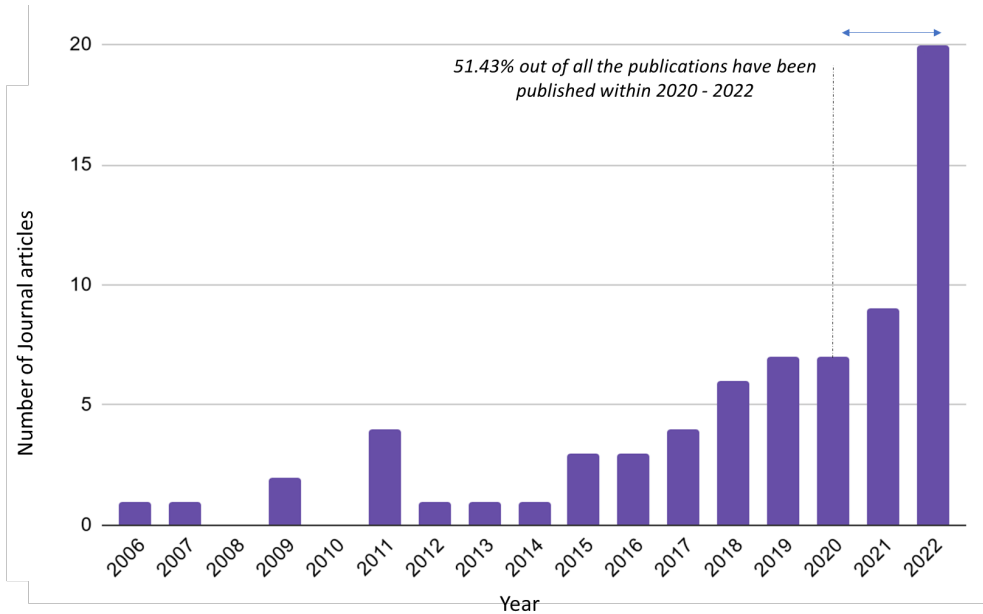
**Figure 2: Keyword Structure - Transparency in textile and apparel supply chains**

In this case, none of the subject areas are excluded since at least a single relevant paper appears in each subject area in Scopus. Once this step is completed, the comma-separated values (CSV) file is ready to be downloaded from Scopus. Our search result includes 115 papers (Updated on 31<sup>st</sup> of Dec). Inclusion keywords are used to extract relevant papers while exclusion keywords are applied to exclude irrelevant papers in the fourth and fifth steps of the systematic process. Then the paper pool is cross-checked with defined benchmarking papers: Bhaduri and Ha-Brookshire, (2011) [22], Cheng et al. (2013) [23], Ma, Lee, and Goerlitz, (2016) [24], Pérez et al., (2020) [12],



Brun, Karaosman, and Barresi, (2020) [11], Gonçalves and Silva, (2021) [8]. End of this step, we ended up with 70 papers in the finalized pool for our analysis.

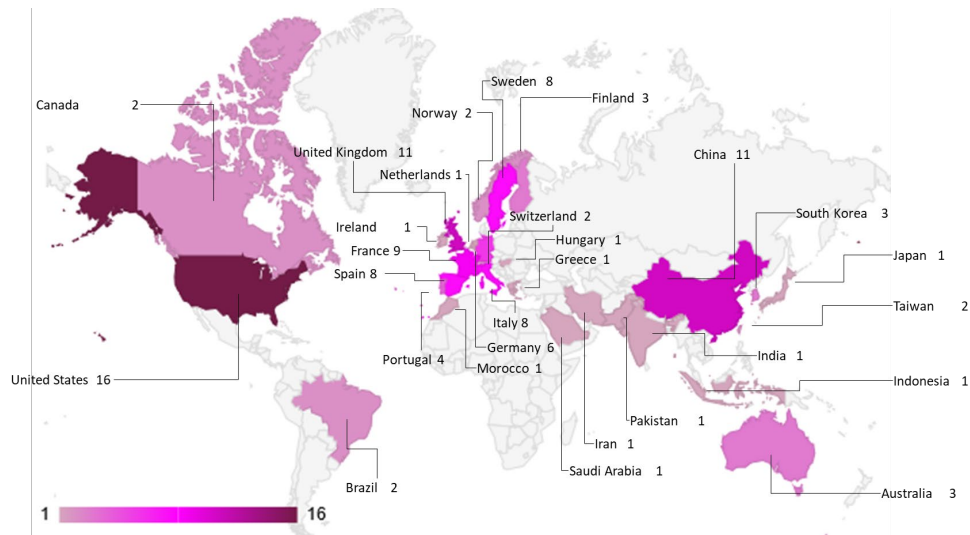
#### 4. BIBILIOMETRIC ANALYSIS



**Figure 3: Annual distribution of studies**

As Figure 3 clearly indicates, there has been rapid growth in publishing under the scope of transparency in apparel and textile supply chains. 51.43% of the papers out of all relevant peer-reviewed journal articles were published in 2020, 2021 and 2022. More than five papers are published from 2018 onwards covering transparency in apparel and textile supply chains and this average number is increased by 400% in 2022.

