UNIVERSITY OF TURKU
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Tracing the value of traceability

Identifying the value of traceability within textile and apparel value chains

International Business

Master's thesis

International Management and Entrepreneurship

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In recent years, the global landscape of the textile and apparel industry has undergone a profound transformation, primarily driven by escalating environmental and social concerns related to the prevalent fast fashion models, unsustainable consumption practices, and misleading green certifications. The industry faces exacerbated challenges due to excessive consumption and rapid production, leading to intensified social issues within complex and globally interconnected value chains. The lack of transparency in these complex networks has spurred various stakeholders, including consumers, suppliers, regulators, and policymakers, to advocate for heightened transparency and access to traceability data.

Recognizing the need for greater value chain resilience in the face of an increasingly volatile business landscape, companies grapple with the urgency for traceability, which, despite being evident, faces a gap in widespread implementation This study centres on the theme of value creation through traceability within textile and apparel value chains, with a specific focus on discerning key drivers for traceability, understanding the intricate flow of traceability data, and establishing robust connections between traceability and business objectives. Understanding the facets that contribute value through traceability is crucial, as companies are unlikely to adopt complex practices unless provided with clear explanations of how they can enhance their ability to create value for the organization, specifying the unique value generated for their circumstances.

The research employed qualitative methods, employing open-ended semi-structured interviews with sixteen stakeholders representing companies operating within the textile and apparel value chain. The findings are consistent with existing literature, emphasizing regulatory drivers as primary in traceability implementation. European companies are noted for their advanced practices and sense of urgency in preparing for upcoming regulatory initiatives.

Traceability emerges as a strategic tool to mitigate risks, offering visibility into external risks in supply chain management, and enhancing understanding of social, environmental, and governmental impacts. It facilitates informed decision-making, supports growth, and unlocks new business opportunities. Additionally, traceability enables access to tax benefits, grants, and opportunities for adjusting pricing of traced products. It serves as a tool for coherent and verified storytelling, meeting consumer demands for sustainability and circularity matters.

The study's insights offer guidance for companies operating within textile and apparel value chains, aiding them in formulating a traceability strategy that focuses on engaging in traceability practices that generate value. Using the commissioning company as an illustrative example, the study provides valuable insights into key drivers for traceability and tools to facilitate effective traceability data flow, thereby enhancing value across stakeholders in the value chain.

Key words: Traceability, textile and apparel industry, value chain, value creation, risk management

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Maailman tekstiili- ja vaatetusteollisuus on kokenut merkittävää muutosta viime vuosina. Tähän ovat ajaneet kasvavat ympäristölliset ja sosiaaliset huolenaiheet, jotka liittyvät vallitseviin pikamuotimalleihin, kestämättömiin kulutustottumuksiin ja harhaanjohtaviin vihreisiin sertifikaatteihin. Teollisuus kohtaa entistä suurempia haasteita ylenmääräisen kulutuksen ja nopean tuotannon vuoksi, mikä on johtanut monimutkaisten ja globaalien arvoketjujen sisällä voimistuviin sosiaalisiin ongelmiin. Monimutkaisten verkostojen läpinäkyvyyden puute on kannustanut eri sidosryhmiä, mukaan lukien kuluttajia, toimittajia, sääntelijöitä ja päättäjiä, vahvistamaan läpinäkyvyyttä ja jäljitettävyyttä alalla. Jäljitettävyyden vahvistamisen ja käyttöönoton pyrkimyksissä on kuitenkin huomioitava, että sen toteuttamiseen liittyy haasteita.

Tämä tutkimus keskittyy arvon luomisen teemaan, fokuksena jäljitettävyys tekstiili- ja vaatearvoketjuissa. Tutkimuksessa perehdytään erityisesti avainajureiden tunnistamiseen, jäljitettävyyden tietovirtojen fasilitoinnin jäsentelyyn sekä yhteyksien luomiseen jäljitettävyyden ja liiketoimintatavoitteiden välille. Jäljitettävyyden avulla lisäarvoa tuovien näkökohtien ymmärtäminen on ratkaisevan tärkeää, sillä yritykset eivät mitä todennäköisemmin ota käyttöön sellaisia monimutkaisia käytäntöjä, joiden avulla ei voida selittää organisaatiolle saatavaa merkityksellistä arvoa.

Tutkimuksessa käytettiin laadullisina menetelminä avoimia puolistrukturoituja haastatteluja, joissa oli mukana kuusitoista eri tekstiili- ja vaatetearvoketjussa toimivan yrityksen edustajia. Tutkimuksen tulokset ovat linjassa olemassa olevan kirjallisuuden kanssa, korostaen regulaattorisia ajureita ensisijaisina kannustajina jäljitettävyyden toteuttamisessa. Eurooppalaiset yritykset saivat tunnustusta edistyneistä käytännöistään ja proaktiivisesta asenteesta valmistautua tuleviin sääntelytoimiin.

Jäljitettävyys näyttäytyy strategisena työkaluna riskien lieventämisessä, tarjoten samalla näkyvyyttä ulkoisiin riskeihin toimitusketjun hallinnassa sekä lisäten ymmärrystä sosiaalisista, ympäristöllisistä ja hallinnollisista vaikutuksista. Jäljitettävyys helpottaa informoitujen päätösten tekemistä, tukee kasvua ja avaa uusia liiketoimintamahdollisuuksia. Lisäksi jäljitettävyys mahdollistaa pääsyn verohyötyihin, avustuksiin ja mahdollisuuksiin säätää jäljitettyjen tuotteiden hintoja. Se toimii työkaluna johdonmukaiseen ja todennettuun tarinankerrontaan, vastaten kuluttajien vaatimuksiin kestävyyden ja kiertotalousajattelun toteutumisesta.

Tutkimuksen löydökset tarjoavat ohjausta tekstiili- ja vaatearvoketjuissa toimiville yrityksille, auttaen niitä muotoilemaan jäljitettävyysstrategiaa, joka keskittyy osallistumaan jäljitettävyyteen arvoa tuottavilla tavoilla. Havainnollisena esimerkkinä käytetty toimeksiantajayritys tarjoaa arvokkaita oivalluksia jäljitettävyyden avainajureista sekä työkaluista, jotka helpottavat tehokasta jäljitettävyyden tietovirran kulkua, siten lisäten arvoa arvoketjun sidosryhmille.

Avainsanat: Jäljitettävyys, tekstiiliala, arvoketju, arvon luonti, riskien hallinta

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1 Introduction

This thesis examines the topic of traceability and how it can be facilitated to create value within textile and apparel value chains. The research introduces literature on the definition of traceability, characteristics of textile and apparel value chains, institutional drivers influencing the implementation of traceability practices, and seeks to find means for companies to facilitate value through traceability. The following section presents the research background, research gap, as well as purpose of the research.

1.1 Background on textile and apparel traceability

The textile and apparel industry is recognized as among the oldest and most critical facilitators of customer commodities, characterized by lengthy and linear supply chains. Despite its historical and current significance, the industry is known to pose substantial sustainability challenges. As an industry marked by high pollution, heavy resource usage, and intensive labour practices, textile and apparel production is acknowledged to contribute 8-10 percent of the overall global climate change. (Quantis 2018; UNFCCC 2018; De Brito et al. 2008.) The sector involves various stakeholders, including suppliers, brands, retailers, logistics and distribution partners, customs, and various service providers, making it a complex industry where not all value chain actors consistently prioritize sustainability (Shih & Agrafiotis 2015, 1027).

Moreover, the rise of fast fashion has shortened the lifecycle of clothing, resulting in an increased demand for textiles and a nearly doubled fiber production in just twenty years (Khurana & Ricchetti 2016, 90-91). In general, stakeholders agree that the integration of sustainability principles into the curriculum of supply and value chain management, has the potential to revolutionize processes in both supply and value chains (Walker & Brammer 2009, 471-472). A growing perspective suggests that “a company is no more sustainable than its supply and value chains” (Krause et al. 2009, 20).

Thus, sustainability has emerged as a major concern for all textile and apparel companies, primarily driven by government and consumer concerns (Kozlowski et al. 2012, 16-17). Labels indicating organic fibers, green certifications, traceability claims, and similar indicators are commonly utilized to convey the sustainability of raw materials or finished products along the textile value chains, ultimately reaching the end-consumers of prod-

ucts (Henninger 2015, 6012). However, many of these claims and initiatives lack credibility without comprehensive traceability within the textile and apparel value chain, including information about the origins of materials used in the products. Since brand owners cannot verify all sustainability claims through laboratory-based experiments, they must compile all relevant traceability information to substantiate their claims. Likewise, systematic retention of product information is necessary to validate claims pertaining to the societal and economic aspects of sustainability, as emphasized by Johansson and Månsson (2013). Therefore, having relevant traceability information is an integral aspect of sustainability, and product-related data plays a crucial role in making accountable claims (Johansson & Månsson 2013, 20).

Numerous organizations have set ambitious traceability targets, committing to publicly disclose data on various topics, including supplier names, emissions data, and social well-being of employees. However, the true challenge lies in the next steps, as companies must now translate these goals into concrete and tangible actions. By doing so, they can convincingly show a diverse range of stakeholders that they have genuinely fulfilled their commitments. (Fashion Revolution 2023.) Nevertheless, implementing full value chain traceability is a complex undertaking, that demands a well-thought-out implementation strategy, considering continually evolving regulatory requirements and meeting stakeholder expectations. Companies that successfully establish robust traceability systems will achieve business objectives, such as ensuring the ability to deliver a precise product efficiently to the right location, at the correct time, with optimal customization and speed, all while maintaining a competitive cost. Furthermore, such companies will exhibit greater resilience in the face of supply-and-demand shocks, as traceability enables them to foresee potential threats in supply chains and respond promptly to disruptions. These numerous advantages will ultimately foster enhanced growth and profitability, facilitating the adoption of innovative business models. (Betti et al. 2021, 3-4.)

Scholars have identified two key perspectives related to value creation in business markets that are comparable to the context of textile and apparel value chains: the "value of products" and the "value of supply-chain relationships" (Lindgreen & Wynstra 2005, 732-733). More specifically, companies employing traceability systems can ensure the exchange of more detailed information about their products, which enhances the overall value of their offerings. Contrarily, traceability systems equipped with high-quality infor-

mation offer buying companies a dependable source of product origin information, enabling more informed purchase decisions. Consequently, the integration of traceability systems, as a component of an ongoing relationship grounded in information sharing, is closely linked to practices in effective supply chain relationship management. (Hingley 2001; Lindgreen 2003; Canavari et al. 2010.) Thus, understanding the value creation process of traceability is crucial as companies are unlikely to adopt new, complex practices, unless they are provided with explanations on how they can enhance their ability to create value for the organization and how value is specifically generated for them (Lindgreen & Wynstra 2005, 743).

1.2 Research gap and purpose of the study

The exploration of traceability within the textile and apparel value chains is a topic that has not been extensively researched in previous studies. Some research has delved into traceability from a digital infrastructure perspective, emphasizing the possibilities offered by emerging technologies like blockchain (Ahmed & MacCathy 2021; Moretto & Macchion 2022). Other studies provide an overarching view of the textile and apparel industry, considering regulations and initiatives that drive the adoption of traceability practices (Nokelainen et al. 2022). Additionally, some studies narrow their focus to specific upcoming legislative initiatives, such as the EU Digital Product Passport (Solita & Gaia Consulting 2022). A brief literature review indicates that several constructs are associated with the traceability of textile and apparel value chains. However, limited studies have highlighted the connection between traceability and value creation within textile and apparel value chains. As proposed by Lindgreen and Wynstra (2005), the implementation of traceability may contribute value in various ways (Lindgreen & Wynstra 2005). Given that companies generally make decisions and take actions based on their perceived value, it was deemed pertinent to examine the topic of traceability from a perspective of value creation.

This study seeks to explore how traceability can create value to companies operating within textile and apparel value chains. The purpose of this study is specified by the research question: *How is value created through traceability within textile and apparel value chains?* Sub-research questions are defined as follows:

1. What are the key drivers for traceability?

2. How is traceability data flow facilitated in practice?
3. How is traceability linked to business objectives?

The primary research question is explored by addressing three sub-questions, each shedding light on different aspects of the studied phenomenon. The initial focus is on identifying institutional structures that drive the adoption of traceability practices. To facilitate understanding on this, the Institutional Theory (DiMaggio & Powell 1983; Scott 1995) is employed to identify normative, regulative, and cultural-cognitive factors driving traceability implementation within textile value chains. Once the drivers for implementing traceability are understood, emphasis will shift to mapping out traceability data flow, including the identification of pertinent traceability data points across the textile and apparel value chains.

The study will investigate the means available to facilitate the collection, storage, and exchange of traceability data by various stakeholders in the textile and apparel value chain. An examination of existing traceability technologies, platforms, and other methodologies is also included. Additionally, this research underscores the connection between traceability and business objectives, shedding light on how it can be leveraged to generate organizational value through the execution of a well-established traceability strategy. This topic is important as it projects the overall relevance of traceability in the industry's journey towards more sustainable, and transparent operations.

While the discussion of traceability should ideally take place on a global scale, given the global nature of textile value chains, the study places particular emphasis on the European Union region. This study's focus is driven by its significance for the Finnish textile technology scale up Infinited Fiber Company, which acts as the commissioning company for this study. Infinited Fiber Company specializes in producing man-made cellulosic fibers composed from textile waste for the textile industry (Infinited Fiber Company 2023). Understanding the perspectives, tools, and value-generating aspects of traceability is crucial for Infinited Fiber Company and its clients, multinational fashion brands. This comprehension is essential as the shift towards transparent value chains requires data not only from Infinited Fiber Company but also from other participants within their value chain. The upcoming chapter will discuss existing literature on traceability and value creation within textile and apparel value chains.

2 Traceability within the textile and apparel value chains

This section provides an overview of the current literature, definitions, and theories pertaining to traceability within textile and apparel value chains. It is organized into five subchapters. The initial subchapter concentrates on establishing a definition for traceability and its relevance to textile and apparel value chains. The subsequent subchapter explores the institutional factors that drive the implementation of traceability practices. The third subchapter outlines the key data points in the flow of traceability data. The fourth subchapter is dedicated to identifying links between traceability and value creation, and finally, the last section summarizes the theoretical background and presents the initial framework of the study.

2.1 Defining traceability and value chains

Numerous attempts have been made to conceptualize traceability, with most of the existing definitions centring around the logistics of traceability. These definitions emphasize the physical movement of a product or material within a specific value chain. Conversely, attribute-oriented traceability shifts its focus to not only tracing a product's flow but also capturing its attributes, such as information related to its quality and safety. (Skilton & Robinson 2009, 41.) Adhering to a widely cited definition, the International Standards Organization (ISO) defines traceability as "the ability to trace the history, application, or location of an object." This definition is specifically related to products and services, encompassing the origin of materials and parts, processing history, and distribution and location after delivery. (ISO 2023.)

Traceability encompasses the foundational process of tracking products throughout their distribution chain, from the origin of raw materials to the destination of the final product, and vice versa. Moreover, it involves the capacity to disclose data regarding compositions and various production events that the products have undergone. (ISO 2023.) Further defining concepts in traceability include a distinction between forward and backward traceability, also known as tracking and tracing, which specifies the direction of tracing. Top-down tracing follows the product from the beginning of the supply chain to the final consumer, while bottom-up tracing identifies the origin of the product. (Islam & Cullen 2021,

56-58.) However, both approaches are deemed necessary to facilitate a holistic understanding of the concept of traceability. In the following chapter, a distinction between the concepts traceability and transparency is further clarified.

2.1.1 Traceability and transparency

Initially, traceability gained significance several decades ago, particularly in sectors with notable health and security risks. It evolved into a legal obligation, especially in response to major crises, to ensure product safety and mitigate potential risks, particularly within the food industry. (Kamann et al. 2019, 12.) Although research on traceability and its application possibilities has predominantly centred around the food industry, recent efforts have demonstrated strong connections with other operational advantages and industries (Kamann et al. 2019, 12-14).

Recent studies have associated traceability with supply chain management (SCM), considering it as a subsystem for quality management (Moe 1998, 211). For instance, in ensuring adherence to specifications and addressing failures within a production chain, traceability serves as a tool to gain understanding and visibility across the entire value chain. Multiple scholars have also linked traceability with strategic management to manage complexity and uncertainty in global distribution systems. When defects or unexpected events occur within a manufacturing process, traceability acts as a tool to investigate the underlying causes of such disruptions. Consequently, it can facilitate the implementation of improved processes and enhanced control systems to detect and prevent defects. (Skilton & Robinson 2009; Roth et al. 2008.)

In discussions about traceability, transparency is often seen as a facilitator for traceability. According to Skilton and Robinson (2009, 42), the level of transparency in a value chain determines the effort required to establish traceability. While a certain degree of transparency is necessary for achieving traceability, the relationship between transparency and traceability is not straightforward. Diminishing the exchange of information among value chain partners results in a lack of transparency within the network, which, in turn, increases the effort needed to track and identify defects. (Skilton & Robinson 2009, 42-43.) Synergies between supply chain management (SCM) and sustainability, highlighted earlier, are further illustrated in Figure 1, where traceability and transparency serve as facilitators for such.

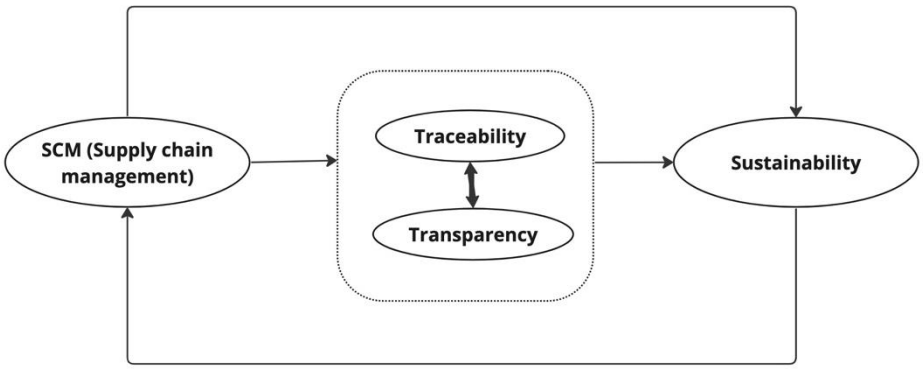

Figure 1: Descriptive model relating to the four key concepts (Modified from Garcia-Torres et al. (2021, 353)

Richero and Ferrigno (2017) define transparency as providing relevant information about a value chain consistently, facilitating shared understanding, convenient accessibility, and a clear vision for stakeholders throughout the value chain (Richero & Ferrigno 2017). Effective communication with all stakeholders in a value chain is crucial for fostering transparency. For example, even though consumers increasingly demand more detailed information about product origins, ensuring reliable information and conveying it in a user-friendly manner pose challenges for value chains with low cooperation and a lack of vertical communication. This principle extends to all parties involved, meaning that relevant production data and information must be converted into suitable formats for each participant. (Nokelainen et al. 2022, 14.)

However, given the multitude of definitions and principles expressed through various terminologies, studies have reached a consensus that there is a widespread lack of shared understanding of traceability, its terminology, and lack of frameworks guiding its accurate implementation in organisations (Ray- Garcia et al. 2022, 356). This is partially attributed to the complex and interdisciplinary nature of the field of traceability, as well as the absence of regulatory initiatives providing frameworks for its implementation (Karlsen et al. 2013). In the absence of industry-specific guidelines, some countries have taken initiatives to implement their own regulations, particularly regarding the raw materials used in manufacturing textile products. For instance, in France, textile manufacturers and importers of textile goods are mandated to either establish their own officially recognized collection and recycling program or collaborate with an accredited take-back system. (Nokelainen et al. 2022, 16.) The upcoming chapter will explore in greater detail the

intricacies of textile and apparel value chains, highlighting their distinctions from supply chains.

2.1.2 Textile and apparel value chains

A value chain, as the name implies, enables a company to generate value beyond the basic cost of delivering goods and services to its consumers. According to Porter's (1985) definition, a value chain is a sequence of functions that collectively create value for a specific product or service. The concept behind a value chain is closely tied to establishing connections with consumer demand rather than focusing solely on the products or services a company produces. The emphasis of a value chain is on testing products, driving innovation, conducting research and development, as well as engaging in marketing activities. Porter (1985) asserts that it is crucial for a company to cultivate organizational expertise in the core activities of the value chain to maximize its competitive advantage. (Porter 1985.)

The primary distinction between a supply chain and a value chain lies in their focus: while the supply chain primarily concentrates on the supply aspect of a product or service, the value chain prioritizes the customer (Porter 1985). In a supply chain, collaboration between suppliers and manufacturers aims to streamline processes, enhance efficiency, and minimize waste, with a particular emphasis on upstream activities. In contrast, a value chain is oriented towards creating value for and with the customer, with a focus on downstream activities. (Porter 1985; Tseng & Lin 2016, 2133-2134.)

Textile and apparel value chains are intricate, buyer-driven networks dominated by large retailers that control global manufacturing networks and specify supply requirements. Buyer-driven value chains are prevalent in industries producing labour-intensive consumer goods such as garments, footwear, and consumer electronics. (Roberts & Thoburn 2001, 32.) In practical terms, within buyer-driven value chains like the textile and apparel value chain, large retailers exert control, coordinate, and manage production on a global scale by specifying raw material inputs, prices, quality, and lead times. Manufacturers, even if they own their own factories, are significantly influenced, and pressured by retailers. Direct information flows from retailers to manufacturers, extending to decision-making on textile compositions, colours, and patterns. (Flanagan 2003.)

To comprehend the intricacies of textile and apparel value chains and distinguish them from related supply chains, it is necessary to delve deeper and provide additional insights (Figure 2).