Our analysis reveals the top peer-reviewed journal outlets of the scope, transparency in apparel and textile supply chains. *Sustainability (Switzerland)* has published 8 peer-reviewed journal articles within the scope. This contribution is significant since the gap between *Sustainability (Switzerland)* and the second in the list is 5 articles which is higher than the contribution of the second in the list. The significant point is all these 8 articles have been published between 2019 – 2022. We identified five peer-reviewed journals which have equally contributed with 3 peer-reviewed journal articles within the scope: *Clothing and Textiles Research Journal*, *International Journal of Fashion Design, Technology and Education*, *Journal of Cleaner Production*, *Journal of Fashion Marketing and Management*, *Supply Chain Management*.



**Figure 4: Origins of publications**

We found that authors who encourage the scope are based in 28 countries. The United States is the most significant player who contributed to 16 papers. China and the United Kingdom are in the second position generating 11 papers equally. V. Kumar of the University of Borås, Sweden is the top author in the scope who contributed to 5 papers of the pool. L. Koehl of Université de Lille, France, and J.E. Ha-Brookshire of the University of Missouri, United States are the second significant contributors who have contributed with 4 papers equally.

Université De Lille, France has contributed 7 papers becoming the top institution of the scope. Soochow University, Taiwan is in second place in the list becoming the second highest contributor with 6 papers. Five papers that come under our scope are published by authors based in University of Missouri, United States while the institution becomes the third most significant contributor in the scope.

## 5. ANALYSIS

Our next attempt is to understand how the research is conducted in the domain by clustering them. Cluster analysis is generated based on the author keywords that are included by the authors of each paper. The following equations formulated by Van Eck & Waltman (2014) [26] are used in the recommended network analysis software [20]-[22]. These equations [26] illustrate how association strength normalization facilitates the construction of a normalized network where the weight of the edge between nodes appears as  $i$  and  $j$ :

The association strength normalization

$$s_{ij} = \frac{2ma_{ij}}{k_i k_j} \dots\dots\dots (1)$$

The total weight of all edges in the network

$$k_i = \sum_j a_{ij} \text{ and } m = \frac{1}{2} \sum_i k_i \dots\dots\dots (2)$$

VOS mapping technique - minimization function

$$V(x_1, \dots, x_n) = \frac{1}{2} \sum_{i < j} s_{ij} \left\| X_i - X_j \right\|^2 \text{ and } \frac{2}{n(n-1)} \sum_{i < j} \left\| X_i - X_j \right\| = 1 \dots\dots\dots (3)$$

VOS clustering technique - maximisation function

$$V(c_1, \dots, c_n) = \sum_{i < j} \delta(c_i, c_j) (s_{ij} - \gamma) \dots\dots\dots (4)$$

Where,

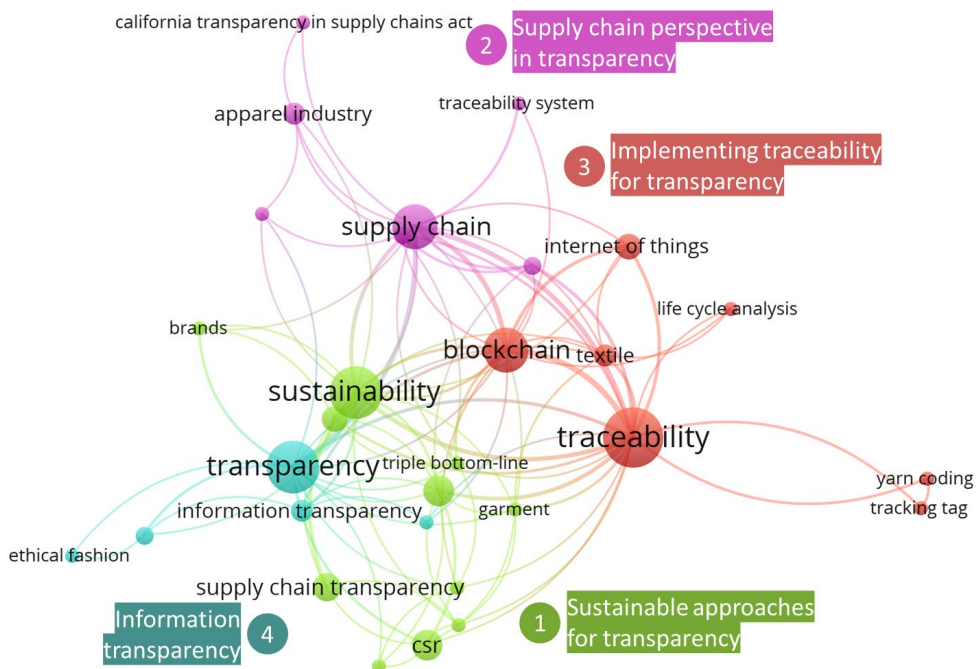
$a_{ij}$	The weight of the edge between nodes $i$ and $j$ . $a_{ij} = 0$ if there is no edge between the two nodes.
$k_i$	The total weight of all edges of node $i$
$k_j$	The total weight of all edges of node $j$
$m$	The total weight of all edges in the network.
$n$	The number of nodes in the network
$x_i$	The location of node $i$ in a two-dimensional space
$\ x_i - x_j\ $	The Euclidean distances between nodes $i$ and $j$
$c_1$	The cluster to which node $i$ is assigned
$\delta(c_i, c_j)$	A function that equals 1 if $c_i = c_j$ and 0 otherwise
$\gamma$	A resolution parameter that determines the level of detail of the clustering