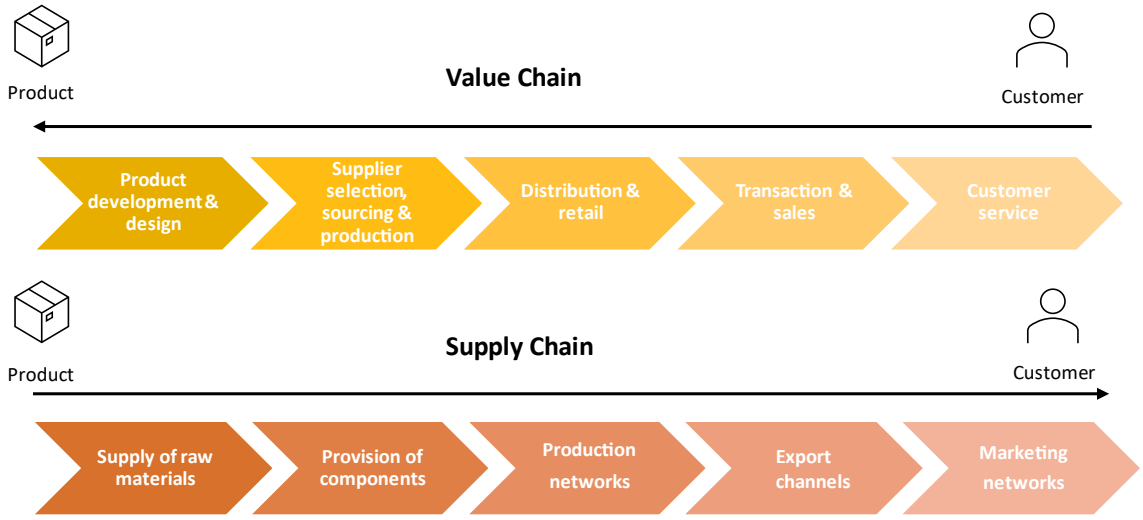

Figure 2. Towards creating value for and with the customer (Porter 1985; Modified from Cura et al. 2022, 8)

According to Gereffi and Memedovic (2003, 3-4) the textile and apparel supply chain is structured around five main activities: the supply of raw materials, encompassing natural and synthetic fibers; the supply of raw materials, including both natural and synthetic fibers; the provision of components such as yarns and fabrics produced by textile companies; production networks comprising garment factories, which include both domestic and international subcontractors; export channels established by trade intermediaries; and marketing networks at the retail level. Such activities are commonly referred to as Tiers[1] (Tier 1-4), which refer to a step along the supply chain in which a supplier performs a specific function to transfer material into a finalized product. (Gereffi & Memedovic 2003, 4; TrusTrace 2023.) In turn, the textile and apparel value chains are structured around five main activities: Product development and design; supplier selection, sourcing, and production; distribution and retail; transaction and sales; and customer service, which demonstrate the value-adding components corresponding to the steps identified in the supply chain. (Gereffi & Frederick 2010.)

[1] Supplier tiering is a method of organizing different suppliers into categories in order. Supplier tiering depicts "how far away" the supplier is from the company and the final product or service.

The textile and apparel value chain begins with the product development phase in which designers, typically working for retailers, define product information such as materials used, fabrics and quantities to be used, technical specifications, designs, and colourways of garments to be produced. These specifications are furthermore delivered to garment, fabric, and yarn manufacturers whose demand is driven by the requests set by such retailers. (Bruce & Daly 2011, 16-19.) To produce the requested materials such as fabric and yarns, the fabric weavers and yarn spinners need to source necessary fibres from fibre producers. This step refers to the raw material source and is commonly referred to as Tier 4. Supply is once again driven by the retailers' requests as the specifications have been laid out in the design phase. (Nayak & Padhye 2015, 12.) This could indicate a specific farm or cotton plant who has grown the raw material indicated to be used in a garment (TrusTrace 2023).

The second step of the value chain introduces the supplier selection, sourcing, and production phase in which suppliers are chosen to conduct the following steps of production. This consists of Tier 3 and 2 of the textile and apparel supply chain in which raw materials are turned into first yarns (Tier 3) and then fabrics (Tier 2). In this Tier 3, fibers undergo spinning, dyeing, weaving, and other processes to prepare them for use in Tier 2 materials. Many brands have limited contact or visibility over Tier 3 suppliers, and reporting on them is often minimal. After the spinning step, Tier 2 suppliers create fabrics used by Tier 1 suppliers to manufacture garments. This Tier involves processes such as printing, ginning, spinning, embroidery, embellishments, tanning, and laundering. (TrusTrace 2023.) While Tier 2 suppliers typically have a direct relationship with Tier 1 suppliers, collaboration with the brand itself is less common. Brands seeking insight into their supply chain beyond direct suppliers must coordinate with Tier 1 facilities to obtain information from Tier 2 and beyond. Finally, Tier 1 suppliers, also referred to as direct suppliers, encompass factories and facilities responsible for cutting, sewing, packaging, and preparing finished garments for shipment to a brand. Fashion brands typically maintain a direct relationship with their Tier 1 suppliers. (Gereffi & Frederick 2010; Nayak & Padhye 2015, 12-15; TrusTrace 2023.)

After the production phase of yarn spinning, fabric weaving, cutting, sewing, assembly as well as finishing inspection, the ready-made garments are ready for packaging and retail, which is the following step of the value chain. In the distribution phase, products are transported around the world by distributors or logistics partners to warehouses or

distribution centres specified by retailers. (Nayak & Padhye 2015, 12-15.) From warehouses and distribution centres, products are furthermore delivered to retailer's point of sale locations, that being flagship stores, retailer stores or stored at warehouses for online sales. Retailers take responsibility in the sale and marketing activities of the products by creating marketing plans for targeted and successful sale of products. Finally, customer service, including sales, resale, renting, maintenance, repair, and recycling services serves as the last step of the value chain, serving as the main end-customer touchpoint for actions regarding the ready-made product. The customer service function lasts as long as the product stays in use or until it is disposed for end-of-life purposes. (Gereffi & Frederick 2010.) The upcoming chapter will delve deeper into the role of traceability as a tool to promote sustainability within textile and apparel value chains.

2.1.3 Traceability as a means to facilitate sustainability

The global textile and apparel industry is undergoing a significant transformation due to the adverse environmental and social impacts associated with the prevalent fast fashion business model and unsustainable consumption patterns among consumers. Textile and apparel production not only has substantial environmental consequences but also raises concerns regarding social sustainability issues. (Henninger 2015.) This challenge is compounded by excessive consumption and faster production times, further worsening social challenges, such as the working conditions of employees in textile factories (Nokelainen et al. 2022, 14). The existing textile and apparel value chains are uniquely globalized, complex, and characterized by a lack of transparency (De Brito et al. 2008). Various stakeholders in the value chain, including consumers, suppliers, regulators, and policymakers, are advocating for increased transparency and access to traceability data, encompassing information about the origin, composition, and production methods of products. Another driving force behind the push for greater transparency within the textile and apparel value chain is the necessity to authenticate products and combat counterfeiting, particularly pertinent for luxury brands offering high-value items. (Nokelainen et al. 2022, 14-16.)

Furthermore, sustainability has become a pivotal marketing tool, employed to enhance a brand's image and identity. De Brito et al. (2008) assert that sustainability functions as a means to connect with environmentally and socially conscious customers. Various indicators, such as organic fiber labels, green certifications, and traceability numbers, are

widely employed to communicate the sustainability attributes of raw materials or finished products to other supply chain stakeholders or end-users. (De Brito et al. 2008, 550.) However, it is crucial to emphasize that many of these claims and initiatives lack credibility without comprehensive traceability within the textile and apparel supply chain. From the customer's standpoint, sustainability encompasses the information provided about a product and its relationship with the fundamental components of sustainability: ecological, societal, and economic. (Henninger 2015, 6013.)

Employing organic cotton, implementing green chemistry processes, and embracing clean energy sources contribute to the ecological dimension of sustainability. Simultaneously, fair trade practices in cotton production and textile manufacturing play a role in nurturing societal and economic dimensions. (Henninger 2015, 6013.) In the textile supply chain, brand owners act as resellers, outsourcing production activities to subcontractors or suppliers responsible for primary production tasks, including the selection of raw materials and chemicals, as emphasized by Lam and Postle (2006). Thus, the achievement of sustainability goals relies on the collaboration of these suppliers and subcontractors. (Lam & Postle 2006.)

Since brand owners cannot substantiate all sustainability claims solely through laboratory experiments, they must compile extensive traceability information to authenticate their claims. Similarly, the systematic retention of product information is imperative for validating claims related to the societal and economic aspects of sustainability, as highlighted by Johansson and Månsson (2013). Thus, relevant traceability information is a fundamental element of sustainability, and product-related data plays a pivotal role in making credible claims (Johansson & Månsson 2013).

The implementation of transparency in the textile and apparel value chain varies based on the accessibility of data from the involved stakeholders (Henninger 2015). If all actors in the value chain undertake the responsibility for identification and data collection, transparency can be accomplished through efficient value chain management. Conversely, if identification and data collection occur after the final product is completed, the process of requesting traceability data becomes considerably more challenging, often leading to stakeholders' reluctance to transition toward a more transparent value chain. (Nokelainen et al. 2022, 16–17.)

Globally, the United Nations (UN) has established 17 Sustainable Development Goals (SDGs) to promote socially, economically, and ecologically sustainable development. The UN's Agenda 2030, encompassing an action plan, employs appropriate indicators and collaborative efforts to facilitate sustainable development. (United Nations 2023.) In response to the escalating sustainability challenges in the textile and apparel industry, there is a need for systemic solutions aligned with the UN's Agenda 2030 and the European Union's (EU) Green Deal ambition of 2019. Recognizing textiles as a value chain of crucial importance, the 2020 Circular Economy Action Plan and the 2021 revision of the EU Industrial Strategy emphasize the urgency for immediate attention to shift towards sustainable and transparent production. (European Commission 2022.)

Undoubtedly, textile and apparel value chains have generated significant economic and social value. However, as stated above, they have had detrimental impacts on the environment especially due to the raise of fast fashion, including the manufacturing of large quantities of inexpensive garments and raise generated of post-industrial as well as post-consumer textile waste. (Akter et al. 2022, 1-2.) Due to investors, consumers as well as governments raising demands, textile and apparel companies have now reached a critical juncture where they need to consider a realignment of their global value chains towards a more sustainable direction (Akter et al. 2022, 3).

Companies are also faced with an increasingly volatile business landscape, in which a greater value chain resilience is needed to ensure supply of materials (Nokelainen et al. 2022). It is argued by Betti et al. (2021, 6) that traceable and circular value chains will be needed to adopt to the changing business environment successfully. This demonstrates a significant transformative shift in decision-making that no individual company will possess the capacity of accomplishing alone. The establishment of traceable value chains will necessitate a higher level of collaboration throughout the whole industry’s value chain. Additionally, extensive public-private partnerships will be essential, along with a fresh approach to managing operations and investment in traceability technology. (Betti et al. 2021, 6-7.) The upcoming section will delve deeper into comprehending the primary factors driving the implementation of traceability within the textile and apparel industry. Initially, attention is directed towards identifying the fundamental structures encompassing the regulative, normative, and cultural-cognitive pillars of the institutional theory.

2.2 Understanding the institutional drivers for traceability

Management and international business researchers frequently utilize the institutional theory to examine the conduct of multinational organizations (Tihanyi et al. 2012, 33). In Martinez's definition (1999, 76), an institution is characterized as an established system encompassing authoritative and standardized social practices, relating to widely accepted norms and socio-economic beliefs associated with various societal aspects like politics, religion, legislation, and education.

The institutional theory operates on the fundamental idea that organizational practices are shaped by institutional pressures and social interactions (Wooten & Hoffman 2008, 130). Scott (1995) posits that all companies are subject to regulative processes, adhering to guidelines established by local and overarching governance structures. Moreover, all companies are socially constructed and, as a result, are subject to the social assumptions that define what is considered legitimate. This pursuit of legitimacy in organizational practices is significantly influenced by socially constructed and accepted norms. (Scott 1995, 136-138.) Effectively operating in each environment necessitates companies' adherence to the perceived rules and guidelines shared by the constituents of that environment (Meyer & Rowan 1977, 315).

Researchers from diverse disciplines, such as political science, sociology, economics, and psychology, collectively affirm that the conduct and decision-making processes of companies are profoundly influenced by their institutional environment (Scott 1995). This environment comprises the regulative, normative, and cultural-cognitive structures that regulate social behavior and contribute to the organization of societal life (Scott 1995; DiMaggio & Powell 1983). The influence of institutional contexts on organizational behavior can be examined through the three institutional pillars (Table 1) delineated by Scott (1995).

Table 1: Three pillars of institutions (adapted from Scott 1995)

	Regulative	***Normative***	***Cultural-Cognitive***
Basis of compliance	Expedience	Social obligation	Taken for granted
Indicators	Rules, laws, sanctions	Certification, accreditation	Prevalence
Logic	Instrumentality	Appropriateness	Orthodoxy
Basis of legitimacy	Legally sanctioned	Morally governed	Culturally supported

The regulative pillar of the institutional theory concerns the rules, regulations, and laws that uphold order and stability within a given institutional context. Regulative processes possess the capacity to establish rules and employ sanctions and rewards to oversee organizational behaviour. The normative pillar encompasses shared values and beliefs unique to a particular institutional context. Values represent conceptualizations of desired or preferred behaviour evaluated against existing structures, while norms specify how things ought to be done and delineate suitable objectives and goals for specific social roles. (Scott 1995.) For a company to thrive, its operations must align with local values and norms. The cultural-cognitive pillar reflects cognitive structures, including social knowledge, religion, and public recognition shared by individuals within a specific institutional setting (Meyer & Rowan 1977, 315). It entails shared beliefs regarding what is commonly accepted or taken for granted. Identifying these cultural-cognitive factors is often challenging as they are typically deeply ingrained within society (Scott 1995).

The forthcoming chapter delves into the examination of institutional pillars in the context of traceability, outlining on the elements of institutional influence and offering a comprehensive perspective on the identified drivers. With a focus on the European Union's pivotal role in shaping traceability regulation and incentives for textiles, the chapter explores both existing and upcoming initiatives especially within the EU region. Additionally, it underscores the evident establishment of internal drivers and objectives for traceability within the textile and apparel industry, including key stakeholders like brands and retailers. These internal drivers, classified as normative and cultural-cognitive drivers, are further explored in this chapter.

2.2.1 Regulative basis for traceability

The adoption of traceability solutions in the textile and apparel industry is significantly impacted by existing and emerging legislation. The diverse array of laws and regulations related to traceability is extensive, and continually changing, creating challenges in identifying the precise data businesses should collect to ensure transparency and the suitable methods for doing so. (Solita & Gaia Consulting 2022, 5-6.) Key regulatory categories such as due diligence, claims and labeling, and sustainability reporting are among the primary types guiding the implementation of traceability solutions, forming the framework around which companies should structure their strategies for gathering traceability data. (OECD 2022, 5-7.)

Yet, categorizing all laws together is not straightforward, as some may incorporate elements from various categories. The European Union, for instance, has instituted a European Committee for Standardization with the goal of standardizing a framework for establishing Eco-Design requirements for sustainable products and laying down rules to enhance the environmental sustainability of products. The regulations overseeing businesses in the textile and apparel industry depend on factors such as the manufacturing, and sales locations, criteria set by third-party retailers, and the scale of the company's operations. (TrusTrace 2023, 13-18.) Table 2 presents a summary of regulatory initiatives concerning traceability. The emphasis is on regulatory initiatives within the European Union, with country specific initiatives from the United States and France highlighted in blue. Additionally, a brief overview of data requirements for compliance with each regulation is provided.

Table 2: Regulative basis related to traceability (Modified from TrusTrace 2023; Solita & Gaia Consulting 2022)

Category	*Overview*	*Example laws*	*Data needs*
Due Diligence	Major brands and retailers must scrutinize their supply chains to evaluate potential risks to both people and the planet. Legal measures will hold companies responsible for any global abuses they may cause.	EU: Regulation prohibiting products made with forced labour in EU US: The Uyghur Forced Labor Prevention Act (UFLPA) EU: Corporate Sustainability Due Diligence Directive Proposal (CSDDD)	PO information on shipment, supply chain mapping, documentation pertaining to payment, production, and transportation, along with the country of origin for all suppliers, should be provided. Annual due diligence strategies and statements must be made publicly available.
Green claims and labelling	New guidelines aimed at combating "greenwashing" and deterring businesses from making inaccurate claims about the environmental advantages of their products and services	FR: The French Anti-Waste for a Circular Economy Law (AGEC) EU: Green Claims directive	Geographical traceability from Tier 1-3. Disclosure of the quantity of recycled material incorporated into the product, and its recyclability. Identification of hazardous chemicals and microfibers surpassing 50%.
Sustainability and reporting	Significant corporations and publicly traded companies will need to publicly disclose their strategies, accomplishments, and objectives concerning social and environmental matters	EU: Corporate Sustainability Reporting Directive Proposal (CSRDP) US: SEC Proposal for Climate Related Disclosure Rules	EU: CSRDP requirements and carbon emissions The environmental and social implications of the supply chain, encompassing Scope 3 emissions and wage considerations.
Eco-design and product specific cross-category	The proposal for Eco-design for Sustainable Products reflects the EU Commission's strategy for fostering more environmentally sustainable and circular products through regulation	EU: Eco-design for Sustainable Products (ESPR) - Including Digital Product Passport (DPP)	Durability, reparability, circularity, waste management, pollution control, carbon footprint reduction, avoidance of harmful substances, and the prevention of unsold goods destruction. Information on product lifecycle accessible to consumers within the DPP

As part of their due diligence, businesses are legally obligated to identify and mitigate social and/or environmental risks within their supply chains (Mejias et al. 2019, 145-148). Compliance with laws against forced labor necessitates the collection of country-of-origin documentation to demonstrate that goods are free from forced labor at any stage of the supply chain. This data must be gathered at the product shipment level, with specific farm locations potentially required by deforestation regulations (TrusTrace 2023, 18). Due diligence laws facilitate the attainment of social impact objectives, such as the establishment of living wages or improved working conditions (Mejias et al. 2019). An example of this is the US Uyghur Forced Labor Prevention Act (UFLPA), which supports the enforcement of the ban on importing goods into the United States entirely or partially manufactured with forced labor in the People's Republic of China, particularly from the Xinjiang Uyghur Autonomous Region, or Xinjiang. (US Customs and Border Protection 2023.)

A mere code of conduct is deemed insufficiently rigorous for achieving these objectives, making traceability solutions essential to demonstrate and visualize social impact performance (Kumar et al. 2017). Companies must be well-informed about their suppliers, possess information on employee salaries, and collaborate with factories to implement wage increases, thereby promoting living wages in their supply chains (TrusTrace 2023, 18). An example of such initiatives is the EU Corporate Sustainability Due Diligence Directive (CSDDD) proposal, which if adopted, would require companies to establish due diligence procedures to address adverse impacts of their actions on human rights and the environment, including along their value chains worldwide (European Commission 2023).

Under the ongoing development of the EU Green Claims Directive, companies are mandated to substantiate any environmental or social assertions with credible and relevant evidence, adhering to regulations governing product claims and labeling. To initiate the collection of comprehensive data, ranging from high-level information to detailed insights about the product life cycle—including environmental score, circularity, traceability, and other sustainability data—the implementation of a traceability solution is necessary. (TrusTrace 2023, 18-19.) The primary objective of the Green Claims Directive is to combat greenwashing and assist consumers in making more credible and trustworthy consumption decisions based on product labeling and green marketing claims (European Commission 2023).

An example of a country specific initiative towards standardizing green claims and labelling, the French Anti-waste for a Circular Economy Law (AGEC) provides guidelines for product labelling, used textile collection, boosting extended product responsibility as well as prohibiting the destruction of unsold items. However, what is most relevant regarding traceability implementation is that it obligates a display of environmental properties, origin and characteristics of every product sold within the French market. In this context, environmental properties refer to the presence of recycled materials in composition, recyclability, the use of renewable resources as well as possible presence of hazardous substances. (Diemer et al. 2022.)

Another set of information needs to be displayed on environmental and social rating (Cura et al. 2022). The rating information will indicate the environmental and social impact of a product. This information will be made available and public through labelling, marking or other digital means. Currently, freedom is given to choose a medium for communication of such product data, however, a common criterion determining the environmental properties and characteristics of products will be provided. In addition, such criterion will also specify the product categories that are included in AGEC and outline the methods for delivering such information. (European Union 2023.)

The proposal of EU Corporate Sustainability Directive drives the implementation of mandatory reporting under the European Sustainability Reporting Standards (ESRS) and audit of sustainability information within the EU area (European Commission 2023). Examples of similar initiatives can be noted from the US with companies preparing for the SEC Climate Disclosure Act, and tracking the proposed New York Fashion Act, California Climate Corporate Data Accountability Act and Climate Related Financial Risk Act, which would require publicly traded companies to disclose information about climate-related financial and environmental risks and improve corporate transparency related to climate risk for investors. (McKinsey 2022.)

In 2022, the European Union introduced a legislative initiative, currently in preparation, which involves the proposed Eco-design for Sustainable Products Regulation (ESPR). This regulation aims to create a comprehensive framework for designing, labeling, and reporting on sustainable products, encompassing requirements such as material origin. (Cura et al. 2022.) It serves as a universal foundation for mitigating adverse environmental impacts throughout the lifecycles of products, expanding beyond the existing Eco-

design Directive, which primarily focuses on energy-related products (European Commission 2022).

The ESPR places emphasis on two distinct categories of requirements: performance and information. Performance requirements dictate the design aspects of products, covering energy efficiency, durability, recyclability, environmental impact, and waste generation. Information requirements pertain to specific details of product performance, guiding the presentation of this information through product manuals, labeling, or product passports. (Cura et al. 2022, 34.) Regarding product passports, the ESPR will outline general, product-specific regulatory guidelines for necessary information inclusion. The general criteria encompass rules related to the interoperability and accessibility of various data points, along with roles and responsibilities for maintaining the data contained in product passports. (European Commission 2022.)

For a product falling under the ESPR to enter the EU internal market, it must be accompanied by a product passport containing all the necessary data points outlined in the ESPR. In this context, a concept gaining traction on the political agenda is the development of a Digital Product Passport (DPP) (Cura et al. 2022, 34). According to Adirson et al. (2021) findings, the DPP is anticipated to be a crucial new tool, providing a holistic and comprehensive view for recording, and tracing the sustainability performance of products. The initial design of the DPP envisions a passport-like function that consolidates all product-related information in one place, compiled by all stakeholders in the textile and apparel value chain. (Adirson et al. 2021, 1-2.)

A key objective of the DPP is to provide consistent track and trace information regarding the origin of materials, composition, repair options, disassembly options, and end-of-life handling for a product. The DPP aims not only to encourage the adoption of a circular economy and facilitate the transition to a more low-carbon future but also to address the existing challenge stemming from insufficient product information. (Solita et al. 2022.) Consequently, the DPP holds significant potential in furnishing essential product-related information to various stakeholders in the textile and apparel value chain, including consumers, tax officials, suppliers, and waste management companies. This information can be instrumental in advancing circular economy initiatives, influencing decision-making in sustainable development, such as guiding informed consumer choices during purchas-

ing and usage, and assisting waste management companies in informed decisions regarding disassembly and recycling processes. (Adirson et al. 2021, 2; European Commission 2022.)