## 5.1. Cluster analysis

Figure 5 is generated following Equation 1, Equation 2, Equation 3 and Equation 4 that use author keywords of studies. There are four clusters are revealed. Then, the keywords that have appeared frequently within the cluster are determined. Subsequently, a meticulous examination of the most recurrently featured keywords within each cluster is undertaken, and these clusters are thoughtfully christened, giving precedence to the salient keywords. This organisational approach involves a methodical alignment of distinctive perspectives, with each cluster representing a

distinct thematic dimension: 1) Sustainability, 2) Supply Chain, 3) Traceability, and 4) Transparency. The nomenclature of each cluster is meticulously crafted, drawing from the preminent keywords encapsulated within, thereby offering a succinct and cogent representation of the thematic essence.

After the keywords of each cluster are inspected, the clusters are named: 1) Sustainable approaches for transparency, 2) Supply chain perspective in transparency, 3) Implementing traceability for transparency and 4) Information transparency. Each cluster will be explored in our further analysis.



**Figure 5: Research clusters - Transparency in apparel and textile supply chains**

### 5.1.1. Cluster 1 - Sustainable approaches for transparency

Sustainable approaches to transparency is the first cluster in which the studies have appeared since 2009. Although the textile and apparel industry contributes significantly to the economic growth of developing countries, it has been criticized for its lack of transparency and the untraceable nature of its supply chain which has questionable sustainability practices. Hence, there is a rising need for supply chains to be transparent in order to prevent unethical practices.

Prior research has predominantly focused on investigating the correlation between sustainability and transparency with the intention of increasing the business value [27]-[28]. A model has been developed by Hazel & Kang, (2018) [29] to determine

the substantiality of a brand's corporate social responsibility information in predicting the consumers' cognitive beliefs and behavioural intentions toward an apparel brand. Garcia-Torres et al., (2019) [30] have conducted a comprehensive and systematic literature review, focusing on the implementation of traceability in global supply chains by companies. The study investigates how this implementation contributes to achieving sustainability goals and supports sustainable supply chain management, with a particular emphasis on the apparel industry as a primary example.

Fast fashion companies have been trying to mitigate the detrimental impacts within their global supply chains over the last decade while research indicates that ensuring sustainability of the operations in their multi-tier supply chains is still a challenge. Mejías et al., (2019) [31] investigated the implementation of traceability management systems and capacity building as innovative approaches to enhance sustainability in the multi-tier supply chain of the fashion industry. The study reveals that companies are primarily implementing traceability management systems to enhance supply chain performance which is a challenging task due to the lack of transparency in the supply chain. A study conducted by Jestratišević et al., (2020) [32] have examined the extent of transparency in sustainability disclosures within the fashion industry, specifically focusing on luxury and mass-market brands. These findings reveal a significant disparity in supply chain disclosure between retail brands positioned at different market segments. Moreover, Jestratišević et al., (2020) [32] conducted a quantitative aimed at identifying disclosure strategies that promote transparency in sustainability reporting. The study contributes to strategic thinking regarding transparency in the fashion industry.

Gonçalves & Silva, (2021) [8] have reviewed the sustainability approaches and standards for fashion products considering the environmental impact, social issues, and the transparency in reporting sustainability. Directing to a different scope in the literature, the fact of gender difference has been considered in studying the impact of supply chain transparency. Bhaduri & Ha-Brookshire, (2015) [34] have conducted a study examining gender differences in information processing and transparency, specifically investigating how consumers evaluate sustainability claims from brands based on their gender. However, the study of Brandão et al., (2018) [35] on the impact of a firm's transparent manufacturing practices specifically on women fashion shoppers. The findings from the study revealed that there is no significant relationship between transparent manufacturing practices and purchase intention among women shoppers. However, transparency was found to have a significant and positive relationship with trust, attitude, and word-of-mouth intention.

Stevenson & Cole, (2018) [36] have conducted a study to examine how organizations detect and remedy modern slavery in their supply chains, as well as their approach to information disclosure in response to modern slavery legislation. As concerns about environmental degradation and resource depletion continue to grow rapidly, research focus has shifted towards socio-environmental issues. In this context, blockchain technology has emerged as a disruptive innovation with the potential to transform the entire supply chain towards more sustainable practices. Hence, a focus towards technological advancement can be observed in literature since 2018 in the transparency aspect in achieving sustainability information. Guo et al., (2020) [37] have conducted a study to explore the impact of blockchain technology on information disclosure regarding environmental initiatives within the fashion industry. The findings of this study contribute to a better understanding of how the blockchain technology can be utilized to implement sustainable practices in the fashion supply chains.

Munir et al., (2022) [38] have conducted a systematic literature review aimed at exploring the existing literature on blockchain for sustainable aspects of blockchain-based supply chain management. The focus of the review is on evaluating the impact of blockchain technology in terms of environmental conservation, social equality, and governance effectiveness within the supply chain context. The findings of this study indicate that blockchain technology has the potential to revolutionize the entire supply chain, emphasizing sustainability aspects. This includes enhancing economic sustainability by enabling effective traceability, improved visibility through information sharing, transparent processes, and decentralization of the overall framework. Additionally, it contributes to environmental and social sustainability through resource efficiency, accountability, the utilization of smart contracts, trust-building, and prevention of fraudulent activities.

A case study is conducted by Benstead et al., (2022) [38] examine how blockchain technology can enhance the triple bottom line performance in the complex multi-tier global fashion industry. This research specifically explores the initial adoption of blockchain technology in the fashion industry, highlighting its practical implementation aspects such as capabilities, operational enhancements, challenges, and limitations.

However, a case study done on the Fast Fashion Industry by Fraser & van der Ven, (2022) [39] indicates that sustainability scandals alone are not sufficient to motivate firms to enhance supply chain transparency. While scandals can contribute to promoting transparency, their impact is limited without the backing of senior management and alignment with domestic norms regarding appropriate corporate behaviour.

Garcia-Torres et al., (2022) [40] have conducted a Delphi study to update, improve, and tailor the understanding of traceability and transparency in relation to sustainability within the fashion-apparel industry. The aim was to identify the critical factors that facilitate or hinder the connection between traceability, transparency, and sustainability in practical applications within the fashion apparel sector.

The first cluster, "Sustainable Approaches for Transparency," encompasses studies from 2009 onwards, focusing on addressing transparency challenges within the textile and apparel industry. Despite its pivotal role in the economic growth of developing nations, this sector has been critiqued for its opaqueness and lack of traceability in supply chains, which raises concerns about sustainability practices. These concerns necessitate heightened supply chain transparency to counter unethical practices. Research within this cluster predominantly examines the nexus between sustainability and transparency, aiming to augment business value. Noteworthy studies include investigations into the link between corporate social responsibility information and consumer attitudes. Additionally, comprehensive reviews of traceability implementation in global supply chains emphasise its role in sustainability, particularly within the apparel industry. Amid the pursuit of sustainability, challenges persist, such as multi-tier supply chain sustainability, as explored through traceability management and capacity building.

Transparency in sustainability disclosure is also contrasted between different market segments, while sustainability approaches and standards for fashion products are reviewed. Gender dynamics are also explored, with examinations of gender-based differences in evaluating sustainability claims. Technological advances are considered, with blockchain's potential for transparency in sustainable practices highlighted. A systematic literature review on blockchain's sustainable impact is provided, as well as a case study on blockchain's role in enhancing triple-bottom-line performance in the fashion industry. The impact of sustainability scandals on motivating firms to enhance supply chain transparency is discussed. A Delphi study is conducted to dissect the interplay of traceability, transparency, and sustainability within the fashion-apparel sector.

### **5.1.2. Cluster 2 - Supply chain perspective in transparency**

The supply chain perspective in transparency is explored under Cluster 2. Customers can make well-informed purchasing decisions by leveraging the improved traceability and transparency of textile supply chains. The fragility of opaque value chains that lack traceability or transparency for brands, suppliers, and customers has been brought to light by the COVID-19 epidemic. According to Rinaldi et al., (2022) [39], the public health crisis also raised consumer awareness of sustainability and the demand for sustainability information.

In 2009, Svensson, (2009) [40] has done a study examining the ethical aspects of supply chain management. The study presented a conceptual framework with empirical illustrations highlighting ethical issues and the ethical commitments demonstrated by corporations in their actions and behaviours within supply chains. The management of supply chains overseas has become more complicated with the globalisation of the apparel sector. Significantly reduced contract pricing, which is provided to compete in international trade, frequently results in the exploitation of workers. Hence, it reveals a greater focus towards the human factor, referring to the available literature on the supply chain perspective in transparency.

In 2012, the California Transparency in Supply Chains Act was implemented with the aim of eliminating slavery and human trafficking from the supply chains of manufacturing and retail companies. Ma et al., (2016) [25] have conducted a study focused on examining the implementation status of this Act within the apparel industry. The research provided valuable insights for manufacturers, retailers, and marketers, highlighting strategies they can adopt to effectively communicate their socially responsible initiatives, particularly in addressing slavery and human trafficking concerns within their supply chains.