Although the DPP shows promise in enhancing transparency and traceability, a universally accepted and consistent practical framework for its implementation is lacking. As a result, there are no clear political initiatives detailing the specific impacts of the DPP on stakeholders across the textile value chain. (Adirson et al. 2021, 2.) In the absence of established governing bodies to define the implementation of a universally accepted DPP, some countries have taken the initiative to create their own legislative frameworks with the aim of enhancing product traceability and transparency (Diemer et al. 2022). An illustrative example is the French Anti-waste for a Circular Economy Law (AGEC), designed to accelerate the transformation of production and consumption models, minimizing waste, and preserving natural resources, climate, and biodiversity. The AGEC law is specifically applied to the textile and apparel industry, encompassing clothing, linen, and footwear products, and seeks to enforce a variety of methods and guidelines to regulate sustainable textile production within the French market. (European Commission 2022.)

2.2.2 Normative drivers for traceability

Normative influences arise from values and conceptions of the desired or preferred behaviour within a specific context (Scott, 1995). In the scope of this thesis, normative influences are sought from industry specific guidelines and standards that have been set to guide the implementation of traceability practices. An overview of identified normative drivers found in literature are presented in Table 3 and described in more detail below.

Table 3: Normative drivers for traceability

Normative drivers	***Indicators***	***Basis of legitimacy***
ISO norms & quality management systems (QMS)	Verification	Morally supported
Prevention of counterfeit goods	Substantiation	Morally governed
Involvement of peers	Accreditation	Morally supported
Blockchain technology	Verification	Morally supported
Pursuit of network disintermediation and interoperability	Accreditation	Morally supported
Media	Accreditation	Morally governed

Garcia-Torres et al. (2022) raise ISO norms and quality systems as key drivers in traceability implementation, in alignment with the standards observed in more advanced sectors, particularly concerning traceability, such as the food or pharmaceutical industries (Torres et al. 2022, 358; Olsen & Borit 2013, 3). ISO norms aim to provide companies with general principles and fundamental criteria for designing and implementing traceability systems, including standardized guidelines for tracing the flow of materials, identifying necessary documentation, and tracking for each stage of production, ensuring effective coordination among involved parties as well as mandating that each party is informed of at least their direct suppliers. (ISO 2023.)

A Quality Management System (QMS) centres on attaining results concerning quality objectives to meet customer needs and expectations. The International Organization for Standardization (ISO) formulated the ISO 9001 series to establish a unified framework for quality management requirements. Additionally, in a benchmarking study of global food companies, it was discovered that most food processors prioritize safety prevention through quality assurance (QA) systems, which encompasses traceability. (Van der Vorst 2006.) Thus, quality management systems can be stated as normative drivers for traceability implementation as they are based on company needs rather than meeting mandatory requirements (Manning & Baines 2004).

Another significant and recurring normative driver promoting traceability in the textile and apparel industry is the imperative to mitigate the prevalence of counterfeit goods (Garcia-Torres et al. 2021). This concern is particularly shared among luxury and high-end brands, as they bear substantial impacts from this issue. According to a study conducted by Moretto and Macchion (2022), the financial losses resulting from the sale of counterfeit products were estimated to constitute 10 percent of their total revenue. (Moretto & Macchion 2022, 1477-1478.) For high-end brands with extensive and deeply rooted histories of producing goods within a specific country, it is also in the interest of governments to support the "Made in" labels with governmental assistance in implementing traceability solutions. Traceability plays a pivotal role in addressing the counterfeit issue, as tracing the origin of a specific product back to its assembly and material production is the only way to provide evidence that it is indeed manufactured by the labelled brand. (Moretto & Macchion 2022, 1478-1479.)

The involvement of other participants in the supply chain has been partially explored in existing literature as a factor influencing the implementation of traceability solutions. The logistics industry has been a focal point in the literature, identifying multiple early adopters driven by the desire to enhance visibility, and establish trust by sharing data among various supply chain participants. In many industries, particularly in fashion and apparel, openly sharing data among industry players has been challenging due to a lack of trust among them. (Moretto & Macchion 2022, 1478-1479.)

Furthermore, some scholars suggest that the adoption of blockchain technology has the potential to address the trust issue within the industry and act as a catalyst for enhancing traceability (Moretto & Macchion 2022; Agrawal et al. 2021). Moretto & Macchion's study (2022) posits that blockchain technology can fundamentally establish trust within a system, preventing individual actors from exploiting or manipulating the system for their personal gain. The essence of blockchain aligns with other traceability solutions, where trust is not necessarily established by verifying every data input in the software. (Agrawal et al. 2021). Instead, each participant takes responsibility for the reported data. The concept is that, with blockchain, collected and controlled data is shared among multiple companies, and each company cryptographically signs data inputs in their information system, taking ownership of the reported information and rendering incorrect data modifications impossible (Moretto & Macchion 2022, 1478).

Other normative drivers identified include the pursuit of network disintermediation and the establishment of common communication layers across all levels of the value chain. The common objective is to create a framework in which companies openly share data about products and production practices, aiming to achieve interoperability among recorded and shared data. (Garcia-Torres et al. 2021, 358.) Many companies have expressed interest in utilizing traceability to cultivate best practices throughout the value chain (Moretto & Macchion 2022). In the case of textile and apparel companies, traceability can be employed to advocate ethical practices among suppliers, validating their ethical performance through the provision of adequate data. When downstream pressure to act responsibly and the demand to showcase performance data align, the adoption of best practices permeates through the entire value chain. (Garcia-Torres et al. 2021, 358.)

The influence of media on companies' inclination to embrace traceability systems has been acknowledged. According to Stranieri et al. (2018), companies consider social pressure to conform to norms significant, given that the media holds considerable power to expose and shame unethical behaviour. Additionally, the media has been recognized as a tool capable of effectively bolstering a company's reputation, with the implementation of voluntary traceability systems serving as a positive enhancement in this regard. (Stranieri et al. 2018, 51.)

2.2.3 Cultural-cognitive drivers for traceability

Numerous textile and apparel companies have openly pledged to mitigate the environmental and social impacts of their operations through ESG (Environmental, Social, and Governance) initiatives. Achieving these objectives requires the crucial implementation of effective traceability solutions and commitment to set targets for adequate traceability implementation. (TrusTrace 2023, 8-12.) These commitments function as cultural-cognitive drivers for traceability, emerging from the company's internal objectives and decision-making processes, thereby aligning with the specific culture of each company. An overview of identified cultural-cognitive drivers is presented in Table 4 and further discussed below.

Table 4: Cultural-Cognitive drivers for traceability

Cultural-cognitive drivers	***Indication***	***Basis of legitimacy***
Commitment toward sustainable materials	Prevalence	Culturally supported
Commitment to emission reduction	Prevalence	Culturally supported
Commitment to circularity	Prevalence	Culturally supported
Pursuit of competitive advantage	Accreditation	Culturally supported
Customer demand	Accreditation	Culturally supported

Demonstration of a cultural-cognitive driver to implement traceability can be noted in commitments towards the use of sustainable materials. Companies that have pledged to increase the overall proportion of recycled, natural, or preferred materials in their product

range must be cognizant of the sourcing origins of their materials. (Textile Exchange 2023.) For instance, when a company endeavors to transition from using virgin cotton to recycled cotton, it must gather tangible evidence to validate that the sourced cotton is genuinely certified and recycled. As the establishment of requisite certification and verification processes is time and resource-intensive, companies with a strong inclination to incorporate such materials into their product offerings need to actively collaborate with their suppliers to facilitate the process. (TrusTrace 2023, 12.) In this context, social impact objectives also become significant. To guarantee the responsible sourcing of materials, such as cotton fibers, companies must confirm that their suppliers adhere to human rights standards and advocate for fair and safe working conditions. The crucial step in attaining this objective involves a meticulous examination of data pertaining to social practices and their impact. (TrusTrace 2023, 12-13.)

Another catalyst of drivers for traceability is the company specific commitment to reducing emissions. Companies with comprehensive emission reduction strategies aligned with science-based targets require a traceability solution to pinpoint precise locations within their supply chain where significant environmental impact is being mitigated. The analysis of data obtained through a traceability system is the only means by which an efficient and focused strategy for reducing emissions can be formulated. (TrusTrace 2023, 12-13.) To verify actions and commitments to environmentally friendly practices, companies need performance data extracted directly from water, energy, and waste consumption, which they can confidently and publicly act upon. It is essential that the collected data, through increased transparency and precise traceability, aligns with industry standards such as the Greenhouse Gas (GHG) Protocol, Global Reporting Initiative (GRI), and the Carbon Disclosure Project (CDP) as these standards are widely used for monitoring emission generation. (European Commission 2023.)

Promoting circularity has also been identified to serve as a cultural-cognitive driver for traceability. Businesses committed to establishing systems for repair, recycling, or resale should gather relevant information on the goods and materials returned to their system. This information should encompass details such as the number of recycled products, the frequency of repairs, and statistics on resale activity. By collecting such data, businesses can assess the success of their circularity initiatives and channel their efforts into the most effective programs. For example, information on repairs enables businesses to design and

produce more durable and long-lasting products. (TrusTrace 2023.) Facilitation of circularity through traceability is also linked to verifying the use of sustainable materials in products. When claiming, for instance, that a certain percentage of components in products are made from recycled materials, a traceability framework must be in place to verify the origin of such materials (Henninger 2015, 6026). Traceability, in this case, involves either tracing and verifying recycled materials as recyclable by the material producer or having the retailer brand trace backward through the product's value chain. Regardless, any claim related to circularity or green initiatives must be adequately supported with relevant data collected through increased visibility in the product's value chain. (Johansson & Månsson 2013, 25.)

It has also been argued that traceability has emerged as a significant component of competitive advantage for companies. It has been suggested that consumers desire knowledge about the history of the products they purchase. Studies have provided industry examples to illustrate the marketing and competitive advantage aspects of improved traceability and traceability's contribution to gaining a competitive edge. (Özkan et al. 2021, 4-5.) Ultimately, traceability can be viewed as a compelling business proposition for companies, as its implementation serves as a tool to gain immediate insights into the movement of materials throughout the supply chain. Companies can leverage this valuable information to enhance their business operations (Shih & Agrafiotis 2015, 1035.) By collecting, analyzing, and utilizing primary data across the value chain, companies gain access to information that not only improves their understanding of the environmental and social implications of their operations but also enables the elimination of inefficiencies, unnecessary expenses, and waste. This sets the stage for a more agile, productive, and strategic business approach. (TrusTrace 2023, 13.)

Companies have indicated their willingness to adopt traceability practices in response to customer demands. Companies intend to improve transparency in their operations as consumers are increasingly demanding disclosure of factors such as the origin of materials, environmental impacts, social factors such as well-being of employees. (Kozlowski et al. 2012, 20-23.) A growing number of conscientious consumers show a strong interest in purchasing from transparent companies. Hence, companies are eager to showcase the authenticity, quality, and features of their products to meet these consumers' expectations. (Henninger 2015, 6012.) In addressing the previously mentioned issue of counterfeit products, traceability facilitates comprehensive tracking of products throughout their

global distribution process, ensuring the authenticity of products available in stores (Moretto & Macchion 2022, 1477). Key companies underscore the importance of leveraging traceability to reinforce the narrative and validate the history of their products. This perspective aligns with similar discussions found in the literature on food products. (Henninger 2015, 6010.) Having defined the key institutional drivers for traceability, the following chapter will explore the intricate flow of traceability data, aiming to enhance comprehension of tools and solutions that facilitate the collection, storage, and exchange of traceability data.

2.3 Engaging in traceability solutions that foster value

According to a study by TrusTrace (2022), it is estimated that 95 percent of existing supply chain data is recorded on outdated systems and distributed via vague e-mail threads, excel sheets and paper records. This poses problems in attaining necessary data, accurately and on a timely basis as well as in a standard comparative and trustworthy form. Moreover, in the existence of no data standards being followed across the industry, collecting, storing, and managing traceability data is challenging and incoherent. In addition to this, the technology level, and tools for collecting, storing, and communicating traceability data varies which poses difficulties in implementing solutions that would encourage and drive collaborative interoperability between the industry's players. (TrusTrace 2023, 37-38.) In this section, some existing traceability data collection, storage, and exchange methods are introduced in more detail, demonstrating how traceability is currently implemented in practice within the textile and apparel industry.

2.3.1 Data in the value chain

Transparency and traceability are viewed as crucial elements for validating sustainability performance, with high-quality data recognized as a fundamental factor in facilitating these aspects. To prevent greenwashing and ensure credibility, companies must not only comply with certifications and regulations but also establish traceability to support the environmental and social claims about their products. However, it is important to note that transparency alone does not guarantee sustainability; it merely provides visibility into essential data on suppliers, making it easier to monitor and identify social and environmental issues. (Cura et al. 2022, 18.) In the context of the textile and apparel value chain, relevant traceability data is considered information that is generated, collected, and shared

among members of the textile value chain. This data is produced throughout various stages of the value chain, including product development and design; supplier selection, sourcing, and production; distribution and retail; transaction and sales; and customer service. (Gereffi & Frederick 2010.) The traceability data generated during key value chain steps is presented in Table 5, along with an indication of the primary stakeholders who primarily utilize this data.

Table 5: Data generated through textile and apparel value chain. (Modified from Cura et. al 2022, 19; Nokelainen et. al 2022, 27-28)

Value Chain Processes	Generated Data	Availability in existing and registered systems	Data used by
Product development & design	Product data: type, ID, measures, raw material composition: material, virgin/ recycled Chemicals: Hazardous and non-hazardous Safety: CE markings	Enterprise systems GS1 SCIP- Chemicals	Textile designers, trend forecasters, and product development unit
Supplier selection, sourcing & production	Actor data: Trade ID, Trade name, location, function Production: batch, date, environmental and social impact of production, safety of chemicals circularity, waste volumes, and deforestation.	European Business Register, national business registers Enterprise systems SCIP- Chemicals	Production planners, sourcing department, warehouses, auditors, textile designers, and inventory managers
Distribution & retail	Production & sales volumes, Shipping data Carbon emissions data Responsible tax strategy	Enterprise systems External sustainability reports	Logistics unit, inventory managers, retailers, data analysts, marketing unit, and business analysts
Transaction, sales & customer service	Rental: Location, composition Resale: Location, composition, origin Repair/maintenance: Composition Recycling: Composition, type of waste	Enterprise systems External SaaS/ B2C platforms for resale, rental, and repair	End-consumers, data analysts, retailers, product developers, recyclers, and trend forecasters

Product development and design data refers to information crucial for aiding the creation of specific product designs and manuals for suppliers to adhere to during production. This

data is also shared across the value chain, where other partners utilize it in subsequent steps (Nokelainen et al. 2022, 19). Recording data on product composition proves beneficial, particularly in the end-of-life processing of garments. Recyclers and sorters leverage this data to efficiently disassemble garments or direct them to the appropriate recycling processes. Additionally, having insight into the chemicals used in the production of raw materials is essential, as some may be harmful, necessitating avoidance in certain end-of-life solutions. Data generated by raw material suppliers is typically documented in enterprise systems that monitor individual steps in the production process. (Cura et al. 2022, 18-19; Nokelainen et al. 2022, 27-28.)

The process of selecting and sourcing suppliers is a crucial phase in the garment value chain. The data generated at this stage encompasses information about various suppliers engaged in the supply chain. Supplier data includes both actor-related information, such as facility location, trade ID, and function, obtainable from national and continental business registers, as well as production data provided by the suppliers themselves. The production data must align with the data requirements set by the commissioning brand, as specified during the product design phase. For instance, if a brand intends to assert that a product is made from 50 percent of recycled materials, this information must be traceable throughout all stages of the production process, particularly regarding material composition. (Nokelainen et al. 2022, 26-28.) Furthermore, if a brand has established targets related to monitoring policy commitments, human rights processes, and environmental aspects such as waste volumes, circularity, chemical usage, deforestation, or carbon emissions within the supply chain, relevant data on these topics must be collected and displayed throughout the production process. (Fashion Transparency Index 2023, 8.) A positive trend in the industry involves major brands increasingly disclosing their first-tier supplier lists, either in company sustainability reports or on open databases like the Open Supplier Hub (TrusTrace 2023).

Concerning product distribution and retail, traceability data must be gathered from selected logistics partners to calculate carbon emissions associated with the distribution process of a product. Furthermore, many companies are focused on ensuring a responsible tax strategy, as the common practice among several fashion brands involves exploiting tax loopholes and tax havens to maximize profits while avoiding contributions to the communities in which they operate. (Fashion Transparency Index 2023, 9-10.) For in-

stance, some brands take advantage of tax benefits by shipping products directly to consumers from China. In the United States, the minimum customs rule allows Chinese producers to ship products valued below $800 directly to consumers, enabling them to bypass U.S. tariffs, taxes, and oversight. Consequently, brands utilizing direct-to-consumer (D2C) models can circumvent taxes and operate beyond the scope of regulations related to forced labor. (Fashion Transparency Index 2023, 10.)

While forthcoming legislation aims to tackle the problem of textile waste, the industry remains deeply concerned about the substantial evidence of overproduction. It is crucial to note, as highlighted in Fashion Revolution's Transparency Index 2023, that 88 percent of brands do not disclose their annual production volumes, nor do they commit to reducing the number of new items they produce. This pervasive issue relates to data regarding transaction, sales, and customer service, and continues to be the elephant in the room within the industry without further disclosure. Without enhanced transparency and improved data collection on overproduction and overconsumption, there is no assurance that brands are effectively collecting data on impacts and addressing global inequality and the climate crisis. (Fashion Transparency Index 2023, 8-12.)

Comprehensive product data regarding material origins and product components can also be leveraged in various stages of the product's lifecycle, including resale, renting, maintenance, repair, and recycling functions. This data enables end-users to share sufficient information on second-hand platforms and offer repair instructions for products that anyone can fix. When the life cycle length of similar products can be measured, appropriate traceability data could provide a real-time estimate of how long the product should last and suggest methods to prolong its lifecycle. (Nokelainen et al. 2022, 41.) As per the Fashion Revolution's annual Fashion Transparency Index (2023), major fashion brands predominantly reveal details about their policies, commitments, and processes concerning human rights and environmental matters. However, there is notably less disclosure about the results, outcomes, and impacts of these initiatives. Areas that receive the least disclosure pertain to issues like social auditing, living wages, purchasing practices, gender and racial inequity, circularity, and chemical use in the supply chain. (Fashion Transparency Index 2023, 8-12.) The next chapter will delve into tools that aid in the collection of traceability data, providing more detailed information on the subject.

2.3.2 Data collection

The ISO 9001 checklist outlines three fundamental requirements for product traceability: "(1) traceability solutions must establish the identity and status of a product, (2) maintain the identity and status for products, and (3) maintain a record of serial and/or batch numbers" (ISO 9001 2023). These criteria provide the foundation for the functionalities of various technological solutions designed to facilitate the management of traceability data. For all traceability solutions, it is crucial to first establish the parameters for defining and tracking the unit of traceability throughout the supply chain to achieve the required level of traceability. Defining the traceable object is not a straightforward process, as it varies depending on the nature of the traced product and its manufacturing process. (Ahmed & McCarthy 2021, 17-18.)

In discussions about identifying a traceable unit, the determination of the level of granularity in the value chain is a key consideration. This involves the vertical dimensions of traceability, where granularity is defined by " different levels of traceable units and is determined by the size of a traceable unit and the number of the smallest traceable units necessary to make up the traceable unit at a specific granularity level" (Karlsen et al. 2012, 79). Establishing the appropriate level of granularity is crucial, as higher levels of granularity may lead to the implementation of overly complex traceability solutions and incur expensive costs (Cura et al. 2022). For example, using 1000 kg of cotton as a traceable token does not account for the batch level or garment level, as the physical product and digital tokens at these levels of granularity are not interconnected. This lack of connectivity poses significant challenges when extending the traceability approach to the garment level, particularly in intricate and high-volume apparel supply networks. (Ahmed & MacCarthy 2021.)

Traceability data is typically collected through barcodes, labels, and various embedded tracers, also referred to as markers, serving as data carriers (Fashion for Good 2022). These tracers exemplify object identification technologies and are commonly employed not only to authenticate textile material or a product but also for tracking and tracing purposes (Cura et al. 2022, 27). Physical materials or products can be linked to digital traceability software using a digital twin. Barcodes and QR labels, physical tags affixed to a product or its packaging, can be printed, embroidered, or woven onto or into a garment. These tags are commonly referred to additive tracers and generally offer consumers

information about a product's origin, raw materials and composition, production processes and locations, chemicals used, sustainability certifications, and more.

Alternatively, NFC chips and RFID tags provide alternative solutions for data collection, often utilized in commercial shipping and logistics, typically attached to larger packaging units like pallets. An RFID tag can also be embedded into a thread during manufacturing, which is subsequently integrated into a garment. Embedded markers, commonly referred to as forensic tracers as defined, are physical additives that can be incorporated into yarn during the spinning process. DNA markers are applied to or within raw materials, yarn, or fabric. Isotope markers, being natural markers in the material, can be analysed to reveal the location of cotton. This is because ratios of stable isotopes in cotton fibers indicate different regions, allowing them to be used to authenticate the origin of cotton. (Cura et al. 2022, 25-26.)

The utilization of scope and transaction certificates provides another method for collecting traceability data, by demonstrating and validating the paperwork collected during the exchange of goods within the product's supply chain (Retraced 2023). Established scope standards, such as the Global Organic Textile Standard (GOTS) or the Organic Content Standard (OCS), validate the entire supply chain or the process of verifying materials. The presence of their logo on a product indicates that all companies involved in the supply chain adhere to the standard's requirements, possess a valid Scope Certificate, and each order for creating the product is supported by a verified Transaction Certificate. For instance, with GOTS certification, consumers can trust that a product labelled with GOTS is genuinely made of GOTS-certified cotton. (Textile Exchange 2023.)

For a product to feature the logo of a Scope Standard like GOTS, every company in the supply chain handling the verified material must hold a valid Scope Certificate. Additionally, the product-selling company must provide evidence of a transaction certificate and link it to the specific product. (Retraced 2023.) Transaction certificates and eTransactions, on the other hand, function as official documents issued by a certification body to validate that products are sold or shipped from one organization to another. The recipients of these products can confidently regard them as materials meeting the specified claims. These certificates contain crucial details about the seller, buyer, shipments, products, and the quantity of certified material utilized in the products. The transaction certificate originates from the certification body's system, and disseminated as physical copies, which are then

passed from one party to another along the supply chain. It is essential to verify each transaction certificate against the certification body's system to ensure its validity. (Textile Exchange 2023.) In the following chapter, traceability data storage and communication tools are observed in more detail.