James & Montgomery, (2017) [41] have discussed getting fashion consumers involved in supply chain transparency and publicising corporate social responsibility. Shayganmehr et al., (2021) [42] employed a hybrid approach combining empirical research and a fuzzy expert system to evaluate various factors in assessing sustainability within multi-tier supply chains. The study utilised the developed fuzzy expert system to assess the readiness status of a textile company as a case application. The findings revealed that the company demonstrated the highest level of readiness in the aspect of 'Transparency,' while it scored the lowest in 'Environmental issues.'

Given the prevailing issues of information asymmetry and low visibility in industries such as textiles and clothing, traceability has emerged as a crucial necessity for multi-tier and multi-site production. Traceability provides visibility and addresses consumer demands for transparency and quality assurance. In this context, it has become increasingly challenging for customers to assess product data that can support ethical purchasing practices and guarantee product authenticity. Additionally, stakeholders may find it difficult to share critical information in an insecure environment, as there is a risk of data manipulation and concerns about losing their informational advantage. In this context, Agrawal et al., (2021) [15] have addressed these challenges by developing a traceability framework for multi-tier textile and clothing supply chains based on blockchain technology. Their research suggests that this approach has the potential to enhance trust among supply chain participants by leveraging technology. The proposed framework enables supply chain transactions to



be securely stored and verified through a distributed ledger. The study highlights that the implementation of a blockchain-based traceability system offers a unique opportunity for all partners to trace their supply network, fostering transparency and sustainability in the supply chain.

Ahmed & Maccarthy, (2021) [45] have discussed recent applications of blockchain technology in the textile and apparel industry. They analysed a notable blockchain traceability solution implemented by a leading global fibre producer. Gayialis et al., (2022) [46] conducted a structured literature review on traceability approaches specifically aimed at combating product supply chain counterfeiting. Their research served as the foundation for the development of a structured classification framework in this domain.

Moretto & Macchion, (2022) [47] conducted a study that focuses on examining the factors that drive or hinder the adoption of blockchain technology to facilitate traceability in fashion supply chains. The research investigates the various variables within the supply chain that influence the adoption of blockchain technology. It highlights the critical role of blockchain in enabling traceability and visibility throughout the supply chain, which has been a topic of increasing interest and exploration in the literature.

Hader et al., (2022) [48] have introduced a novel framework for traceability in the textile supply chain, leveraging blockchain technology. This framework aims to create an information platform that promotes transparency and facilitates information sharing among all members of the supply chain. However, given that blockchain technology is still in its early stages, it possesses certain inherent limitations, with scalability emerging as a primary and pressing concern when dealing with large-scale data in real-world applications. To address this issue, the study proposes an innovative approach that combines blockchain and Big Data technologies. By integrating these two technologies, the decentralised systems can handle and process vast amounts of data at scale. The research explores how the combination of blockchain empowered by Big Data can be effectively utilised and implemented to enhance control over traceability and information sharing across global supply chains.

Cluster two, "Supply chain perspective in transparency," delves into the significance of transparency in textile supply chains. It emphasises how improved traceability empowers consumers to make informed decisions and reveals the vulnerabilities of opaque value chains, particularly highlighted during the COVID-19 pandemic. The cluster draws from various studies to explore ethical concerns, the California Transparency in Supply Chains Act's implementation, consumer involvement, and the role of technology, notably blockchain, in enhancing transparency and

traceability. It acknowledges challenges, including information asymmetry, and suggests innovative solutions, such as blockchain combined with Big Data, to address scalability and improve transparency in global supply chains.

### **5.1.3. Cluster 3 - Implementing traceability for transparency**

Cluster 3 is based on the implementation of traceability for transparency. In order to facilitate effective object tracking in large-scale traceability networks, Wu et al., (2011) [43] offer a solution that facilitates the communication of traceability data across independent firms in a pure peer-to-peer (P2P) fashion. Kumar et al., (2017) [44] introduced a framework aimed at implementing traceability within the textile supply chain. The framework addresses internal and external traceability and includes a sequential diagram illustrating the interaction and information exchange among the various actors in the supply chain when traceability information is requested.

Agrawal et al., (2018) [51] have proposed the utilisation of a secured tag to implement traceability within the textile and clothing supply chain. Their concept revolves around item-centric secured traceability, which aims to monitor and control manufacturing processes and supply chain activities. A study has been conducted by Kamann et al., (2019) [17] examining the development of traceability management between 1990 and 2017, analysing 124 articles. The study discusses relevant theories, identifies bottlenecks, and explores future prospects, such as the potential of using systems thinking and big data analysis as an enabling factor.

A Delphi study has been conducted by Agrawal & Pal, (2019) [52] which is aimed to investigate and categorise the factors that influence the implementation of traceability in the textile and clothing supply chain. The study also sought to cluster important traceability-related information in this context. The findings emphasised that the most influential elements in the application of traceability in textile and apparel supply chains are risk management, product authentication, and visibility.

Pérez et al., (2020) [12] have proposed a framework that aims to guarantee transparency, authenticity, reliability, and integrity in the supply chain of ready-to-wear clothing. This framework ensures the validity of retail end products and all the components involved throughout the entire supply chain. Chen et al., (2021) [53] have proposed a traceable anti-counterfeit management system for branded clothing. They utilised Hyperledger fabric technology and harnessed the unique features of blockchain to record the precise production processes of branded clothing. This system ensures the authenticity and legitimacy of production information related to branded clothing.

Cluster three, "Implementing traceability for transparency," focuses on the practical application of traceability within the textile supply chain. Key contributions include

solutions for peer-to-peer traceability data sharing, comprehensive frameworks addressing internal and external traceability, and secure tagging systems for monitoring manufacturing and supply chain processes. Additionally, studies discuss the evolution of traceability management, the factors influencing its implementation, and the significance of risk management, product authentication, and visibility. Furthermore, innovative frameworks utilising blockchain technology are presented to ensure transparency, authenticity, and reliability in clothing supply chains, thereby enhancing control over production information and combating counterfeiting.

#### **5.1.4. Cluster 4 - Information transparency**

Cluster 4 is based on information transparency, which plays a vital role in ensuring accountability, enhancing environmental sustainability, and safeguarding workers' rights. Although information transparency has traditionally been linked to financial institutions, its application within the apparel supply chain remains relatively unexplored. In this concern, Bhaduri & Ha-Brookshire, (2011) [23] have conducted a study aimed at comprehensively examining the factors that could influence customer attitudes and purchase intentions towards apparel products sourced from transparent supply chains.

However, the research conducted by Egels-Zandén & Hansson, (2016) [45] challenges the notion that consumers actively utilise transparency in their decision-making process. Instead, their study suggests that transparency positively influences consumer willingness to make purchases. Modi & Zhao, (2020) [46] have conducted a social media analysis to examine consumer opinions regarding apparel supply chain transparency. Their study utilised social network analysis to analyse user-generated data from social media platforms, representing a novel approach in textile and apparel industry research.

Richards, (2021) [47] discusses about the concept of 'radical transparency' as a means for fashion brands to counter the lack of visibility in their supply chains. By embracing this approach, brands can share detailed information about the production of their garments, thereby revealing the true value of fashion. With the help of blockchain technology, improved information transparency becomes possible, extending to sub-suppliers and customers. A series of experimental research has been conducted by Reck et al., (2022) [48] to investigate the influence of brand strength and information transparency on consumers' purchasing intentions for fashion products. The findings suggest that while the presence of transparency decreases consumers' perceptions of large brands, it enhances their responses to the corporate social responsibility (CSR) efforts of smaller brands. The study also highlights the role of trust as a mediator in these relationships, as transparency cues increase consumer trust in smaller brands in comparison to larger ones.

Carrières et al., (2022) [49] have conducted a study to evaluate the potential benefits of incorporating blockchain traceability data into the Life Cycle Assessment (LCA) of textile products. The study also aimed to determine the actual value of utilising this specific traceability data.

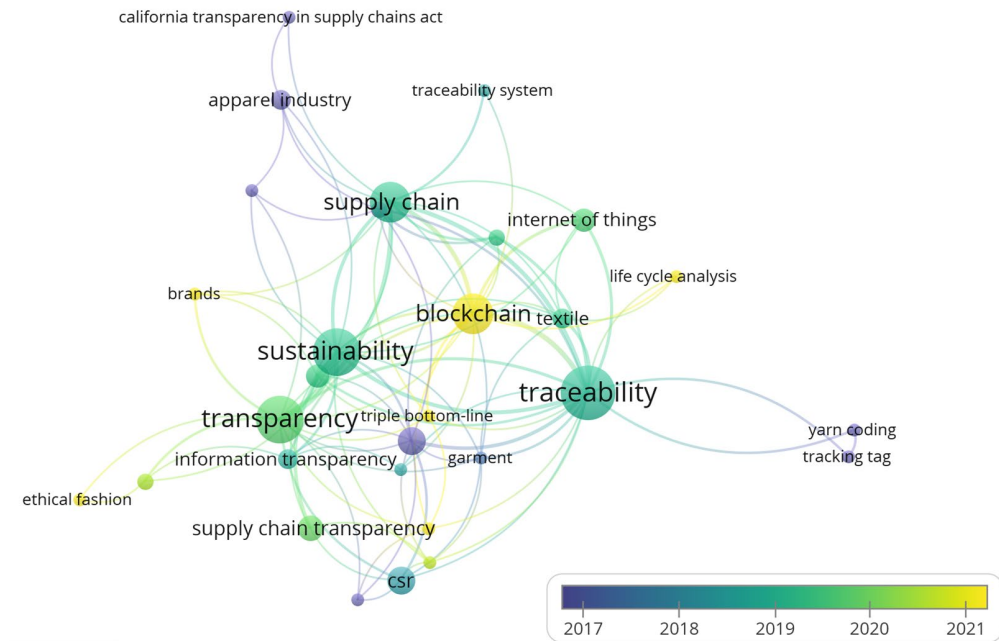
Modern slavery legislation in the fashion industry serves as a means of progress for activist movements that have persistently advocated for greater attention to supply chain practices in order to enhance the working conditions of garment workers. Richards, (2022) [59] has done a study on investigating the role of the Australian Modern Slavery Act 2018 and its effectiveness as a reporting mechanism in preventing the utilisation of forced labour within global supply chains.