2.3.3 Data storage and communication through solution providers

Data generated throughout the textile value chain can be stored using various data storage systems, such as centralized, decentralized, and distributed systems. In a centralized system, a single computer or server, typically owned by a single entity, is employed. On the other hand, decentralized storage systems may be hosted in clouds with multiple owners (servers), ensuring data duplication across all of them. In both centralized and decentralized systems, data can be stored in various formats, including spreadsheets, ERP (enterprise resource planning), PLM (product lifecycle management), PO (purchase order) systems, and software. In today's textile industry, data storage tools mainly concern production systems and are not specifically tailored for gathering and storing sustainability data. This leads to compatibility issues with technology solutions for managing sustainability data. (Cura et al. 2022, 29-30.) During the initial phases of developing and implementing a Digital Product Passport, as recommended by the European Commission, decentralized data storage systems are considered as the preferable option. Blockchain-based technologies serve as illustrative examples of distributed systems. (Solita et al. 2022.)

The exchange and communication of traceability data represent a crucial step that adds value to all efforts in collecting and storing such data. Effective communication should encompass every stage and Tier of the supply chain, extending to practices like reuse, repair, rental, and recycling. (Cura et al. 2022.) In recent years, there has been a significant surge in innovative traceability solutions to meet the growing demand for scaling sustainability and addressing industry requirements. The primary focus of traceability innovation landscape lies in the form of Software as a Service (SaaS) digital platforms. (Fashion for Good 2022.) These platforms effectively map, trace, verify, and communicate information related to suppliers, materials, environmental and social impact, as well as ESG credentials throughout the product lifecycle. The traceability innovation landscape includes multiple solution providers that concentrate on different aspects of traceability. (Cura et al. 2022.) Commonly existing solutions can be categorized into three main

groups, as illustrated in Figure 3: digital platforms, social innovation, and physical tracer technologies (briefly introduced in Chapter 2.3.2).

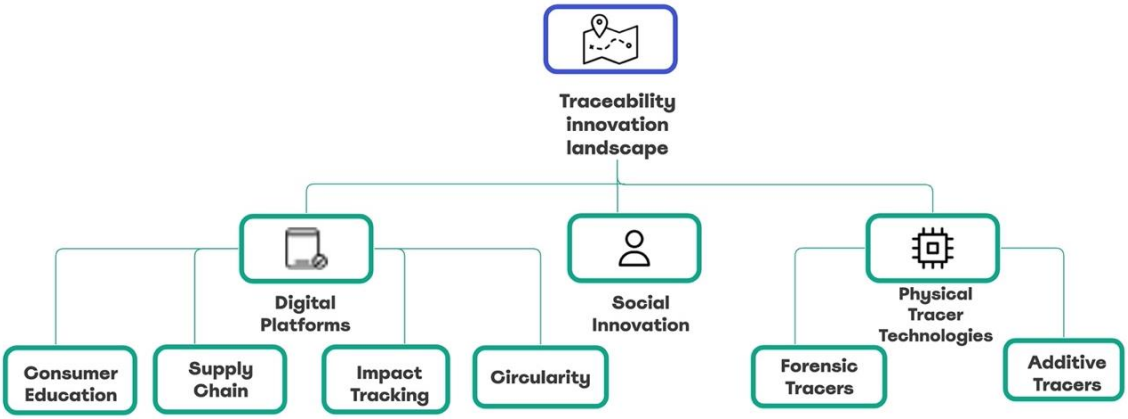

Figure 3: Transparency and traceability innovation landscape (Modified from Fashion for Good 2022)

Traceability platforms aim to compile and verify paperwork related to the chain of custody while providing data integrity and system validation for material and product certification, such as Textile Exchange's certification standards (Textile Exchange 2023). This includes sustainability requirements related to processes, scope certificates, and transactional certificates. These platforms are also utilized to enhance visibility and digitization of data points related to products, suppliers, the environment, and social aspects. They facilitate the creation of profiles for facilities, provide batch and product traceability, and enable API interaction with the internal systems of suppliers and brands. Commonly, existing solution providers are blockchain or cloud-based, offering visualization and supply chain mapping tools that typically cover up to Tier 1 to 4. (TrusTrace 2023, 39.)

A key distinguishing factor among traceability platform providers is whether the traceability solution is oriented towards a fiber-forward or garment-backward approach. Service providers with fiber-forward capabilities can generate real-time and secure digital identities concurrently with the movement of commodities. Alternatively, a more traditional approach involves mapping the supply chain starting with the finished garment and working backward in the value chain. (Ahmed & McCarthy 2021.)

An alternative category of traceability solution providers offers impact trackers, which are digital solutions utilizing primary data from suppliers to measure various indicators

such as carbon emissions, water and energy consumption, land use, and biodiversity impact (Fashion for Good 2022). Using these trackers, companies can enhance visibility and control over their impact hotspots, meeting the requirements of the Product Environmental Footprint (PEF) as part of the EU's Green Products Initiative (European Commission 2022). This empowers them to pinpoint specific areas for emission reduction and prioritize actions that will effectively reduce their overall carbon footprint. Impact tracers are specifically designed to measure the indirect environmental impacts of a company, originating from its suppliers, customers, and transportation activities. These emissions are often more challenging to trace, and control compared to a company's direct Scope 1 and Scope 2 emissions[2], even though they may constitute a significant portion of the company's total carbon footprint. (TrusTrace 2023, 39-40.)

Another focal area for traceability platform providers is monitoring circularity performance (Ahmed & McCarthy 2021). Circularity platforms for waste mapping are digital solutions utilizing blockchain and/or cloud-based technologies, aiming to map the textile waste supply for efficient systems in collection, classification, and recycling (Fashion for Good 2022). These digital systems enable data analytics, offering insights into the quantities, types, and locations of waste flows. Clearly defining waste availability and identifying pertinent institutional contacts are crucial steps to establish connections between waste supply and demand in the textile industry. (TrusTrace 2023, 40.)

An array of social innovation platforms such as mobile applications has emerged to assess the sustainability of fashion brands, enhancing consumer awareness regarding the sustainability performance of brands and products. These social innovation platforms employ rating systems that combines diverse standards, certifications, and publicly available data to generate comprehensive scores. (Fashion for Good 2022; TrusTrace 2023, 41.) This methodology fosters transparency within the fashion industry, empowering consumers to stay well-versed about the ethical and sustainable attributes of brands. Consequently, consumers can make conscious purchasing decisions based on the information

[2] Relevant literature uses term “scope 1 emissions” to describe direct emissions that are owned or controlled by a company, whereas “scope 2 and 3 indirect emissions” result from the company's activities but emanate from sources outside its ownership or control.

provided. (Henninger 2015, 6025.) These consumer engagement platforms hold the potential to integrate with Digital Product Passport solutions in the future, potentially linking brand performance ratings with product impacts (TrusTrace 2023, 41).

Physical tracer technologies present an innovative and distinct approach to traceability solutions, encompassing two subcategories known as additive tracers and forensic tracers. These are employed to trace and authenticate fibers and materials, elucidating their geographical origins (Cura et al. 2022, 25-26). Additive tracers involve applying physical additives to fibers and materials during the supply chain process or consumer engagement, with these additives being detectable later to provide proof of origin. Conversely, forensic tracers utilize technologies analyzing the micro-particle and biochemical composition of fibers and materials, establishing their origin through scientific examination. The increasing demand for physical tracer technologies can be attributed to forthcoming corporate due diligence legislation, compelling companies to demonstrate the geographic and supply chain origin of sourced fibers. (TrusTrace 2023, 40-41.)

Given the diverse scopes of existing traceability solutions, which vary based on the targeted business case and ESG (Environmental, Social, Governance) objectives, there is no singular traceability solution meeting all users' business and ESG needs. (Cura et al. 2022, 37.) Fashion companies are advised to adopt a collaborative portfolio of partners, considering a range of innovations. Through collaboration and information exchange, these partners can collectively strive toward achieving their goals (TrusTrace 2023). Transitioning from the discussion on traceability data flow, the subsequent chapter will explore the intersection of traceability and value creation, aiming to elucidate how scholars perceive a connection between these two concepts.

2.4 Traceability and value creation

From a strategic business administrative perspective, the process of implementing value chain traceability shares similarities with a digital transformation. Executing a traceability solution is a time-consuming endeavour that necessitates a well-thought-out strategy for incorporating necessary changes. The extensive array of existing traceability technologies and potential applications can be perplexing, causing delays in the implementation process within organizations. To facilitate organizations' crucial transition towards enhanced traceability, it is argued that creating a strategic framework, highlighting the value creating components aligned with strategic goals, is essential. This framework should provide

an understanding of how traceability expedites the journey toward achieving more sustainable outcomes while concurrently enhancing value-base long-term business results and overall competitiveness. (Betti et al. 2021, 3.) This section aims to shed light on how textile and apparel companies can construct a traceability framework to effectively assess industry regulatory requirements, meet customer expectations, take charge, and enhance the ability to create and facilitate value for their organization.

2.4.1 Components of value creation through traceability

Multiple research streams contribute to the comprehension of value creation in business and organizational context. It has been argued that the primary goal of all organizations is to generate value for their stakeholders (Cedergren & Larsson 2011, 1). Value creation can occur through diverse methods, and one such avenue is the development of new products. Most research endeavours to elaborate exactly how product attributes contribute to the specific value or utility of a product. In this context, 'value' is defined as a preferential judgment, while 'values' refer to the criteria influencing those judgments. (Holbrook 1994.) Conversely, Miles (1961) asserts that competition determines the path a company must take to ensure the value proposition in its goods or services. The producer's perception of 'value' differs from that of the user; in other words, for the same item, there are different types of value. (Miles 1961.) Additionally, marketers work to understand consumers' values, preferences, or beliefs, measure and categorize consumer lifestyles, and create various classifications (Cedergren & Larsson 2011, 2).

Relevant literature has given rise to two distinct research streams on value: (1) the evaluation of value of products, and (2) the value of buyer-seller relationships. These streams, in turn, propose diverse perspectives applicable to business contexts (Lindgreen & Wynstra 2005, 733). According to Kotler (2003), the success of a firm's market offering hinges on its ability to deliver value and satisfaction to prospective buyers. A buyer will make choices among available alternatives in the market based on their perception of which would deliver the highest value to them. (Kotler 2003.) In this scenario, competitive advantage arises from the capability to present target customers with an offer that embodies more perceived value than those of competitors. This perceived value comprises three elements: the perceived benefits of the product minus both the product price and the costs associated with ownership. (Doyle 2000; Kotler 2003.) However, companies engage in commerce not solely for the acquisition of value linked to goods or services

(Håkansson 1982; Reichheld 1996) but also to appreciate the appealing attributes of the offering, such as the supplier's reputation, location, or innovativeness. Scholars, emphasizing the value of buyer-seller relationships, assert that even future capabilities hold value; establishing a relationship with a capable supplier enables the buyer to initiate a connection that may eliminate the need to switch suppliers in the face of future market shifts. This form of relationship value transcends the tangible product or service being exchanged. (Håkansson 1982; Reichheld 1996.)

In the context of traceability, within textile and apparel value chains, various components contributing to value creation can take diverse forms. According to a 2021 study by Betti et al., companies employing existing traceability solutions use them to pursue a range of objectives closely tied to the performance of their value chains (Betti et al. 2021, 9). Primarily, for most companies, the key objective and value-generating element revolve around meeting regulatory requirements, given the emphasized potential sanctions for non-compliance associated with traceability (Betti et al. 2021, 3). Nevertheless, there is significant emphasis placed on ensuring the reliability and efficiency of the value chain.

Comprehensive traceability empowers companies with the capability to monitor products throughout the value chain and gather precise data regarding supplier sourcing, production, and input provenance. Armed with such data, companies can conduct scenario analyses, make predictions, and optimize their operations with heightened accuracy, taking a holistic view of their value chain. (Silva & Mattos 2019, 5-6.) Achieving cost and operational efficiency becomes feasible through the optimization of resource consumption, swift responses to external shocks and shifts in demand and supply, and improvements in order management. Moreover, companies can pinpoint valuable strategic opportunities within the value chain, expedite innovation, alleviate the impact of internal and external disruptions, ensure safety, and validate the sustainability of processes and products. (Betti et al. 2021, 5-6.)

The cumulative advantages arising from enhanced visibility, operational efficiency, and the exploration of new valuable strategic opportunities have been recognized as substantial value drivers for companies. These factors typically lead to increased revenue growth, reduced costs, expanded market share, and enhanced returns on investment. (Dessureault 2019, 18-19.) While supply chain management practices have traditionally prioritized re-

liability and efficiency as the primary objectives, there is an evolving imperative to transcend these conventional business goals. This shift aims to attain a competitive advantage and ensure the sustainability and resilience of value chains when confronted with global shocks or disruptions. Moreover, additional value is discerned in industry leaders who play a pivotal role in shaping and establishing traceability standards and regulations. Active participation in industry and national working groups underscores their proactive involvement in this regard. (Betti et al. 2021, 5-6.)

Conversely, companies neglecting investment in traceability implementation face heightened vulnerability to supply chain disruptions and potential allegations concerning product safety and provenance. A case in point is the incident involving a stranded 400-meter cargo ship blocking the Suez Canal in March 2021, causing significant disruptions in global supply chains. Companies with knowledge of their cargo ship movements were able to reroute shipments effectively, minimizing disruptions in distribution times and supplies. It was observed that those lacking visibility suffered the most severe consequences during this event. (Betti et al. 2021, 6-7.)

As an example of the value created through relationships, engaging with customers stands out as a significant value-creating component for many companies, particularly given the increasing external demands from consumers for the sustainability and circularity of textile and apparel products (Silva & Mattos 2019, 8; Dessureault 2019, 2-3). For companies striving to improve their circularity performance through practices like reusing, remanufacturing, or recycling products and materials, it becomes crucial to understand the ultimate destination of these items after the point of sale and use. Introducing a traceability solution that extends to the end-of-life of a product may lay the groundwork for new avenues of growth. Brands can contribute to their customers' comprehension of end-of-life solutions by transparently illustrating the lifecycle journey of a product from manufacturing to final disposal. This not only enhances engagement and trust between the consumer and the brand but also has the potential to foster long-term value for the company. (Betti et al. 2021, 3.)

Similarly, gaining visibility into current end-of-life processes can assist companies in preparing for the forthcoming European Union Extended Producer Responsibility (EPR) policy, which aims to shift a product's lifecycle costs, including design, take-back, recycling, and final disposal, to the producer. In this context, implementing a traceability solution

may generate value by helping map out current realities and, in turn, shedding light on future collaboration opportunities with recyclers, sorters, second-hand platforms, and other relevant players within the field. (European Commission 2023.) The upcoming chapter will explore the essential role of collaboration and partnerships in facilitating the efficient flow of traceability data and in scaling the implementation of traceability activities across textile and apparel value chains.

2.4.2 Prioritization of collaboration and partnerships

The imperative for unified efforts in expanding traceability implementation across textile and apparel value chains is apparent. In the textile and apparel industry, various stakeholders, including investors, media, and others involved in the textile value chains, must collaboratively work towards establishing collective standards and practices for collecting, storing, and sharing traceability data in a format that is functional for all parties. This underscores the inherent value derived from utilizing existing traceability solutions, as forging partnerships not only strengthens the competitive advantage of individual companies but also contributes to the growth of the community ecosystem. (Cura et al. 2022, 21-22.)

Policymakers play a crucial role as key enablers of innovation, ensuring that economic aspects align with business interests. While innovation is often associated with technology, there is a technological facet to textile innovation, encompassing the development of sustainable materials and innovative textile recycling methods. However, social innovation is equally crucial. (Cura et al. 2022, 42.) Policymakers need to establish appropriate rules, regulations, and universal frameworks that facilitate the expansion of traceable business models. This comprehensive approach ensures the success of traceability implementation within the textile industry. (Garcia-Torres et al. 2020, 358.)

In alignment with the above considerations, numerous companies recognize the paramount importance of collaborating with stakeholders and existing partners in the value chain to expand traceability (De Brito et al. 2008). However, there is often reluctance to establish robust alliances. One reason for such hesitancy is the unfamiliarity with collaborating with companies beyond their own business operations, including competitors. (Betti et al. 2021,13.) Industry-wide secrecy prevails, for instance, with brands being hesitant to openly disclose their suppliers, posing challenges in sharing Scope 2 and 3 data publicly. Nevertheless, with the advent of new technologies and the implementation

of appropriate platform models, cooperation can become more accessible and seamless both vertically among suppliers and horizontally with competitors. Additionally, co-creating standards for collaboration and developing high-impact traceability ecosystems can reduce costs for all involved players and incentivize dominant market leaders to contribute to the sharing of pertinent traceability data. (Cura et al. 2022.)

Involvement of the biggest players in the field, will serve as most crucial step in scaling traceability implementation and encourage smaller companies to participate (De Brito et al. 2008). Finally, various industry specific incentives can play a driving role in persuading suppliers to implement traceability data collection tools that for instance reward such companies for the disclosure of additional traceability data. An example of such incentive can be found from the seafood industry, where a blockchain based seafood traceability and data ecosystem incentivizes supply chain stakeholders to share data by receiving rewards in return for data disclosure. This ultimately allows seafood buyers to have better insight into product safety and quality. (Betti et al. 2021,13.)

In the future, it is expected that all companies will have similar access to existing traceability data. This is why each company should possess the adequate and effective tools to convert such traceability data into valuable insights and construct the necessary business processes to transform these insights into a competitive advantage. It is argued that companies that excel in creating the most effective value creation model, tied to traceability, will surpass their competition and be true market leaders within their operational field. (Betti et al. 2021.) However, the foundation of traceability implementation and collaboration relies on trust, and therefore it is necessary for each company to establish their role in the transformation process and to act according to their best ability towards the targets set to convince others about the development and possibilities for change. (Garcia-Torres et al. 2019, 91.)

2.4.3 Defining a value-based traceability strategy

A crucial initial step in implementing a traceability solution is establishing a traceability strategy. This strategy determines where tracing will yield the greatest value for the company, both presently and in the future. As suggested by the Betti et al. (2021), the traceability strategy is formulated through five maturing stages, each stage encompassing a distinct target and corresponding action point (Figure 4).

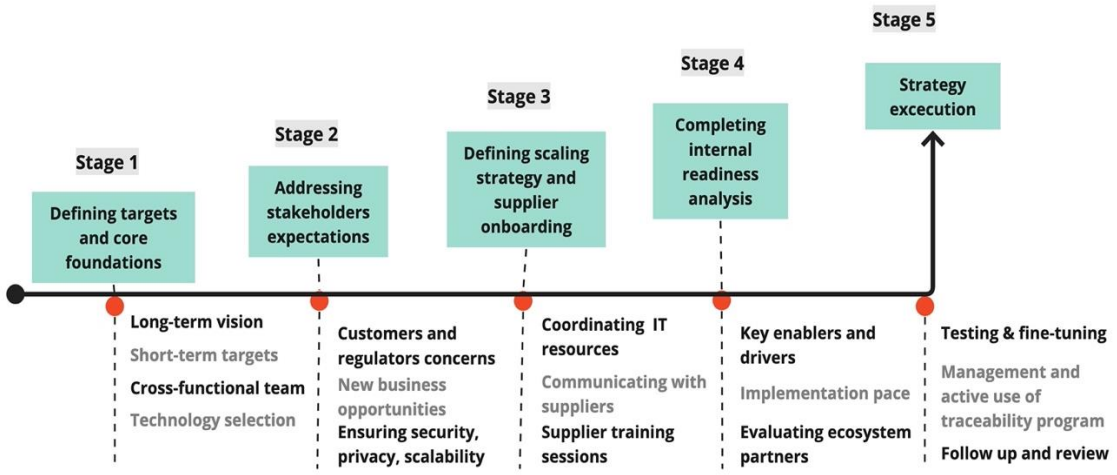

Figure 4: The maturation process of a traceability strategy, (revised from Betti et al. 2021)

The first stage of the traceability strategy includes an act of defining a vision, goals, needs, and milestones for traceability within a specific scope and timeframe or period (Kumar, et al. 2017, 10). Defining a traceability strategy necessitates cross-functional coordination throughout the entire value chain and involves creating a cross-functional core team responsible for launching and managing the traceability solution. The team should comprise experts from various business functions, such as marketing, sales, and communication, to ensure that the traceability solution adequately meets the targets and scopes of all functions. (Betti et al. 2021, 3-7.) There may also be a requirement to establish new internal team positions, focusing on areas such as policy advisory for supply chain legislation, traceability integrity for product certification, policy data, and circularity. (TrusTrace 2023, 45-46.)

Another critical step in developing a traceability implementation strategy involves choosing the appropriate foundational technology for sharing and hosting traceability data (Kumar et al. 2017, 10). This process requires prioritization, as each company must first determine the scope of their desired traceability coverage and classify their supply chain data into "obligatory data needs" and "non-obligatory data." Prioritization lays the groundwork for defining short-term traceability needs and long-term goals achievable through solutions provided by selected traceability service providers. (Betti et al. 2021, 3-7.) Based on business priorities for obligatory data needs, companies can decide to integrate a specific traceability platform that facilitates the collection of prioritized data.

This may encompass data points related to policy disclosure, material certifications, or impact tracking. (TrusTrace 2023, 42.)

By addressing crucial questions, leadership teams can prioritize the most essential traceability applications: What processes or product inputs are of utmost concern to current customers or regulators? How might the implementation of a circular value chain open new business opportunities and foster innovative business models? What new capabilities could provide a competitive edge in terms of unit economics, resilience, and sustainability? When deciding on a traceability solution, ensuring data security, privacy, and scalability of the technology across collaborations and various application domains are also vital considerations. (Kumar et al. 2017, 9-10.) It is imperative for the technology to seamlessly integrate with existing systems and be interoperable with both internal and external traceability systems. Fulfilling these requirements requires substantial investments, and partners will play a pivotal role in determining the most suitable approach. (Betti et al. 2021.)

Derived from a history of unsuccessful digital transformations, the most significant risk for companies is the potential trap of entering a pilot doom loop. While experimenting with new ideas is relatively straightforward, achieving transformation on a large-scale poses challenges. This complexity becomes particularly crucial when dealing with intricate, cross-functional subjects like traceability. To ensure success, it is essential to predefine the scaling strategy for each application area and initiative. (Betti et al. 2021.) Encouraging a multi-phase project plan is vital, as it allows the establishment of a phased approach with multiple goals to achieve. Commencing with an initial phase that focuses on attaining immediate accomplishments is crucial to prepare for broader levels of IT integration and higher expectations for outcomes. (TrusTrace, 2023, 46-47.) The path to successful traceability implementation often starts with a small-scale implementation, targeting a high-value application. This strategy enables companies to establish appropriate standards for data, technology, and collaboration while ensuring that every participant derives value from the effort. (Betti et al. 2021.)