An empirical study has been carried out by Tong & Su, (2022) [60] to investigate the influence of cost transparency on consumers' perceptions of a brand and their intentions to purchase its products. The results of the study reveal that providing consumers with detailed cost breakdowns, as opposed to withholding specific cost information, leads to higher perceived quality and value, as well as a more favourable brand attitude. Additionally, the study finds that implementing a cost transparency strategy is particularly effective in cultivating a positive brand attitude for lower-priced brands. Moreover, customers who demonstrate more ethical behaviour tend to perceive higher quality and exhibit greater purchase intent for companies that adopt pricing transparency.

Cluster four, on "Information transparency," highlights its pivotal role in ensuring accountability, promoting environmental sustainability, and safeguarding workers' rights within the apparel supply chain. This cluster explores consumer attitudes and behaviours related to transparency, investigates the potential benefits of technology like blockchain, and evaluates the impact of cost transparency on brand perception and purchase intentions. These studies collectively illuminate the multifaceted nature of information transparency in the apparel industry.

## **5.2. Evolution of transparency in textile and apparel supply chains**

Figure 6 showcases how research areas have evolved under transparency in apparel and textile supply chains. Colours have been applied based on publication year. Broad perspectives such as supply chain management, fashion industry and social responsibility are focused before 2015 as a trend. Corporate Social Responsibility (CSR), transparency in supply chains acts, manufacturing, tracking tag, yarn coding are the areas that have been focused mostly within 2015-2017.



**Figure 6: Evolution of transparency in apparel and textile supply chains**

Areas such as supply chain transparency, IOT, sustainability, traceability, information transparency, fashion supply chain and traceability systems are trending between 2018 and 2020. The areas of ethical fashion, life cycle analysis, blockchain, brands, sustainable supply chain and modern slavery appeared very recently between 2020 – 2022. The scope of transparency in apparel and textile supply chains moves towards these areas, evolving from broad scopes such as supply chain management, fashion industry and social responsibility. The recent trend of publishing within the scope of transparency in apparel and textile supply chains is proven under the bibliometric analysis. This trend publishes more focused research within the scope of transparency in apparel and textile supply chains in niche areas.

## 6. FINDINGS - POTENTIAL AREAS FOR FUTURE RESEARCH

### 6.1. Cluster 1 - Sustainable approaches for transparency

On using sustainable methods for transparency, certain crucial domains have been proposed for further investigation. As revealed by Gonçalves and Silva, (2021) [8], the objective is to carry out research aimed at formulating a dependable scientific methodology that can be utilised across the supply chain to assess the social and environmental sustainability and transparency of fashion items. Moreover, it is imperative that this approach is comprehensible to consumers on a global scale.

In the study of Guo et al., (2020) [37] on information disclosure games over environmental efforts, it is recommended to create games that encourage the disclosure of information regarding other sustainable practices, such as the utilisation of child labour in the fashion sector. Furthermore, it is advised to investigate how market competition affects these information disclosure games. The suggestion is to examine the potential of various advanced technologies, other than blockchain, for their value in promoting information disclosure games. As suggested by Munir et al., (2022) [38], there is a suggestion that future research on developmental research should incorporate the combination of blockchain, big data, LCA methods, IoT, and RFID to be effective.

The proposal recommends that the limitations of blockchain in terms of information management, governance frameworks, and smart contract feasibility should be taken into account. In addition, the potential impact of blockchain adoption on non-technical factors such as company policies, culture, and societal acceptance must be investigated. Further research should examine how blockchain could impact operational costs, risks, uncertainties, and disruptions. The role of the government in promoting blockchain adoption should also be considered.

Fraser and van der Ven, (2022) [50] recognised that researching the evolution of transparency scores has been complex due to the limited data and changes in measurement methods. The proposal is for future research to employ longitudinal data to offer a more comprehensive understanding of transparency growth. This approach would enable identifying the most effective interventions for enhancing transparency in the fashion industry.

## **6.2. Cluster 2 - Supply chain perspective in transparency**

To enhance transparency in the supply chain, multiple pathways have been recognised. The study of Agrawal et al., (2021) [15] conducted a study on creating a traceability framework using blockchain provides a fundamental base for future research in multiple areas. One such area is the development of a sector-specific smart contract that caters to the specific requirements of individual actors in the supply chain.

Furthermore, it is crucial to explore the performance of different blockchain systems that interact and integrate with each other. This would be particularly useful when a supply chain partner is working with multiple suppliers or buyers on multiple blockchain networks. As revealed by Ahmed and Maccarthy, (2021) [51], more empirical research is required to assess the adoption of blockchain technology across various sectors. The objective is to gain insights into how the technology can be used more widely and effectively to facilitate and promote traceability.

Gayialis et al., (2022) [52] reveal that in the future, it is important for research to focus on a comprehensive analysis of all aspects of specific product supply chains. This can aid in the precise and effective implementation of a traceability system. Additionally, there is a need for further research to identify effective strategies for traceability that can combat counterfeiting in product supply chains. The study of Moretto and Macchion, (2022) [53] on blockchain adoption highlights that it is necessary to provide a more comprehensive understanding of the perspectives of both suppliers and focal companies, along with a comparison of different actors' viewpoints in the supply chain. Moreover, the statement suggests that future research should involve action-based projects to evaluate the effects of blockchain implementation on company performance.

### **6.3. Cluster 3 - Implementing traceability for transparency**

Future research directions focusing on key areas have been identified for the implementation of traceability to promote transparency. In the study of Kumar et al., (2017) [44] on traceability implementation, the recommendation is to apply the suggested framework in an operational textile supply chain to gain a better comprehension of its limitations and to make any necessary modifications for its improvement.

Additionally, it is recommended to incorporate concepts such as 'smart cities' and the 'Internet of Things' with traceability information and incorporate any necessary changes in the suggested framework. As highlighted by Agrawal and Pal, (2019) [54], the suggestion is to utilise the conclusions from their Delphi study in future research by exploring different approaches. For instance, the outcomes could be applied to conduct in-depth qualitative research, like interviews. They could also be used to study traceability from various strategic theoretical perspectives, such as information asymmetry. Additionally, it is recommended to integrate further developmental research, building on this study's results, to better understand the design considerations and effectiveness of traceability systems.

### **6.4. Cluster 4 - Information transparency**

Future research directions were identified as a number of recommendations in the context of promoting information transparency. In the social media-based study of Modi and Zhao, (2020) [46], a number of important recommendations were proposed. One such proposal is to carry out a cross-cultural or cross-regional investigation of social media data. This would enable organisations to personalise their communication strategies, aiming to engage their target audiences based on their specific needs and interests. Additional research in relation to consumer perceptions of transparency within the fashion supply chain on other social media platforms like

Facebook or TikTok could be explored. One potential avenue for further research is to collect firsthand data via surveys or interviews, with a focus on understanding the factors driving consumers' participation in social media campaigns. As highlighted by Carrières et al., (2022) [49], the authors propose conducting a broad-based deployment of LCA-blockchain traceability systems, which will help corroborate the various hypotheses and observations discussed in their article. Additionally, future research needs to address the crucial issues of data quality and trustworthiness of information recorded on the blockchain.

### **6.5. A future avenue - Comparison with other industries**

The exploration of comparison with supply chain transparency in other industries emerges as a promising and necessary avenue for future research. While the provided content underscores the significance of transparency in the textile and apparel sector, there is a conspicuous gap when it comes to comparative analyses. Supply chain transparency is not exclusive to the fashion industry. Multiple sectors, including agriculture, food, electronics, and pharmaceuticals, have embraced transparency initiatives driven by various factors such as sustainability concerns, regulatory requirements, and consumer demand. Hence, a comparative examination of how different industries approach and implement supply chain transparency can offer valuable insights. Researchers can investigate the strategies, technologies, and practices employed in these diverse sectors to foster transparency and sustainability. Such a comparative study could shed light on the unique challenges and opportunities faced by the textile and apparel industry and inspire cross-sectoral learning.

Moreover, cross-industry comparisons can help identify transferable best practices and innovative solutions. For instance, the experience of other sectors in implementing blockchain technology or utilising social media for transparency purposes can provide the textile and apparel industry with valuable lessons and inspiration. Additionally, considering the dynamic nature of supply chains and the evolving landscape of regulations and consumer expectations, a cross-sectoral perspective can assist in anticipating future trends and potential challenges. By examining how different industries navigate issues like information disclosure, traceability, and the impact of advanced technologies, researchers can contribute to a more comprehensive understanding of effective transparency strategies.

## **7. CONCLUSION**

This systematic review aimed to explore transparency in the textile and apparel supply chain. A surge in research publications on methods to improve traceability and transparency has been observed recently, but these have been mostly limited to



the sustainability or economic realm of the textile and apparel sector. This study attempts to provide a broader overview of the literature, organised into four research clusters based on a cluster analysis of author keywords, namely sustainable transparency methods, transparency from a supply chain perspective, traceability implementation for transparency, and information transparency. However, despite the substantial increase in publications in recent years, collaborations between academia and industry have been largely lacking. Therefore, there is a pressing need for more research collaborations between industry and academia. It was observed that studies on ethical fashion, life cycle analysis, blockchain, brands, sustainable supply chains, and modern slavery have notably increased. Future research should focus on the research directions identified within or beyond these four research clusters. There is a need for more systematic reviews on transparency in textile and apparel supply chains to improve our understanding of the current state of research.

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