In addition to defining the strategic context and potential value sources for traceability, leadership teams must assess the current capabilities of their suppliers and other partners in the value chain (Lambert & Cooper 2000, 67). This evaluation involves scrutinizing

the visibility of the value chain both upstream and downstream and identifying any existing gaps. Furthermore, it includes analysing the company's position relative to its competitors and determining whether suppliers or other partners in the value chain are already developing robust traceability applications. Reaching out to direct suppliers is necessary to investigate existing capabilities in generating traceability data and finding synergies in similar data formats and communication channels. When preparing for the initial rollout of a traceability program, engaging suppliers in training programs is essential to facilitate understanding of various suppliers' roles and responsibilities in terms of producing traceability data within their step in the value chain. Grouping suppliers based on the geographical location of their operations and value chain processes can be viewed as an effective way to enhance understanding and ensure effective participation in the traceability program rollout. (TrusTrace 2023, 46-49.)

Another crucial step in comprehending a company's starting point in a traceability transformation involves evaluating the key enablers and drivers for traceability (Kumar et al. 2017). Enablers primarily encompass the current operating model, cross-functional engagement, external collaborations, involvement in ecosystems, existing technology, data collection methods, as well as certifications. Naturally, an internal readiness analysis is necessary to ensure that a traceability strategy aligns with organizational capabilities. (Betti et al. 2021, 8.) Determining the necessary pace for traceability implementation can be achieved by assessing the company's current position and competitors' commitment to traceability. Identifying the pace for such a transformation aid in recognizing potential ecosystem partners and achieving a leading position within the industry if desired. (Betti et al. 2021, 7-8.) Most companies are still in the early stages of their traceability journey. Only fifteen percent have made progress in investing and scaling traceability technology, while twenty-two percent are still in the initial stage, grappling with strategy definition. (Betti et al. 2021.)

Finally, the concluding segment of the traceability implementation strategy execution encompasses testing, fine-tuning, active utilization, and the overall management and execution of the program. (Kumar et al. 2017, 2.) The testing and fine-tuning phase entail close collaboration with the solution provider to configure and, if possible, personalize the system in accordance with the company's priorities and traceability targets before extending its deployment to other value chain partners. Once the system is prepared for full-scale execution, active participation in program review meetings becomes essential

to address any identified problems or malfunctions in the solution. A close partnership with internal IT functions is a pivotal factor in ensuring the effective management and seamless transition of traceability data. (TrusTrace 2023, 46.) The upcoming chapter will introduce the initial framework of this study, providing a synopsis of the principal findings gleaned from the literature review concerning traceability and value creation.

2.5 Initial framework

This chapter summarizes the literature review to develop an initial theoretical framework for the study. The initial framework builds from the previously identified concepts around traceability and demonstrates the synergies between key drivers, traceability data flow in the through key action points and value-generating goals for traceability within textile and apparel value chains. To address the main research question, "how is value created through traceability within textile and apparel value chains", it is essential to gain a holistic understanding of the value generating components of traceability and the various factors that companies should be aware of when making the pivotal shift towards enhanced visibility of their value chains through traceability implementation. The initial framework (Figure 5) provides an understanding of the scope of traceability within the textile and apparel value chains and guides the following study.

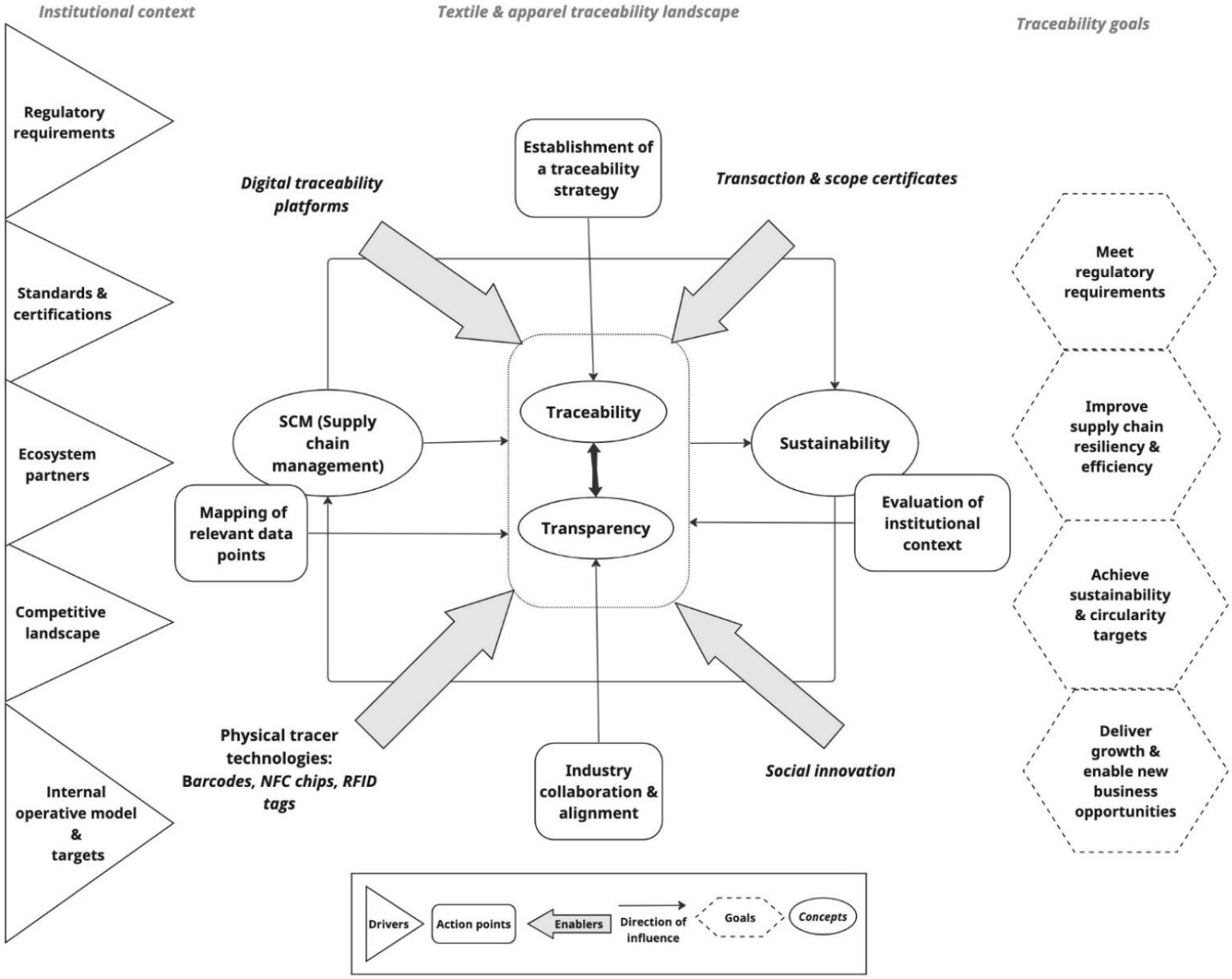

Figure 5: Initial framework

The initial framework is built from the various elements of traceability within the textile and apparel industry identified in existing literature. In this thesis context, the initial framework outlines the elements of the textile and apparel value chains, applicable to other industries for evaluating traceability. The framework envisions transforming textile and apparel value chains by scaling digital traceability for sustainability, circularity, and efficiency. It adopts a left-to-right approach, identifying first key traceability drivers, categorized based on institutional influences (Scott 1995; DiMaggio & Powell 1983). Notably, legislation, particularly from the European Commission, is a significant driver, aiming to enhance visibility in textile value chains. The upcoming EU Digital Product Passport seeks to standardize the exchange of product and manufacturing-related traceability data in an interoperable, decentralized manner (Adirson et al. 2021, 2-5).

Another category of institutional drivers involves normative drivers, which stem from values, concepts, guidelines, and standards established to guide traceability practices. These drivers emphasize the common goal of achieving network disintermediation and establishing uniform communication layers throughout the textile and apparel value chain. Achieving transparency through open data sharing about products and production practices, requires collaboration among all ecosystem partners, including competitors, NGOs, and governments (Moretto & Macchion 2022). Additionally, certifications may serve as normative drivers, influenced by external stakeholders' requests rather than obligations. Furthermore, businesses in the textile and apparel industry often publicly commit to reducing environmental and social impacts through ESG (Environmental, Social, and Governmental) initiatives. The implementation of effective traceability solutions is crucial for fulfilling these commitments, categorizing them as cultural-cognitive drivers, rooted in a company's internal targets, decision-making processes, and culture (TrusTrace, 2023, 8-12).

The illustrated grey arrows represent traceability enablers, crucial tools linked to traceability data flow in practice. These tools facilitate the collection, storage, and exchange of traceability data throughout textile and apparel value chains. Recognized enablers include digital traceability platforms, transaction and scope certificates, physical tracer technologies, and social innovation (TrusTrace 2023). Notably, the innovation in traceability platform providers is predominantly in the form of Software as a Service (SaaS) digital platforms. However, given the diverse business cases and ESG targets, no singular traceability solution caters to all users' business and ESG needs (Ahmed & McCarthy 2021).

After identifying key drivers and enablers for traceability, it is essential to assess key action points to achieve traceability goals. Successful implementation requires organizations to collaborate with industry peers, establish a well-thought-out traceability strategy, evaluate institutional context, and map relevant data points. The imperative for unified efforts in scaling traceability across textile and apparel value chains is evident. In this industry, stakeholders must collaborate to establish collective standards and practices for collecting, storing, and sharing traceability data in a compatible format. This collaborative approach facilitate value by enhancing the competitive advantage of individual companies and contributes to the growth of the community ecosystem. (Cura et al. 2020.)

The implementation of any traceability solution involves developing a traceability strategy that identifies where tracing will generate the greatest value for the company in the present and future. This strategy encompasses the disclosure of a vision, goals, needs, and milestones for traceability within a specified period. (Betti et al. 2021.) Companies utilizing traceability solutions aim to enhance value chain performance, with regulatory compliance being a primary focus, alongside a commitment to value chain reliability and efficiency. Optimization efforts contribute to cost and operational efficiency, enabling companies to refine resource consumption, respond promptly to external shocks and market shifts, and enhance order management. Moreover, companies can identify strategic opportunities, expedite innovation, mitigate disruptions, ensure safety, and certify the sustainability of processes and products (Betti et al. 2021). The following chapter will delve deeper into the research design, providing insights into the methodologies employed for data collection and analysis. A detailed introduction of the commissioning company of this study will be included, followed by an evaluation of the study.

3 Research design

Research design refers to the framework used to answer the research questions and show trustworthiness of the conducted study. This part of the study aims to explain why the qualitative research method is chosen and justify this choice. This chapter describes the empirical part of the research by presenting the research approach, data collection method, and data analysis process. Moreover, the trustworthiness of the study is evaluated.

3.1 Qualitative research approach

In this study, the qualitative research approach is employed primarily because of its suitability for investigating the chosen research topic. The qualitative research method offers the opportunity to delve into, critically analyse, and reflect upon a real-life phenomenon. With respect to the study's research topic, the qualitative research approach allows for a focused exploration of the complexities within textile and apparel value chains, examining them from various stakeholder perspectives (Eriksson & Kovalainen 2008, 1-2). According to Eriksson and Kovalainen (2008), the central focus of methodology is to illustrate how a specific topic or issue can be examined. In this context, methodology refers to the guiding principles that delineate the structure of any research process and its organizing factors. Research methods are generally categorized into qualitative and quantitative approaches. (Eriksson & Kovalainen 2008, 16-17.) The rationale for adopting the qualitative research approach in this study stems from its reliance on human participants as the preferred data collection instrument. Given that the research aims to explore traceability through the perspectives of key stakeholders in the textile and apparel value chain, the active observation and engagement in real-life situations are crucial for gathering pertinent data. (Miles & Huberman 1994, 6; Hirsjärvi et al. 1996.)

Furthermore, the qualitative research approach aligns well with the objectives of this thesis, where the study's sample was deliberately chosen rather than determined through random sampling. This deliberate selection process is characteristic of qualitative research, which focuses on comprehensive descriptions of the studied phenomenon within its contextual framework, as opposed to measuring or quantifying data results (Stranieri et al. 2018).

It is crucial to emphasize that this study does not center around making statistical generalizations about value creation within textile and apparel value chains. Instead, the primary goal is to gain insights into perceptions concerning the topic from key stakeholders in the value chain. The preceding section highlighted findings from the literature that influenced the selection of the research approach. The following section will introduce the commissioning company, and delve deeper into the applied methodology, and the data collection process.

3.2 Description of commissioning company

Infinited Fiber Company is a Finnish technology firm that transforms discarded textiles into new, high-quality fibers for the textile industry. Presently, the company operates two pilot facilities along with its headquarters in Espoo, Finland. The company's innovative technology stems from the research conducted by the Finnish oil refiner Neste in the 1980s and the Finnish Research Institute VTT from 2010 onwards, enabling the chemical recycling of textiles. The company was established in 2016 to commercialize the technology. Infinited Fiber Company's patented technology involves the conversion of cellulose-rich textile waste, through a chemical recycling process, resulting in a regenerated textile fiber known as Infinna™. (Infinited Fiber Company 2023.)

Pretreated textile waste proceeds to a carbamation process, which serves as the fundamental process of Infinited Fiber Company’s fiber production, involving the initial conversion of cellulosic material into a powder through a chemical reaction induced by exposure to urea. This carbamate powder is subsequently dissolved, and the resulting liquid undergoes wet spinning to crystallize back into fiber form. Notably, Infinna™ fiber production utilizes significantly fewer harmful chemicals compared to e.g. traditional viscose production. The regenerated Infinna™ fiber finds diverse applications in the textile and apparel industry, serving as a sustainable alternative to virgin fibers such as cotton. Figure 6 illustrates the structure of the regenerated Infinna™ fiber. (Infinited Fiber Company 2023.)

Figure 6: Regenerated Infinna™ fibre from textile waste. Picture by Daily Mail (2020)

Infinited Fiber Company has established enduring partnerships with several multinational fashion brands in the textile and apparel industry, including Adidas and H&M (Zalando 2021). Currently, the company's primary focus revolves around its scale-up plans, as it has announced intentions to open its first commercial-scale factory in Kemi, Finland. Despite this, the company intends to further increase its production volumes beyond the initial flagship factory and has strategic plans for geographic expansion into the European and Asian markets (Infinited Fiber Company 2023).

In the context of traceability, an evaluation of the various components and stakeholders within the fiber production's value chain is essential. The emphasis will be placed on scrutinizing the origin of feedstock and the assessment of energy and transportation processes employed in the Infinna™ manufacturing process. These individual components form their own value chain within the fiber manufacturing process, making it pertinent to discuss them within the context of this research topic. This discussion aims to enhance our understanding of how traceability can contribute to value generation for Infinited Fiber Company.

3.3 Data collection

Primary data, collected through interviews, was chosen as the qualitative data source for the study (Hirsjärvi et al. 1996; Ghauri & Gronhaug 2002). Interviews were selected as a suitable method, being widely used in qualitative research for their purposeful interaction to gather information from individuals. This method is particularly valuable when exploring complex topics, requiring explanations, or engaging in dialogues for thorough investigation. (Sahoo 2021, 2.) However, it was recognized in the decision-making process, that interviews pose challenges such as being time-consuming and resource intensive. Therefore, the selection of appropriate interviewees becomes a priority to ensure successful data collection. Challenges may also arise from language barriers and misunderstandings in terminology. The interviewer's expertise and ability to guide discussions impact the conversation's quality, emphasizing the importance of meticulous planning. (Tuomi & Sarajärvi 2018; Hirsjärvi et al. 1996, 201–203; Ghauri & Gronhaug 2002, 102.)

This study utilized the semi-structured interview method for data collection, chosen for its appropriateness in maintaining a structured approach while allowing flexibility in discussions. As highlighted by Daniels et al. (2004), this approach facilitates a balanced synergy between topic coverage, allowing interviewees to provide personal interpretations and ensuring adaptability in wording. The flexibility of the semi-structured approach was particularly advantageous in accommodating the diverse stakeholder groups among the interviewees, as noted by Hirsjärvi et al. (1996, 201) and Metsämuuronen (2006, 113).

A total of sixteen informants were chosen from ten distinct companies operating within the textile and apparel industry. Seven of these companies are identified as global textile and apparel brands, and both current and prospective, clients of Infinited Fiber Company, while the remaining three companies comprise suppliers of Infinited Fiber Company. This establishes them as relevant stakeholders for the study, emphasizing their role in the commissioning company's value chain when implementing traceability solutions. According to Tuomi & Sarajärvi (2009), the selection of informants for a study should prioritize individuals with relevant experience and knowledge of the studied phenomenon (Tuomi & Sarajärvi 2009, 85). Thus, it is crucial to engage with informants who possess the most suitable expertise from the relevant stakeholder companies. The primary criteria for selecting interviewees for this study was their managerial or directorial positions, ensuring their awareness of strategic plans and the development of traceability solutions within

their respective companies. Additionally, the interviewees needed to comprehend the concept of traceability from either the sustainability or data management perspective.

All informants were contacted and asked to participate in the interview via email by the interviewer. The research topic, sub-questions and interview questions were introduced in the cover letter email (Appendix 1) along with a privacy policy notice. In this study, an individual interview method was primarily used, which allowed the interviews to focus on one person at a time to discuss the studied phenomenon. The number of interviewees was chosen to ensure the successful completion of the study within the given timeframe. The consideration of saturation was also considered when deciding on the number of conducted interviews. Saturation refers to a point in research where the data begins to repeat itself, indicating that interviewees are no longer providing new information relevant to the study's scope (Tuomi & Sarajärvi 2009, 87). In the context of this thesis, saturation was achieved with 10 interviews, and this was deemed sufficient for the study. In some interviews, there were more than one informant from the target company side as the informants considered it be best to have multiple supporting views around the interviewed topic. Four interviews included two informants, one three informants, and the remaining five one informant from the represented company.

All interviews were conducted via Microsoft Teams video stream platform which enabled video camera discussions to ensure a free and comfortable atmosphere for discussion. The interviews were recorded with the agreement of all informants for subsequent transcriptions. The initial seven interviews with brands were conducted in English, while the subsequent three with suppliers were conducted in Finnish. The duration of the interviews ranged from approximately 40 min to one hour, and notes were taken during the interview to serve as a backup in case of recording failure and to support further analysis. Titles and affiliated companies of the selected informants are presented in Table 6 along with the duration and language of conducted interviews. Adhering to good scientific practice and to protect the confidentiality of each informant, names and represented companies are not disclosed in this study.

Table 6: Description of informants, their represented organizations, and interview specifications

Organization	Description	Informant(s)	Duration	Language
Apparel company A	Nordic outdoor and sports brand	Sustainability Director R&D Manager	1h 03min	English
Apparel company B	American contemporary, sustainability focused brand	Traceability Manager	1h 07min	English
Apparel company C	European athletic apparel and footwear company	Senior Manager Materials, Footwear & Environmental Sustainability	1h 05min	English
Apparel company D	American clothing company, which owns multiple brands	Director, Traceability	50min 58sec	English
Apparel company E	Multinational corporation specializing in luxury goods	Sustainable Supply Chain Specialist	48min 49 sec	English
Apparel company F	Nordic global home furnishing & textile brand	Material & Innovation area Manager Material & Innovation Developer	40min 33sec	English
Apparel company G	European contemporary ready-to-wear fashion company	Traceability Manager	40min 15 sec	English
Waste management company	Finnish municipal waste management company	Post-consumer Textiles Expert Sales & Marketing Specialist	51min 50sec	Finnish
Logistics company	Multinational logistics company	National QSHE Manager, National Customer Solutions Manager, National Key Account Manager	53min 40sec	Finnish
Energy company	Large energy solutions provider in the Nordics	Sales Manager Sales Manager	51min 19 sec	Finnish

To ensure that all pre-determined themes and concepts were covered during the interviews, an operationalization table (Appendix 2) was created and used as a basis of interview questions (Appendix 3). In this context, operationalization aims to bridge the theoretical framework to real-life situations, aligning the research question and sub-questions with the theoretical framework (Eskola & Suoranta 1998, 75). The operationalization framework establishes a connection between the study's sub-questions and the proposed research questions. This study's interview guide was formed theoretically based on the study's operationalization framework. Themes included in the interviews were (1) *institutional drivers* (2) traceability *data flow and* (3) *value creation.*

The first interview theme delved into the institutional context and its drivers for traceability implementation. This theme aimed to chart how traceability operates within the industry's structures and the extent to which normative, regulative, and cultural-cognitive factors impact its implementation. The emphasis of the second theme was on the flow of traceability data, intending to elaborate on the current methods in use for collecting, storing, and communicating traceability data. The conversation also encompassed perspectives on how the present solutions contribute value to the target companies and considered the potential onboarding of existing or new solutions in the near future to enhance value further. The third theme focused on mapping value creation in the context of traceability. It charted the perspective of value creation from both the interviewed companies and the commissioning company, examining how traceability is regarded as a value. The theme delved into how a shift towards traceability could be mutually supported by both parties to attain shared value and benefits especially in the context of linking traceability to the company's business objectives. While the themes were crafted to address sub-questions, certain answers had the capacity to impact other questions in diverse situations.

The interview questions were structured to align with the research questions. The interview questions progress from general to more specific to help interviewees acclimate to the discussed topics. Additionally, some questions include specific follow-up and probing questions to enhance discussion and facilitate a more in-depth exploration of issues and points raised within specific themes. (Daniels et al. 2004.) At the end of each interview, time was left for open discussion and the interviewee was given time to clarify and add comments if they felt something essential was left unanswered. The interview questions included both open and closed formats, aligning with the typical characteristics of semi-

structured interviews. Tailoring questions based on the stakeholder group and the interviewee's background was done to consider the informants' diverse input possibilities on specific topics, following insights from Daniels et al. (2004) and Kvale (1996, 88). In contrast to structured interviews, where a predetermined script is strictly followed, semi-structured interviews allowed the interviewer the freedom to vary the wording and structure of questions within a predefined set of topics and themes (Daniels et al. 2004).

3.4 Data analysis

In this research, the thematic data analysis method was employed, centering on the identification and examination of specific patterns or themes within the gathered dataset. The purpose of analyzing qualitative data is to interpret, organize, and map out collected research data to facilitate further answers to the pre-determined research questions. Data analysis is considered as one of the most crucial phases in conducting research and it involves various steps such as defining and categorizing collected data, integrating, and furthermore clarifying pertinent elements in it. (Hirsjärvi et al. 2004, 209–211.)

The choice of the thematic data analysis method for this study was primarily influenced by its alignment with the investigated phenomenon and its versatility in organizing and interpreting data. This method was preferred due to its lack of constraint to a specific theoretical framework, enabling its straightforward application for analyzing a diverse dataset obtained from various stakeholder groups. Furthermore, its flexibility facilitates a thorough and detailed examination of data, a crucial element when exploring a complex and dynamic phenomenon. (Braun & Clarke 2006, 78-79.) Boyatzis (1998) highlights that thematic analysis originally emerged as an offshoot of content analysis, but it evolved into a distinct approach with its own distinct research objectives. In addition to structuring data into themes, this method also involves interpreting facets of the phenomenon under examination. (Boyatzis 1998.)

During the data analysis phase of this study, a systematic process was implemented to ensure the efficiency and thoroughness of the analysis. The process commenced by identifying and narrowing down the interesting content within the collected data. Subsequently, the identified material underwent a thorough review, distinction, and marking based on predetermined points of interest. The data underwent classification, thematic grouping, and typing in accordance with the chosen method, and was summarized appro-

priately. (Tuomi & Sarajärvi, 2018.) An integral aspect of this thesis thematic data analysis process was the creation of themes, also referred to as thematization. According to Braun and Clarke (2006), a theme is something significant that emerges from the data and is relevant to the research question. Additionally, a theme is seen as representing a pattern within a specific set of data. Since it is common to identify multiple, varied themes within a dataset, it is at the discretion of the researcher to determine the relevance of themes to the research questions. The key criterion for this judgment is not the frequency of a certain theme in the data but, rather, the thematic relevance in connection to the main research question. (Braun & Clarke 2006, 79-82.) The process of identifying relevant themes was not straightforward, given the presence of multiple themes that could have served as a viable foundation for thematic analysis. However, upon a detailed analysis of the data, three distinct themes: (1) *institutional drivers* (2) *traceability data flow, and* (3) *value creation* were selected to form the basis for thematic analysis and further exploration.

Thematic analysis, as applied in this study, allows for the construction of a network perspective on the collected data. As seen in Figure 7, the identified three distinct themes of this study were applied to the thematic analysis networks in a structured manner to demonstrate how raw data is organized into basic themes (representing low-level characteristics of a higher-level theme found in the data), organizing themes (acting as middle-level categorizing themes that group basic themes together), and global themes (representing the highest-level themes that encapsulate major concepts of the data in their entirety). Global themes group together a set of organizing themes, collectively providing insights into the data. (Attride-Stirling 2001, 387-389.)

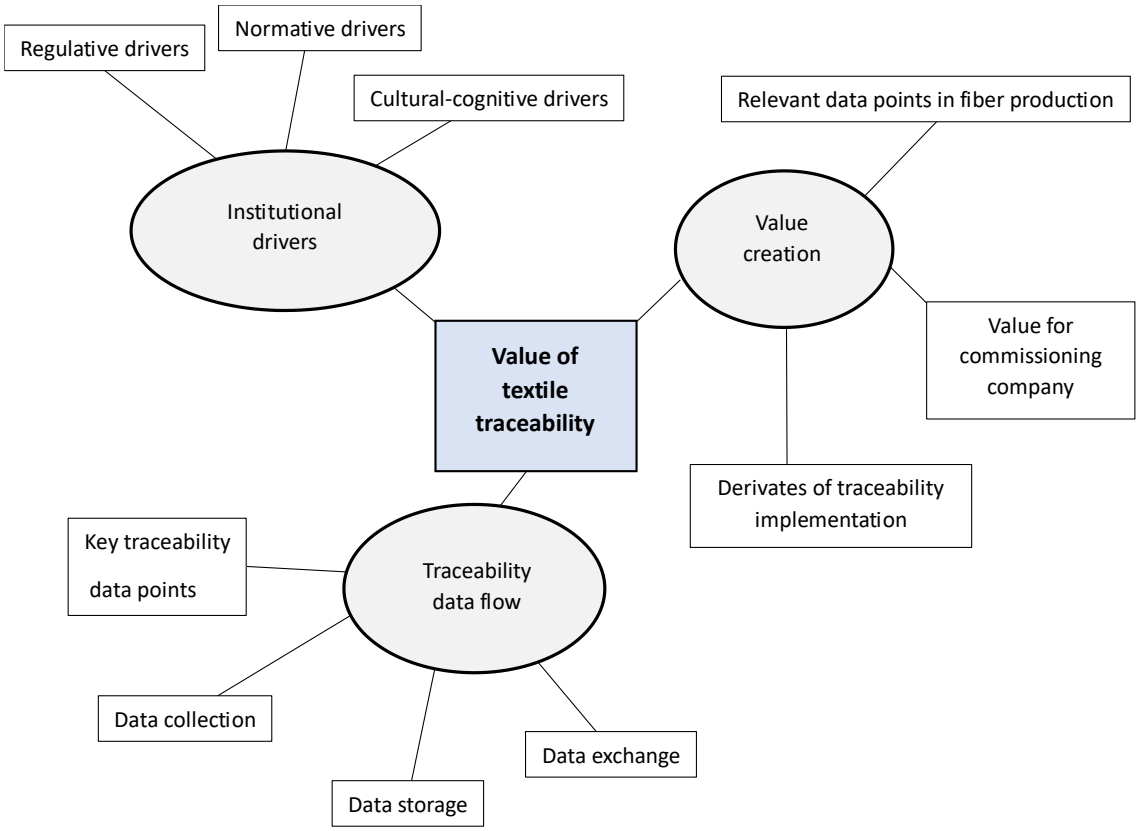

Figure 7: Thematic Networks created around the study's identified main themes

In this thesis, thematic networks served as a method for organizing the data obtained from interviews. Given the bottom-up approach recommended for constructing thematic analysis, this study illustrates the emergence of such networks from the conducted interviews. A thematic network takes the form of a mind map, highlighting the absence of a hierarchy among the identified themes. The construction of a thematic network commenced with the identification of basic themes, which were then organized under higher-level organizing themes. Subsequently, these organizing themes were further grouped under global themes, resulting in the development of a network-like figure. This figure served as an interpretive tool for both readers and the researcher of this study. It is crucial to note that the thematic framework is not perceived as a pre-packaged analysis of the collected data but rather as a tool for subsequent analysis. Its primary focus lies in describing the formed networks and discerning patterns in comparison to theoretical assumptions. Only through this approach can the chosen thematic data analysis method effectively address the identified research question. (Attride-Stirling 2001, 389-390, 393-394.)

While the study initially proposes the use of three key themes based on the operationalization table (Appendix 2) as the foundation for empirical research, thematic networks are

employed as a tool to categorize the interview data. Within the context of this study, an assumption is made that global themes influence and reflect versions of these key themes, forming a baseline for analysis. The collected raw data is classified under the identified three key themes. The thematic networks created for this study can be found in Appendix 4.

The data analysis process was conducted carefully both during and after the interviews. Throughout the analysis, both transcribed interview materials and the researchers' personal notes formed the basis for data examination. Upon completing first seven interviews with textile and apparel brands, the transcripts were carefully transcribed, categorized, and, in total, 103 pages of transcribed text were transferred to NVivo, a computer-assisted qualitative data analysis software program. After transcribing the interviews, the researcher thoroughly read and familiarized herself with the content. Following the guidelines of Braun and Clarke (2006, 87), the material was actively read multiple times to gain an overall understanding of the collected data, with patterns being sought on each iteration. Concurrently, the researcher made notes in the NVivo program. The subsequent phase involved generating initial codes. These codes were employed to identify and explore features of the data that intrigued the researcher. During this stage, the emphasis was on coding the data as comprehensively and extensively as possible. Once all the data were coded, the third phase commenced with the organization and integration of codes into potential themes. (Braun & Clarke 2006, 88–89.)

The development of themes employed the inductive method, wherein themes were derived solely from the data. The first seven interviews with textile and apparel brands were chosen to serve as the basis for forming themes, as the commissioning company wanted to primarily explore the perceptions around traceability from the relationship between the brand and supplier, which in this case was the commissioning company. After identifying factors perceived as generating value, these were consolidated and further explored through the remaining three interview with Infinited Fiber Company's suppliers, including an energy company, waste-management company, and logistics company. These discussions aimed to gain a deeper understanding of how such identified themes around value-generating components could be integrated into the fiber manufacturing value chain of Infinited Fiber Company.

A similar process of using NVivo for making notes and analysing the transcribed text was performed on the last three interviews with the commissioning company's suppliers. The theoretical framework guided theme construction, which was initiated during the planning of the semi-structured interviews. The interview themes served as a foundation for forming analysis themes. Initial exploration of themes occurred using NVivo but outlining on physical notes also aided in drafting preliminary themes. Braun and Clarke's recommendation (2006, 90) guided the creation of an initial thematic map, outlining themes and sub-themes. In the final phase of the analysis, the identified themes were scrutinized. An examination was conducted to ensure that the themes were internally consistent, coherent, and distinct from each other. At this point, a few initial themes merged, giving rise to a new theme. The thematic map evolved through the combination of themes, and considerations were made regarding how the themes interplayed with the entire dataset. Finally, the material underwent a thorough re-reading to ensure the identification of all relevant aspects. (Braun & Clarke 2006, 90-91.)

3.5 Evaluation of the study

This section will focus on the trustworthiness and ethics of the study by using Lincoln and Guba (1985) criteria, where trustworthiness can be assessed through four categories: credibility, transferability, dependability, and conformability. *Credibility* refers to the internal validity, how well the findings correspond to reality. This can be achieved through a prolonged period of engagement, persistent observation, and triangulation. (Lincoln & Guba 1985, 296-307.) The researcher's familiarity with the topic, gathering of sufficient data, and ability to use multiple perspectives to overcome biases all improve the credibility of the research (Eriksson & Kovalainen 2008, 294). In this study, a prolonged period of engagement was fulfilled by the researcher familiarising herself in-depth with the studied phenomenon by having worked within the textile and apparel industry for over a year and being familiar with the industry's various approaches to traceability.

To achieve triangulation, the researcher used different sources of data and more than one theory. Information was collected from both structured and unstructured contexts. The structured approach involved planned interview sessions, while the unstructured approach involved impromptu discussions with diverse industry stakeholders at events such as in-

dustry fairs, corporate gatherings, and other social occasions. This indicated that the researcher possessed a solid comprehension of the studied phenomenon prior to initiating the research.

Transferability refers to the external validity, how well can the findings be generalised in similar settings. For this, the researcher is required to show a connection between their findings and previous studies. They should also provide a detailed description of the research context and underlying assumptions, enabling the reader to transfer the study across different types of persons, settings, and times and make their own transferability judgments. (Lincoln & Guba 1985, 290-291; Eriksson & Kovalainen 2008, 294.) In this study, the research setting, approach, and method are thoroughly described. The findings showed similar results to previous research and literature, further supporting the transferability of this study. It was found that findings supported the previous findings of institutional factors influencing traceability implementation. Similarities were especially noted from the food industry as well as battery industry, where established regulations were put in place to improve traceability.

Dependability refers to reliability and describes how well the research process is documented (Lincoln & Guba 1985, 300). Reliability has been used synonymously with rigour – being accurate, confirmable, and transparent during the research process. This is concerned with logic, traceability and how each step of the research process is conducted. (Eriksson & Kovalainen 2008, 294.) To strengthen the dependability, the research process was described as clearly as possible to allow the reader to follow the line of thought and the interpretations of the researcher. The data used in the analysis has been systematically and unambiguously coded. The terms used throughout the study have been selected for their prevalence in the field. (Lincoln & Guba 1985, 300-324.)

Confirmability refers to the objectivity, how intersubjective and neutral is the study from the researcher's personal constructions (Lincoln & Guba 1985, 300-324). Therefore, findings and interpretations of the study should be strictly linked to the data collected in ways that are easily understood and replicated by others (Eriksson & Kovalainen 2008, 294). The data analysis process is described in detail, and the links between data and interpretations have been illustrated in direct citations from informants and figures, which improve the comprehensibility of the narrative. The interpretations made from collected data

are not based on the researcher's particular preferences and viewpoints but are grounded in the data.

This study considers research ethics and adherence to the principles of good scientific practice. Ethical considerations in this study involve sending informed consent notes to all participants of the study, anonymizing the information of both participants and their respective companies, and implementing ethical governance procedures. Now, having evaluated the trustworthiness of the study, the subsequent section will delve into the principal findings of the research.

4 Perceived value of traceability in the textile and apparel industry

This section focuses on explaining how traceability contributes to value generation in textile and apparel value chains. Addressing the three sub-research questions, it examines factors driving traceability implementation, traceability data flow in practice and demonstrates how companies leverage it to achieve business objectives. The findings discuss key drivers, methods of traceability data exchange, and explore diverse outcomes associated with traceability implementation. The discussion concludes by summarizing the themes within the context of the commissioning company, Infinited Fiber Company, providing a comprehensive example illustrating how value is created through traceability for a fiber producer. The initial framework is then restructured to align with the study's results.

4.1 Identifying drivers for traceability in target companies

The initial theme, "institutional drivers," delved into the perspectives of the informants regarding institutional drivers that currently influence and are anticipated to influence the traceability practices of the target company in the coming years. This theme establishes a foundation for comprehending the necessity of traceability implementation and how the institutional context sets boundaries for implementing such practices within target companies. To better grasp the value creation process within traceability, it is crucial to understand the drivers for traceability implementation as a new investment and organizational practice. The focus was on identifying perceptions of current drivers emerging from the target companies' institutional context, with some consideration given to potential future drivers, especially those arising from the regulatory environment.

As defined in the literature review, the institutional context in this study encompasses regulative, normative, and cultural-cognitive elements existing within a specific institutional setting, characterized by a particular culture, geographical location, and time. According to the study's findings, the informants' views on institutional drivers largely conformed to the initial framework, which suggests that traceability implementation is motivated by all the identified institutional elements. However, there were differences in how the informants perceived the extent of influence these identified drivers exerted on the traceability practices of the target companies.

4.1.1 Regulative drivers

The conducted interviews revealed that both existing and forthcoming EU legislation targeting textile and apparel value chains are regarded as crucial regulatory drivers for traceability implementation. All sixteen informants were aware of the upcoming EU legislation and its specifications regarding traceability and target applications; however, differences in the perceived urgency for immediate action were observed. It became evident that brands with strategic key operations and a primary market within the EU area expressed greater concern about the impending legislation. This urgency stemmed from the need to swiftly establish structures to support compliance with the upcoming legislative requirements. While traceability legislation was considered a non-negotiable requirement, there was a belief that in the absence of readily available legislation, members of the textile and apparel value chain might not actively pursue traceability implementation. One informant suggested that the influence of a few frontrunners is anticipated to initiate the ultimate push for widespread implementation, a process that may not fully unfold until the next twenty years:

> "Yeah, I think traceability is non-negotiable. We all know we need it, but until we have legislation come out, I don't think all companies will adhere to it. So, in the meantime it's still all those handful of frontrunners and leading companies that will pave the way pioneering, and then I hope more followers will follow. I don't think we're gonna be there in the next 20 years." (Director, Traceability, Apparel company D, 28.4.2023)

In the realm of traceability, this sense of urgency manifested in activities such as tracking material origins and addressing issues like tracing emissions data from Tier 1-4. European brands, in particular, felt a heightened need to take proactive measures and make decisions to thoroughly prepare for impending regulatory initiatives. Conversely, one brand located outside of Europe, displayed a lesser sense of urgency in their attitude toward immediate action and the adoption of new traceability practices:

> "I think that we need to wait what the governments are deciding. Nothing about the EU regulation is decided on which makes it hard to know exactly what to prepare for. This is why I believe it is better to be on the safe side and not make any irrational movements in this area." (Traceability Manager, Apparel company B, 8.3.2023)

A general understanding among the informants was that solutions for traceability would likely be adopted following the European example once regulatory initiatives are fully implemented by European counterparts. However, it's important to note that brands located outside of Europe, but with goods sold in the European internal market, must meet the same requirements as European brands in terms of collecting material and production data. This is necessary for passing customs checks and being eligible for sale in the European market. (European Union 2023.) Therefore, the same criteria for traceability performance will be applied to non-European companies, raising questions about the urgency of implementation. One informant conveyed their thoughts on the sense of urgency for traceability implementation in the following manner:

> "We're currently looking at models out there because at least in Europe we're going to be forced to do reporting soon in any event and it is something that we believe in. It's just a very time and labour-intensive topic so we haven't done a huge amount to begin with yet." (Sustainability Director, Apparel company A, 2.3.2023)

On the other hand, alternative perceptions were shared by one informant, who stated that as they have multiple teams focusing on the upcoming legislation, as well as good connections with their supply chain, they are not as concerned about the sense of urgency and extensive workload behind complying with upcoming legislation:

> "We have two different teams that are looking at the EU legislation, because when it becomes a law, we need to interpret what it means for us. But since we know our supply chain so well, I think we're not as worried as maybe some other companies are." (Material & Innovation Area Manager, Apparel Company F, 24.3.2023)

Assessing the driving impact of the EU Digital Product Passport (DPP) on traceability implementation evoked varied perspectives among the informants. While the majority were aware of the regulative initiative, there was generally limited practical knowledge of implications, making it challenging to comment on specific actions taken to prepare for the implementation of the DPP. The overall approach to preparation involved ensuring that all relevant traceability data points were identified throughout the value chain and that suppliers were onboarded into a chosen mode of data collection to ensure cohesive data for the DPP. Some informants asserted that the DPP currently does not serve as a

significant catalyst for traceability implementation, as there may not be much practical action to undertake until precise guidelines and frameworks for the context, digital architecture, and technological foundation of the DPP are unveiled. One informant shared their thoughts on the DPP in the following manner:

> "It's not quite decided what kind of technical solution it's going to be, if it's NFT [3] or what. So, I don't really know how much work there is to prepare for it before we know what is going to be approved. I think we try to do our homework as much as we can but before we know the criteria, everything is still quite unclear." (Sustainability Director, Apparel company A, 2.3.2023)

However, informants observed similarities between existing legislative initiatives, and in their preparation for such initiatives, they perceive themselves as also supporting the implementation process of the DPP. Commonalities were recognized in the French Anti-Waste for a Circular Economy (AGEC) Law, which outlines guidelines for product labelling, used textile collection, and enhancing extended product responsibility. The AGEC law is scheduled for implementation between years 2023 and 2025, mandating brands to disclose environmental properties, origin, and characteristics of every product sold in the French market (European Union 2023). For companies' goods to be sold in the French market, such data needs to be displayed, thus establishing structures to collect and verify such data supports preparation for the DPP. Two informants shared their thoughts on the relationship between the AGEC law and the DPP:

> "In addition to the EU Digital Product Passport, there is also the AGEC law in France which came into effect this year [2023]. This law is somewhat like the DPP, and this French law is going to be relevant for us probably from 2025 onwards. So, what we have done so far is that we've investigated different options for applying unique identifiers to all our products based on a QR code, and that is mostly for product authentication. That is honestly just a side effect that also works for the DPP and it's going to help us in the preparation of the DPP, because we will need to have some kind of unique identifier on product level." (Traceability Manager, Apparel company B, 8.3.2023).

Another informant expressed a similar approach, emphasizing the importance of starting DPP preparations by first addressing the AGEC law requirements and initiating impact

[3] A non-fungible token (NFT) is a unique digital identifier that is recorded on a blockchain and is used to certify ownership and authenticity.

assessment reporting with a local partner. This approach was seen as a catalyst for implementing traceability measures. The informant highlighted the significance of exploring various product impact assessment tools and options as part of the preparation for the impending DPP. QR codes, in particular, were identified as effective tools for product authentication:

> "We are applying unique identifiers to all our products based on a QR code, and that is mostly for product authentication. And then the new partner for traceability, does an impact assessment of each product, which is in line with the AGEC law." (Traceability manager, Apparel company G, 27.3.2023)

It was also recognized that specific reporting requirements, based on company size, ownership structure, and sustainability certification status such as the B-Corporation [4] status, were regarded as significant regulatory drivers for traceability. To obtain and maintain the B-Corporation certification, companies must achieve a minimum score of 80 on an evaluation of their social and environmental performance and integrate B Corp commitments to stakeholders into their company's governing documents. Companies with B Corporation status is obligated to undergo recertification every three years and produce an annual report disclosing environmental and social performance related to the evaluation. (Benefit Corporation 2023.) Thus, two informants mentioned that writing the annual B-Corp status report has been their most formalized reporting process to date, as both companies are family-owned, eliminating the need for additional external disclosure on traceability topics.

For publicly listed companies, the obligation to report on ESG-related topics, including traceability within these subject areas, was identified to be more regulated. The EU Corporate Sustainability Reporting Directive (CSRD), in effect since January 2023, was recognized as a key legislative driver for external sustainability reporting (European Union 2023). According to some informants, the CSRD mandates that companies conduct a comprehensive assessment of their social and environmental footprint. For the textile and apparel companies interviewed, a significant portion of this impact is embedded within

[4] The B-Corporation certification status indicates that a business is meeting high standards of social and environmental performance, assessed through standardized measurement practices by the global non-profit organization B Lab.

the value chain and while sustainability reporting encompasses more than just traceability, integrating traceability is a crucial initial step for the brand to gain insights into and communicate its impact. Without precise information about supplier locations, manufacturing methods, and the materials and chemicals used in their products, much of the impact analysis was considered to lack a solid foundation.

Four informants representing publicly listed companies referred to the GS1 traceability data protocol for use in their organizations to facilitate data management and external reporting on traceability topics. The GS1 traceability data protocol was identified to delineate and emphasize the essential criteria for collecting and disseminating data through a straightforward model that is applicable within established and reliable chains of custody or ownership. The data related to traceability is collected and shared on a scheduled basis in relation to the aspects of "who, what, when, where, and why" to provide applications with the necessary business context required to make optimal use of this data. Therefore, the findings suggest that among listed companies, adherence to the GS1 traceability data protocol, serves as a key driver for traceability and leads to a more organized, and proactive implementation of traceability, in contrast to non-listed companies where the foundation and structure of reporting lack organization and standardization.

4.1.2 Normative drivers

The study uncovered that most informants consider validating current sustainability claims as a key normative driver for gathering traceability data. There was a consensus that accurate sustainability claims rely on environmental data that accurately represents a product or company's actual impacts. With consumers showing a growing preference for sustainable products, it is crucial for companies to verify every environmental claim made about a product with trustworthy and sufficient data. One participant articulated this sentiment as follows:

> “Our main focus towards external communication is to back up sustainability claims and collect all this information you need to justify them.” (Senior Manager Materials, Footwear, Environmental Sustainability, Apparel company C, 28.3.2023)

It was emphasized that the gathering of traceability data should occur either beforehand or at the time of making claims. Previously, this practice was carried out only after the

claim had already been published, and data was collected solely for due diligence purposes. This process is known as substantiating green claims, and it has become a crucial function in marketing departments dedicated to avoiding greenwashing and adhering to anti-greenwashing goals:

> "Now it appears that, we're going to have to report data on the time that we are making claims, which is different to before when we collected traceability data for only due diligence purposes." (Traceability Manager, Apparel company B, 8.3.2023)

Another significant normative driver identified for traceability implementation involves the sourcing of certified materials for material traceability. Informants revealed that their company prefers to procure certified materials over their non-certified counterparts. As defined by TrusTrace (2023, 12-13), material certification serves as the identification of a specific material, revealing its origin and quality, and providing insights into the conditions of its production. By opting for certified materials, these companies stated to gain access to data that supports their material traceability and provides visibility into social and environmental performance factors. One company mentioned that they have established a material certification framework tailored to each material, which they use in sourcing all materials for their existing product range. This implies that each sourced material must have at least one certification identified in the framework; otherwise, it cannot be included in the material portfolio. While many informants concurred, that certified materials were preferred for ensuring transparency in the production process and material origin, some mentioned exceptions, such as accepting organic cotton without a certificate.

It can be inferred that variations in the strictness of material certification were also observed, with one company noting that certifications are notably expensive. Consequently, requiring every supplier to hold a certificate was considered too strict of a requirement. One informant expressed this perspective as follows:

> "As certifications can be quite costly, I don't think that they are going be a minimum requirement if the supplier can prove in some other way that they are a responsible business, and that they purchase organic cotton and not conventional cotton. It's also important that they don't use coal as a source of energy, and that they have socially acceptable working standards. That is for us going to be fine instead of a certification." (Traceability Manager, Apparel company G, 27.3.2023)

In line with the theoretical framework, industry non-governmental organizations (NGOs), along with their established standards, solutions, and certifications geared towards implementing traceability throughout textile value chains, were recognized as significant normative drivers influencing traceability implementation in the interviewed companies. An exemplary illustration is Textile Exchange, a global non-profit organization making a positive impact on traceability implementation in the apparel and textile industry. Textile Exchange achieves this by issuing transaction and scope certifications designed to trace the chain of custody from fiber-related processes onward (Textile Exchange 2023). One informant explained how they have employed certifications from Textile Exchange for material traceability:

> "We follow Textile Exchange's certifications because we're also a member of Textile Exchange. We started to get certified on Tier 4 level with two brands now for RWS [5]and RDS[6] and we collect them on Tier 2 level, and we'll now start collecting the scope certificates on Tier 1 level. "(R&D Manager, A, 2.3.2023)

According to some informants, there is a keen interest in tracing a product's chain of custody process using scope and transaction certificates, as it ensures the accuracy of claims related to the fiber content in a finished product, such as "organically grown" or "recycled." This is crucial due to raw materials frequently traversing the globe for various processes like spinning, dyeing, weaving, cutting, and sewing. By obtaining certification for a product according to a third-party content claim standard like Textile Exchange, these companies can guarantee that every step of this journey adheres to necessary precautions, ensuring that the input materials ultimately align with the product's claims:

> "So, we ask all our suppliers to have a scope certificate. Without it they are unable to furnish us with the garment transaction certificates, which is essential for substantiating our claims." (Director, Traceability, Apparel company D, 28.4.2023)

Lastly, third-party audits were also acknowledged as a normative driver for traceability implementation among the companies represented by the informants. Since traceability

[5] Responsible Wool Standard (RWS), certified by Textile Exchange (2023).
[6] Responsible Down Standard (RDS), certified by Textile Exchange (2023).

data is disclosed to external stakeholders through annual reports and other external materials, it is considered a non-financial metric and is consequently subject to an audit. In scenarios like this, a third-party auditor must verify that the disclosed data has been collected and measured accurately, and the basis of an audit is the ability to trace such data; otherwise, the data cannot be authenticated. This necessitates the implementation of traceability systems, ensuring visibility into the measurement and tracing of specific ESG-related data points.

4.1.3 Cultural-cognitive drivers

The research revealed that all interviewed companies had established company-specific targets to enhance traceability activities and had formulated internal action plans to operationalize these objectives. Most informants stated that a cultural-cognitive influence on traceability implementation was observed through internal targets set to deploy traceability solutions. The objective was to enhance transparency within their value chains, typically progressing from Tier 1 or 2 levels to Tier 3 or 4. Despite achieving full traceability with fabric (2), and ready-made garment (1) suppliers, these companies aimed to establish contact and achieve full traceability for the yarn (3, and fiber (4) manufacturing stages:

> "We currently have contact with the factories producing garments and products referring to Tier 1 and then we also have contact with all the materials suppliers going under Tier 2. Our aim is to reach Tier 3 level suppliers by the end of this year." (R&D Manager, Apparel Company A, 2.3.2023)

This entailed implementing solutions to map and establish contact with suppliers operating within these tiers. Additionally, there was an emphasis on onboarding solutions facilitating the tracking of material flow and origin from these stages in the value chain. It was not merely about supplier mapping but also a genuine ambition to advance product traceability. This involved enchantingly tracing and visualizing the material origin and flow through the specific chain of suppliers. Another informant conveyed their viewpoint on this matter in the following way:

> "We're currently in the process of moving away from supply chain mapping to product mapping on Tier 3 level as that is a really key piece right there as we need to be able to account for product impact." (Traceability Manager, Apparel Company B, 8.3.2023).

However, it was observed that there were variations in established company targets for improved visibility based on different materials. Two informants pointed out that since certain fibers and materials, such as natural fibers, are more easily traceable further back in the supply chain compared to others, internal targets should be tailored accordingly. The challenge of achieving traceability for specific materials, such as synthetics, was attributed to longstanding industry practices that have traditionally prompted suppliers and companies to maintain confidentiality regarding supplier relationships and material origins due to intense industry competition. These two informants expressed their perspectives on the subject as follows:

> "Internal targets for traceability depend on the type of material and fiber, as some fibers and materials are easier to trace further back in the supply chain than others, for instance natural materials." (Sustainability Director, Apparel Company A, 2.3.2023)

> "Traceability depends on the fiber you're talking about as some fibers we have more traceability to, as for example regenerative organic cotton. We have farm law certification for down and wool. Also, for others such as natural rubber we have a farm level certificate and that's not easy to maintain because it changes every year." (RTW Sustainable Supply Chain Specialist, Material Innovation Lab, Apparel Company E, 3.5.2023)

Another cultural-cognitive driver for traceability was identified through the way companies conducted external communication with their stakeholders. Particularly for non-listed companies, the interviewed individuals perceived external communication to heavily rely on storytelling. In this approach, the emphasis was on constructing a cohesive and informative narrative centered around company values, product lifecycles, and material origins. There was a shared recognition of how storytelling had evolved beyond merely presenting an engaging narrative about company history and values. It had progressed towards substantiating product composition claims and providing specifications on environmental impacts. Informants highlighted the importance of supporting marketing assertions and crafting a consistent, verifiable storyline as a crucial driver for swiftly adopting traceability solutions to gather and authenticate such data. One informant articulated their perspective on external storytelling in the following manner:

> "Our focus is on backing up our product marketing claims. This means that if we're going to have a story about recycled materials in our products and the way that they support circularity targets, I would need to collect information about material origin, production processes and with that create acceptable claims for that product. This has a lot to do with making product comparisons in terms of impact data, greenhouse gas emissions, water usage to give an example." (Material & Innovation Area Manager, Home furnishing brand F, 24.3.2023)

Mapping and selecting suppliers based on sufficient sustainability performance data or existing certifications were also recognized as a significant driver for the implementation of traceability solutions within interviewed companies. Given the historical tendency in the textile and apparel industry to establish linear, enduring relationships with specific companies, the increased visibility into the supply chain has allowed brands to engage directly with suppliers throughout the entire value chain. While fashion brands traditionally bought ready-made garments or fabrics from familiar suppliers, regulatory pressures have compelled brands to delve deeper into the value chain and material origins. This shift has enabled brands to form connections with suppliers further down the value chain, fostering new relationships. Brands now have the opportunity to choose suppliers for their value chains based on shared company values, social and environmental sustainability performance, and critical evaluation factors, including certifications. Traceability has increasingly become an independent criterion for collaboration among many companies, and the absence of it might lead to the termination of cooperation with a specific company, as expressed by one informant:

> "I would say that so far, traceability has been seen as a nice to have but with regulations to come and with an increased focus on risk management, longer supply chains, it becomes more and more of focus in the company. And now it's also part of our mutual business agreement that we signed with all our contractual supplies that they are going to be transparent about their supply chain with us. We might decide that if this supplier is not willing to share this information with us, like the material supplier, for example, we will ask our supplier to go to a different material supplier." (Material & Innovation Area Manager, Home furnishing brand F, 24.3.2023)

Building on this, one informant highlighted that their represented company exclusively sources certified fibers across its material portfolio. The rationale behind this approach is the belief that certification provides a level of reassurance and verification of traceability

from the supplier side, making it a criterion for all sourced fibers. This does not necessarily mean that a cotton fiber must have every conceivable cotton-related certification but, at a minimum, one widely recognized certification, such as the GOTS[7] certification. The informant articulated the company's requirement as follows:

> "What we don't need is all of them [certifications] all together. You need RCS[8] or GRS[9] if you use recycled materials. If you use organic materials, you need GOTS or Organic Cotton certification. All accepted certifications have been chosen according to material and you need at least one of them." (Senior Manager Materials, Footwear, Environmental Sustainability, Apparel Company C, 28.3.2023)

Therefore, it can be concluded that the enhanced implementation of traceability has been observed to provide additional freedom and resources for a more comprehensive and intentional supplier selection process. In summary, it can be affirmed that all three pillars of the institutional theory—normative, regulative, and cultural-cognitive factors—contribute to driving traceability implementation within the interviewed companies. However, the degree of influence and emphasis of these drivers varies depending on company. Moving beyond the identification of key drivers for traceability, the following chapter will delve into how traceability data flow is facilitated within target companies. Additionally, it will explore how traceability serves as a strategic tool to address business objectives.

4.2 Traceability data flow in target companies

The second theme, "Traceability Data Flow," offered insights into the state of traceability within the interviewed companies and how existing solutions and tools were utilized to add value to both the interviewed companies and their value chains. The objective was to develop a comprehensive understanding of current traceability practices by outlining the steps involved in traceability data flow, encompassing processes such as data collection,

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[7] The Global Organic Textile Standard (GOTS) is the worldwide leading textile processing standard for organic fibres, including ecological and social criteria, backed up by independent certification of the entire textile supply chain (GOTS 2023).
[8] The Recycled Claim Standard (RCS) is an international, voluntary standard that sets requirements for third-party. It is a chain of custody standard to track recycled raw materials through the supply chain (SCS 2023).
[9] The Global Recycled Standard (GRS) is a voluntary product standard for tracking and verifying the content of recycled materials in a final product (GRS 2023).

data storage, and external communication. The literature review highlighted the significant role played by traceability platform providers and existing management software, such as ERP[10] systems and PLM[11]s, in facilitating these processes. (TrusTrace 2023). Therefore, an in-depth exploration into the value-generating functions of these platforms was undertaken. Additionally, the study delved into the role of external traceability solutions, including traceability platforms and physical tracers, within the context of the target companies. The research sought to understand how informants perceived these solutions as creating additional value for the organization. Furthermore, the investigation explored informants' perceptions regarding relevant, value adding traceability data, aiming to comprehend the focal points of target companies in their traceability implementation efforts.

4.2.1 Perspectives on value-based traceability data collection

The topic of traceability data flow was approached by first identifying how traceability data is collected within the target companies. Various approaches to traceability data collection were identified and, upon synthesizing the findings, categorized into two overarching methods: soft and hard approaches for collecting traceability data. Notably, the majority of , seven, target companies reported that they employed the hard method for traceability data collection, while the remaining three advocated for the soft approach. The hard data collection method entailed the gathering of tangible data in numerical or other descriptive forms, systematically collected with a predetermined, structured tool. Consistent patterns emerged among the tools employed by the target companies to facilitate the collection of hard data, encompassing management systems, questionnaires, software applications, or external platforms specifically designed for supplier communication or the acquisition of material data. One informant provided an illustration of a hard data collection method:

> "We collect data from suppliers in Excel or Google sheets questionnaires to get an overview and to be able to consolidate and compare data collected from different suppliers. These sheets we store in Google Drive." (Traceability Manager, Apparel company G, 27.3.2023)

[10] Enterprise resource planning (ERP) refers to a type of software that organizations use to manage day-to-day business activities such as accounting, procurement, project management, risk management and compliance, and supply chain operations.
[11] Product Lifecycle Management (PLM) software serves as a solution that oversees information and processes throughout every stage of a product or service lifecycle.

Practitioners adopting the hard approach agreed that the rationale stemmed from the recognition that collecting concrete data on subjects such as the workforce characteristics of suppliers, production emissions, and held certifications—thereby validating supplier claims—was deemed to yield the most value for the company in the realm of data collection. It was unanimously acknowledged among informants that the collection of traceability data held little significance if the data lacked comparability or verifiability. Some informants highlighted a key practice in which they acquired necessary hard traceability data in the form of Chain of Custody certification. This certification serves as a direct demonstration that the entire value chain behind a product has received certification. The chain of custody ensures that each step in the value chain possesses verified claims regarding attributes such as "recycled" or "organically grown" fiber content. Consequently, these attributes can be rightfully claimed in the final product as well. (Textile Exchange 2023.) An informant shared their perspective on the simplicity and comprehensive application of Chain of Custody certifications in the collection of traceability data:

> "I would say we rely a lot on the Chain of Custody certification that exists. As a brand at the very last party in the supply chain, we rely on it from an industry perspective. So, standards like Textile Exchange's and their Chain of Custody certification are built on the fact that you don't have to trace all your fibres and materials, but that you only need to request a Garment certificate from your final supplier to have assurance that the entire chain has been certified." (Director, Traceability, Apparel company D, 28.4.2023)

Regarding the identification of pertinent traceability data points, practitioners of the harder approach concentrated on gathering concrete data related to workforce and manufacturing characteristics, environmental data points and certifications validating the traceable movement of specific materials. A crucial practice in this regard was identified in acquiring Scope and Transaction certificates, directly demonstrating that suppliers have a proven capability to adhere to relevant standard requirements as verified by an accredited certification body. Transaction certificates, in turn, were identified to play a pivotal role in enabling a product to obtain and sustain certification for a specific standard. Additionally, it was noted that some companies opted to pursue brand certification, meaning that they not only required suppliers to be certified but also obtained certification them-

selves. This approach allowed them to issue transaction certifications to wholesale customers upon request. Consequently, the wholesale client gains access to the full chain of custody without the need to trace it from Tier 4 onwards.

The alternative data collection approach identified falls under the category of a soft method, signifying a more straightforward process of engaging with suppliers to gain a deeper understanding of their operational practices, organizational structure, and how the company functions within the environmental, social, and governmental (ESG) framework. Advocates of the soft data collection method emphasized that their primary focus was genuinely centred on gaining insights to confirm that the supplier is conducting its operations responsibly. An informant explained the soft approach to data collection adopted by their represented company in the following manner:

> "Currently we don't collect any hard ESG data from our suppliers. We will start collecting Scope certificates or other certificates from our Tier 1 suppliers and some have already shared with us some of them. Some have not certified so far, so we will also start tracking the transaction documents for here and we've done this in the past because of the restructuring of our processes we had to implement a new way of working." (R&D Manager, Apparel company A, 2.3.2023)

It was identified that using the softer approach to traceability data collection, data was frequently not gathered periodically, preventing the evaluation and comparison of data from various suppliers. However, a common rationale for opting for the softer approach to data collection stemmed from the belief that a more structured, detailed, and periodic data collection method would impose a burden on suppliers. Thus, a softer approach was chosen to facilitate a more lenient process. One informant expressed this perspective in the following way.

> "As we know we are not the only brand but there are a lot of other brand peers that are asking a lot from them [suppliers] not only on traceability but a lot on other fronts. So, we don't want to overwhelm our partners." (Traceability, Director, Apparel company D, 28.4.2023)

The perception of overwhelming suppliers with the requirement to provide hard traceability data was found to be associated with the manual nature of many data collection processes. It was observed that, in many cases, the collection of traceability data still

involves predominantly manual work. This necessitates suppliers to input data into company-specific centralized databases and manually update the information regularly. The centralized data architecture of these databases requires separate management, restricting suppliers from reporting their data to multiple sources simultaneously without manual intervention. The manual nature of the process also implies additional time spent on updating collected data, leading to platforms having insufficient data for external reporting or other functions:

> "Simply to put it, yes, we are connecting it [traceability data] via Excel files and then we store it in the Google suite. And then once we have a PLM system, we will also store certificates in there. But that is all not decided yet. So, for now it is still all very, very manual." (Material & Innovation Area Manager, Home furnishing brand F, 24.3.2023)

Despite a shared understanding among informants about the potential value of decentralized data management systems, a lack of comprehension on how existing technological solutions could be employed to build such architectures has limited the implementation of such systems.

4.2.2 Perspectives on pertinent traceability data and storage solutions

In the realm of data collection, detailed discussions were held with informants regarding their perceptions of relevant traceability data. Sustainability data, encompassing environmental, social, and governmental data points, was regarded as pertinent information for traceability. A significant social concern for many informants revolved around the origin of specific materials, dictated by company policies aimed at avoiding sourcing from locations labelled as "unethical," with the Uighur area in China being a commonly referenced location of concern. To adhere to these established company policies, informants recognized the necessity of implementing traceability solutions to track the geographical locations of production facilities and to understand how these facilities operate in terms of upholding human rights and equality. One informant articulated the company policies regarding sourcing from restricted locations:

> "It is important for us because we want to make sure that our suppliers are meeting our common sourcing policy and not sourcing from China, Uzbekistan, or Turkmenistan. We are also looking for what is the breakdown of workers, how many migrant workers there are, and looking at human- and labour rights issues." (Traceability Manager, Apparel company B, 8.3.2023)

Governmental concerns and data needs largely aligned with the identified social issues related to sweatshop conditions, union-busting, gender discrimination, and forced and child labour. The interviewed companies collectively held the belief that heightened visibility into the value chain was essential to bring attention to these issues and take action to address them. These concerns were viewed as pervasive worldwide and unfortunately inherent in the global textile industry, where the rights and safety of garment workers are systematically neglected.

Concerning environmental data, key data points were emphasized in areas such as responsible chemistry, waste management, energy usage, and emissions calculation. Many informants underscored their company's commitment to collecting verified data on product- and facility safety, ensuring that products or materials are manufactured using non-harmful chemicals and in a safe, sustainable environment. Some companies highlighted the existence of a restricted substances list that is shared with fabric producers for compliance. An informant emphasized the safety of finished products as a result of the production chain and material components. Therefore, visibility into this aspect was deemed highly important:

> "In terms of traceability data, we need to know that the product is safe, and that there are no harmful chemicals. It is important to have some kind of reassurance that the product that they [consumers] are buying is produced sustainably and responsibly." (Sustainability Director, Apparel company A, 2.3.2023)

The theme of circularity and recycling was also highlighted within this context, with couple informants prioritizing recycling and circularity topics in traceability data collection. Emphasis was placed on the need for disclosing, for example, the quantities of waste generated from production and deadstock—unsold garments—to assess these factors before efficiently implementing a circularity program through a recycling process.

Transitioning from traceability data collection, the subsequent stage in traceability data flow was recognized as data storage. Informants were queried about how traceability data is presently stored in the interviewed organizations, and from a systems perspective, an understanding of whether the data is stored in centralized or decentralized databases was sought. It was discerned that there were various approaches to storing traceability data.

Consequently, the general categorization of these solutions was split into either using an external platform for storing traceability data or integrating traceability data management tools into existing comprehensive management software systems like ERPs or PML systems. The reasons for adopting different approaches were largely influenced by available resources for onboarding new systems, facilitating their integration with existing ones, and the state of existing internal infrastructures for data storage.

In general, it was observed that larger companies with greater financial resources had more robust capabilities to pilot external traceability platform providers and further streamline the integration process of such platforms into existing management systems. However, the company's size in this context could also impede the implementation of external platforms, as the often-intricate existing management systems need to be thoroughly evaluated to understand how new solutions would bring additional value. Nonetheless, multiple informants concurred that a crucial value-adding aspect of an external traceability data management system would be to function as a data hub, consolidating all data from different internal systems into one easily accessible location without impacting existing systems. This would be particularly advantageous from a resource management perspective, as it eliminates the need to establish entirely new systems for managing all aspects of traceability, especially if the required data is already being efficiently collected. The key, however, lies in consolidating all data into a centralized location for easy monitoring. One informant expressed their perspective on establishing an internal infrastructure to support a centralized approach for data storage:

> "Something that we're doing internally is that we are trying to create an internal infrastructure, an internal system, that can basically form a data hub that can pull all the data from those different five platforms in one internal system where we can pull data points from the various systems that we use." (Director, Traceability, Apparel company D, 28.4.2023)

For most target companies, the prevailing method of storing traceability data was achieved by utilizing existing ERP/PML systems. In many instances, the collection, and storage of traceability data was primarily managed by the sourcing department, given its direct correlation with placing orders for suppliers through such platforms in use. As an illustration, transaction certificates were primarily gathered through a connected purchase order (PO) initiated via an ERP system. In many scenarios, companies had established a dedicated team responsible for liaising with vendors to ensure the requisite certifications

were obtained for specific purchase orders (POs). In such cases, the process of sourcing materials or other products could only be concluded upon receipt of all pertinent traceability documentation from a supplier. One informant even emphasized that the use of existing systems was underscored to minimize the additional workload associated with the manual procedures linked to onboarding an external traceability platform for data storing:

> "We have tested an external traceability data storing tool but for now we concluded that it is so much manual work because we had to download the bill of material, insert it there and use a lot of Excel. This is why we concluded that we need to build an API integration among those systems so having an own PLM system in place for all our textile brands is more beneficial for us at this point." (R&D Manager, Apparel company A, 2.3.2023)

Given that the primary method for storing traceability data was deemed to be the utilization of existing management systems, the adoption of external platforms did not garner extensive support. Despite recognizing the value in the customer-facing interfaces that these platforms sought to provide, many companies found that their existing software already furnished the required data, obviating the necessity for new solutions to fulfil additional data needs. Nevertheless, the perceived value of external traceability platforms was subject to further scrutiny in the subsequent chapter.

4.2.3 Creating shared value through exchange of traceability data

The facilitation of data exchange and communication of traceability data represents the final stage in the traceability data flow, thus warranting further exploration in the context of this study. The objective was to comprehend how traceability data is exchanged and communicated to various stakeholders within target companies and value is generated through such exchange. Informants' insights and experiences regarding the utilization of tools and technologies for implementing traceability activities were examined to determine whether traceability implementation through external traceability platforms, the incorporation of physical tracers in materials to monitor various stages of the value chain, or the use of distributed technologies like blockchain were perceived to bring additional value for the company.

In line with the conclusions of the literature review, the results of the study affirmed that no informant believed that a single traceability solution provider had the capability to

comprehensively address all aspects of traceability, spanning from supplier management to product traceability. This aligns with scholars' arguments that the scope of existing traceability solutions varies based on the targeted business case and ESG (Environmental, Social, and Governance) objectives, thereby negating the existence of a singular traceability solution meeting all users' business and ESG needs (Ahmed & McCarthy 2021). For some informants, the multitude of existing traceability platforms had impeded the process of testing or piloting one, hindering the assessment of the additional value generated through their use. This reluctance was attributed to the necessity of pre-evaluating the proposed solutions to gain a better understanding of their utility for the represented company's use case. One informant further exemplified this perspective:

> "We are focusing on smaller scale pilots, and then see what the use cases are like, and how successful we were to map the entire supply chain. And then if there's a potential, we'll increase the rollout to a bigger pool of suppliers. But it's definitely not a Big Bang." (Director, Traceability, Apparel company D, 28.4.2023)

Another informant expressed similar intentions to conduct tests and pilots with solution providers, ultimately aiming to narrow down the most intriguing and value-generating solutions. However, it was emphasized that the right solution does not need to be identified immediately:

> "We are currently in the exploring phase of these platforms. There's so many now it's really hard to narrow it down, and it's interesting, but we are not most focused in finding the right one now." (Traceability Manager, Apparel company B, 8.3.2023)

Informants currently utilizing or piloting an external traceability platform noted the necessity of simultaneously exploring multiple solution providers to develop a more comprehensive approach to traceability. Each solution provider, as mentioned, tends to tailor their solution to a specific niche within the broader topic. Furthermore, it was observed that if experiences with testing a particular platform proved unsuccessful, pilots were initiated with another solution provider in the pursuit of a more functional solution to meet the established traceability targets.

> "We had one project with Provenance, a UK based traceability or like more transparency platform, but since they focus on transparency that was more of a front-end solution, we did not choose to continue with them. So, they helped us verify claims that suppliers indicated to us, and then we publicly displayed it on our website on product level." (Traceability Manager, Apparel company G, 27.3.2023)

In turn, unsuccessful pilots aided companies in fine-tuning their traceability targets, and approaching solution providers with more customized solutions for new scopes. Nevertheless, the effectiveness of these new trials did not always align with expectations, particularly in terms of the ease of use of such platforms:

> "[…] and then end of last year we started a pilot with a traceability platform Retraced, and we are currently in the reviewing process of this pilot because their platform is quite complex, and you can ask for a lot of information from suppliers. It easily becomes overwhelming, and the platform interface from what we've experienced is not very user friendly." (Traceability Manager, Apparel company G, 27.3.2023)

Engagements with various traceability platform providers aided target companies in identifying focal points within their traceability implementation strategies. Pilots with solution providers provided valuable insights into how concentrating on specific aspects of traceability could bring value to the company. Differences were observed, with some platforms placing a greater emphasis on verification, some solely storing data, and others displaying data in the consumer interface. Varied approaches were adopted to pilot and collaborate with traceability platform providers, aligning primarily with company-specific sustainability and traceability targets. For example, one informant described initiating a pilot with a French-based company called Fairly Made, assisting them in creating an impact assessment tool in alignment with the company's sustainability goals. Through Fairly Made, the company could generate lifecycle assessments for all their products based on primary data collected throughout their supply chain.

In the absence of specific guidance from company sustainability or traceability targets, it was discerned that one of the key criteria for target companies in selecting a traceability platform for piloting was the engagement of peers. Many informants expressed a preference for a platform provider that is already widely adopted within the industry. This ap-

proach was noted to help minimize supplier onboarding efforts and contribute to the systemic change necessary to standardize data management and verification practices. Six informants cited Textile Genesis as an example of a platform that has gained prominence in the industry by partnering with the certification body Textile Exchange to facilitate seamless traceability of various materials based on collected Transaction and Scope certificates. Given that the proposed platform illustrates a pre-established value chain for each material, it becomes easier for a brand to create a material-specific traceability journey for each product, as described by one informant:

> "We wanted to move to some tool that was already quite common in the market, and when we talked to our main suppliers, we discovered that they were already using Textile Genesis for instance. With their specialized platform we can trace different materials specific to their unique value chains. I think that a standardized approach for each material supports a needed systemic change within the industry." (Sustainable Supply Chain Specialist, Apparel company E, 3.5.2023)

The literature review identified physical tracer technologies as an alternative tool for facilitating traceability data exchange, presenting two subcategories—additive tracers and forensic tracers. These are utilized to trace and verify fibers and materials, establishing their geographical origins. (Fashion for Good 2023.) When exploring informants' perspectives on the use and additional value generated by physical tracers, the views were largely unanimous. Physical tracers were seen as quite superfluous solutions for facilitating traceability data exchange between stakeholders, resulting in less active engagement in pilots with solution providers. This was attributed to additional costs, primarily borne by the brand, and the fact that brands did not yet have visibility throughout the entire value chain, from fiber production to ready-made garments. As an example, two informants deemed this visibility necessary to facilitate traceability with physical tracers, as the nomination of suppliers onboarded in the physical scanning process would be facilitated by the brand:

> "We are not piloting with physical tracer technologies because we don't nominate our own fibers as we source our fabrics through our ready-to-made, cut, make and trim manufacturing suppliers. The physical tracker wouldn't give us any benefit because we see it as a high-risk project as we wouldn't know where our fibers are coming from." (Sustainable Supply Chain Specialist, Apparel company E, 3.5.2023)

> "This is something that the innovation team looked at some point, having some kind of device in the box of shipment but there were noticeable challenges and cost implied to this, so we didn't think it was useful to continue the development." (Sustainability Director, Apparel company A, 2.3.2023)

An alternative perspective was put forth by a company that delved deeper into the utilization of physical tracers for DNA testing, applied to a blockchain-based digital traceability platform. Despite the apparent success of the conducted pilots, there was support for a hybrid approach that combines different solution providers. It was emphasized that onboarding new technology solutions demands time and support for suppliers, who may not be familiar with such emerging technologies. This indicated that possibilities were seen in incorporating a hybrid approach for the exchange of traceability data, however, focus needed first be placed in facilitating further the onboarding process of supply chain partners and conducting successful pilots with such.

In general, the informants had varying opinions on the necessity and quantity of externally communicated traceability data to stakeholders, including customers purchasing ready-made products. Concerns about overwhelming customers with data overload were expressed among informants, as not all collected data was deemed relevant for all stakeholders simultaneously. It was emphasized that a proactive approach to data exchange was not implemented because most companies perceived themselves to be in a pilot phase with numerous solution providers. It was anticipated that traceability efforts would become more professionalized after the piloting phase, leading to improved impact assessments and better communication on the subject. In essence, it can be concluded that most informants preferred to communicate about professionalized traceability efforts rather than focusing on the piloting process and flawed data. Tools and methods for communicating traceability data in a meaningful and useful manner, without overwhelming the audience, were currently under exploration in many of the target companies:

> "It is difficult to back up your claims in a comprehensive way without creating data overload. What we see is that most of our customers want us to provide the information, but they don't want to spend time looking at it." (Material & Innovation Developer, Home furnishing brand F, 24.3.2023)

Building on this, some informants emphasized that the absence of external disclosure on traceability topics does not necessarily indicate non-compliance. For instance, some companies were hesitant to disclose information until they had identified the right tools, foundation, and consistency for data disclosure. Moreover, the need for communicating traceability data and efforts elicited varying viewpoints among informants. Several informants mentioned that their company has opted to communicate only a portion of the efforts made in the field of sustainability and traceability to avoid accusations of greenwashing. This decision was largely influenced by the insufficient verification methods for collected data, as companies faced challenges in finding a unified and standardized way of verifying data:

> "How to communicate sustainability in a way that is both interesting and yet rigorous. So much of what's happening right now around marketing is very difficult. There's greenwashing and then that leads to consumer scepticism, and as those are not good either we need to try to stop it and have differentiation between real claims." (Traceability Manager, Apparel company B, 8.3.2023)

The informants advocated for industry regulators to standardize elements such as vocabulary, measurement units for reporting data, as well as schedules dictating when data should be recorded, shared, and verified. Standardization in these areas within the industry was seen as highly valuable, offering a structured framework for communicating on traceability topics without the risk of potential greenwashing. Collaborative industry efforts in this direction were particularly acknowledged for their value, especially in segments such as high-end and luxury brands, which traditionally refrained from disclosing information about used suppliers and materials due to competitive concerns. As transparency initiatives within these segments gained traction, other industry peers were inspired to follow suit. Industry alignment was thus recognized as a pivotal factor driving traceability implementation efforts across various segments of the textile and apparel value chains.

Next, in alignment with the concluding theme of value creation, the study will delve into a more detailed discussion of the key value-adding components of traceability for represented companies. Since the essence of value is predominantly recognized in its ability to advance business goals, these pivotal components of traceability are further classified as strategic tools designed to address business objectives within the represented companies.

4.2.4 Traceability as a strategic tool to address business objectives

Based on the conducted interviews, it was determined that the majority of informants identified enhanced risk management as a key factor in value creation, facilitated by the adoption of traceability practices. The informants' perspectives on improved risk management were largely aligned, drawing from similar experiences in the field. Many informants emphasized that increased transparency serves as a valuable tool for effectively recognizing, managing, and mitigating risks associated with global supply chains. Given the inherent complexity and global nature of these chains, enhanced transparency through traceability enables companies to navigate external crises, such as component shortages, environmental disasters, and social scandals, and make necessary adjustments to the remaining parts of the chain to the best of their ability. Lack of transparency throughout value chains could leave a company unaware of whether a particular crisis directly or indirectly impacts its operations, as outlined by one informant:

> "For us traceability works as a risk management tool. So, for example if there is a fire outbreak in India, we can be sure that we have not been part of this facility or if we have, we will gain understanding of why it has happened and how can we help." (Traceability Manager, Apparel company G, 27.3.2023)

Building on the theme of risk mitigation and management, another significant outcome of enhanced traceability within target companies was identified as the broad support for making more informed and value-driven decisions across various aspects of the business. For instance, some companies highlighted that by gaining increased insight into suppliers' operations and understanding how data collected from suppliers' environmental and social performance aligns with the company's own social and environmental targets, they could make more value-driven decisions during the onboarding process and in forming an improved supplier strategy. Some companies even reported discontinuing partnerships with certain suppliers after gaining a deeper understanding of their practices, either through collected data or due to the suppliers' unwillingness to share such information for unknown reasons.

The increased availability of data supports decision-making and assists in prioritizing when shaping company policies and goals. The sentiments shared by informants on this matter can be encapsulated in a general statement: "What gets measured, gets managed,"

underscoring the value of increased data in facilitating an understanding of necessary actions for change and improvement. One example of a shared concern among many brands was the working conditions of Uighur cotton pickers in the Xinjiang area of China. With mounting evidence indicating that over half a million Uighur workers are being coerced into cotton picking under conditions posing a high risk of coercion, many brands have acted by prohibiting the use of Xinjiang cotton in their collections. Thanks to increased traceability, the risks associated with engaging in forced labor activities have come to the attention of brands, enabling them to take actions to disassociate from such human rights violations. One informant shared their thoughts on mitigating risks associated with procurement processes:

> "I think that in general the generated value would be to create a more stable supply chain, and more direct relationships with all suppliers. Less risk associated with buying as you will be sure of what you're buying. Also, there has been the social scandal in Xinjiang, China for forced labour conditions. So, you will be able to avoid being associated with this kind of situation because at that moment maybe you're buying from there, but you don't know." (Sustainable Supply Chain Specialist, Apparel company E, 3.5.2023)

A shared perception of the value generated through enhanced traceability was recognized in facilitating a deeper understanding of the overall impacts of the target company. For many of the companies interviewed, internal targets had been established to commit to climate action initiatives, such as science-based targets. Therefore, an increased understanding of the impacts generated by engaged value chains was considered highly beneficial in mapping overall impacts and assessing progress toward performance goals related to such ambitions. Additionally, a connection was identified between product lifecycle analyses (LCAs) and traceability, with many companies referring to LCAs as commonly used tools to map the environmental and social impacts of products. While LCAs provide the basic structure for communicating product information, several informants emphasized the need for accredited data to support the verification process of conducted LCAs based on industry standards:

> "We want to have accredited LCA data on footprints that are audited. We don't want to reinvent the rules of the game by doing our own calculations. We always want accredited data, based on which we build our impact calculations." (Senior Manager Materials, Footwear, Environmental Sustainability, Apparel company C, 28.3.2023)

Discussions regarding waste management, water usage, the energy mix utilized, emissions calculation, responsible chemical use, transportation, and manufacturing processes were highlighted as crucial areas of attention in the target companies. This implies that efforts in traceability were deemed most valuable for enhancing visibility into these aspects for the companies. Furthermore, informants emphasized the necessity for verified facts concerning actual achievements in reducing impacts to support external communication based on the collected data. The upcoming chapter will further explore the study's findings within the framework of the commissioning company. It aims to furnish specific examples demonstrating how traceability can enhance value for a fiber producer such as Infinited Fiber Company. Moreover, attention will be directed towards the commissioning company's value chain partners, as well as the drivers and roles of traceability for fiber producers, when implementing traceability solutions.

4.3 Commissioning company perspective for value creation through traceability

The concluding topic, “value creation”, was designed to foster a broad comprehension of how traceability can be employed in textile and apparel value chains to promote value within targeted organizations. This aspect was explored by prompting the participants to pinpoint the essential outcomes of heightened transparency, resulting from the implementation of traceability, which has contributed value to their respective organizations. The examination of value creation was furthermore carried out within the value chain of the commissioning company, Infinited Fiber Company, to enhance understanding of how traceability can generate value for a fiber producer. A refined version of the initial framework is presented to illustrate the application of the study's findings within a company-specific context, thereby showcasing the key drivers for traceability, along with the key components of value through traceability for the commissioning company.

4.3.1 Value of traceability in fiber production

As outlined at the outset of this study, functioning as a fiber producer, and supplier for numerous multinational textile and apparel brands, Infinited Fiber Company was particularly interested in delving into how traceability could contribute additional value to its

own operations and those of its clients. The approach to this subject continued with interviews of target companies, prospective clients of Infinited Fiber Company, to ascertain their perceptions regarding what traceability data they would find valuable from Infinited Fiber Company's production standpoint. The outcomes of these discussions provided a comprehensive overview of how value can be generated through traceability for the commissioning company’s prospective clients and how traceability could serve as a strategic tool for a fiber producer, such as Infinited Fiber Company.

Perspectives on the data deemed relevant from the Infinna™ fiber manufacturing process closely aligned with the topics outlined in Chapter 4.2.2, "Perspectives on pertinent traceability data and storage solutions." Significant data points in fiber production were identified in the environmental, social, and governmental realms, encompassing aspects such as energy consumption, waste generation volumes, and emissions generated within the Infinna™ fiber manufacturing process. Given that the Infinna™ fiber manufacturing process involves chemical recycling, informants also emphasized the importance of understanding the responsibility and safety aspects of the chemicals employed. Of particular interest was ensuring that the chemicals used adhered to the REACH regulation, designed to guarantee the safety of chemical substances used within the EU area (European Commission 2023).

Compliance with legislative requirements, contingent on the operating country, emerged as a paramount concern for all informants. Consequently, prioritizing the tracing of value chains to identify any unsustainable working practices or issues was deemed a key focus for all. The imminent EU Digital Product Passport was emphasized, with brands expressing the belief that partnerships, such as with Infinited Fiber Company, would contribute substantial value in preparing for these forthcoming initiatives. Many brands underscored the importance of shared discussions concerning industry-known issues and upcoming regulations, viewing this as a value-generating practice, and expecting such engagement from Infinited Fiber Company, given its pivotal role within the industry.

In line with the findings identified in Chapter 4.2.4, "Traceability as a strategic tool to address business objectives" a shared perception of the value generated through enhanced visibility into the Infinna™ fiber production process was recognized to facilitate a deeper understanding of the overall impacts of the target companies. Some informants stressed

that this could be achieved by Infinited Fiber Company providing their clients a comprehensive Life Cycle Assessment (LCA) for the Infinna™ fiber, presenting all essential lifecycle data in a compatible format. A common viewpoint among informants was that the greatest value would be derived if Infinited Fiber Company could enhance understanding of the fiber's tangible achievements in reducing environmental impacts compared to virgin materials, for instance. Consequently, a comprehensive understanding of value chain partners, their impacts, and the overall effects of fiber production was deemed to bring additional value for the target companies as outlined by one informant:

> "What is relevant information for us is the LCA on your [Infinited Fiber Company] fiber, and to be able to have verified facts around the actual achievements in reducing our impact with using the fiber in our garments." (Traceability Manager, Apparel company B, 8.3.2023)

Given that the Infinna™ fiber is derived from cotton-rich textile waste, the origins of the feedstock used in the manufacturing process also piqued the interest of informants. In particular, they considered information about the origin country of the collected textile waste and the form of waste—whether post-industrial, pre-consumer, or post-consumer waste—as relevant details. Many informants emphasized the importance of gaining visibility into the transportation process of waste streams to Infinited Fiber Company's facilities, expressing a desire to understand the environmental impacts of transporting such feedstock from its source. This perspective was in line with the findings stated in Chapter 4.2.4 with traceability serving as a risk mitigation and management tool, and companies demanding increased visibility into their suppliers' operations to ensure no risks were associated with engaging in for example forced labor activities and enabling them to take actions to disassociate from such human rights violations. Certain informants exhibited a more stringent approach to global sourcing strategies, emphasizing the significance of Infinited Fiber Company locally sourcing textile waste to minimize excessive transportation from outside of Europe. They underscored the value of supporting companies that contribute to waste management solutions in their home market, where most of their sales and production activities occur.

In supporting the closed-loop framework of circularity, some informants mentioned an interest in further understanding the recyclability of garments made with Infinna™ fiber. This understanding of the fiber's recyclability with available chemical recycling processes

would assist designers in avoiding certain blends or finishing chemicals that hinder the recyclability of finished garments back into fiber form. This was again in line with the previously identified statement that value generated through enhanced visibility was recognized in facilitating a deeper understanding of the value chain's overall impacts, such relating to also suppliers' processes. Additionally, some informants expressed curiosity about how Infinited Fiber Company itself participates in the closed-loop system by ensuring that its generated production waste is managed in a circular manner, thus aligning with the principles of a fully circular system:

> "It would be really nice you know where you [Infinited Fiber Company] buy from and what it is and what's going into your process and what's coming out." (Sustainability Director, Apparel company A, 2.3.2023)

Informants also exchanged perspectives on the pricing of the Infinna™ fiber and how full lifecycle traceability could serve to support it further. A common view was shared that a fully traced fiber manufacturing process would reduce the need for the brand to themselves initiate extensive external auditing procedures. In practice this means that a brand would be willing to pay more for a fully traced fiber, if it indicated potential cost reductions related to the reduced need for auditing at another stage of the value chain. In the scenario where Infinited Fiber Company could not provide traceability for its fiber, it would pose a greater risk for the brand to purchase a product with an unknown origin and impacts associated with its production process. With visibility into the entire manufacturing process, brands would prefer to forego extensive auditing and traceability practices, opting instead to purchase a higher-priced fiber that includes necessary data on material origin and impacts of manufacturing. Thus, accredited impact data presented in a comparable, standardized format, would create additional value for both brands and their customers.

Some informants suggested that added value could be generated by educating consumers on chemical recycling processes and the overall impacts of the textile industry. This statement was in line with the previous findings indicating that an increased availability of data could support internal decision-making processes, and assists in prioritizing when shaping company policies and goals. This education would support the brand's storytelling and its transformation towards the implementation of recycled materials, as customers

would be aware of the reasons behind the necessary shift from conventional to circular materials:

> "I think you [Infinited Fiber Company] could also add value in educating our customers of what you do, as it is so special and unique. It's an eye opener what you're able to do, and I think a lot of people would love to understand how you create this fiber, and what it is made of." (R&D Manager, Apparel company E, 3.5.2023)

Finally, in the following chapter, value is identified from synergies between the commissioning company and their suppliers, ecosystem partners, to devise concrete solutions for implementing value generating traceability practices for the commissioning company. The target companies comprised of Infinited Fiber Company's key suppliers, including a national waste company responsible for sourcing textile waste used as feedstock in the Infinna™ fiber production process, an energy company providing renewable energy for the fiber manufacturing process, and a logistics company managing logistics throughout various stages of fiber production from feedstock to fiber.

4.3.2 Identifying value from synergies between the commissioning company's value chain partners

It was recognized that in line with the initiative of ensuring the full lifecycle traceability for the Infinna™ fiber, Infinited Fiber Company could derive additional value for by collecting traceability data regarding the feedstock used in its production process. As the feedstock is composed of textile waste collected and sorted by an external partner, waste management companies were identified as key players in collecting such comprehensive traceability data from pre-collection and sorting stages. The collection of comprehensive feedstock data would enable Infinited Fiber Company, as well as its clients, to enhance their storytelling by providing information on from which geographical location, and of which nature: post-industrial, pre-consumer, post-consumer, the utilized textile waste consisted of. Data on garment and textile compositions would in addition help the to enhance the speed and accuracy of sorting and recycling processes which yet run very much on manual practices. In addition, value was identified in the fact that data collected from sorting and material components would be available in interoperable data sources, that could facilitate easy and efficient exchange of traceability data between value chain partners. Also highlighted synergies with the DPP, were noted, stating that the DPP could be

particularly valuable in supplying verified information about material compositions. This, in turn, could contribute to a more efficient and verified textile sorting process.

Although data on textile waste volumes, type, and location of waste were identified as valuable data points for Infinited Fiber Company's processes, considerations such as the original production location of an individual garment ending up in end-of-life waste treatment processes was deemed irrelevant and beyond the scope of traceability. This was explained by the fact that post-consumer textiles collected at their end-of-life stage in Finland encompass everything imported to Finland, rendering the identification of specific countries of origin irrelevant. In sum, the overall mass balance of the textile waste was considered more pertinent, thus data around waste mass balance, and its traceability was considered to hold additional value:

> "End-of-life textiles are collected in Finland, meaning that the waste issue in Finland is addressed. Thus, it is no longer our responsibility to trace their [garments] importation process. Instead, they are brought into Finland by other parties and sold here, sourced from various locations. It can be said that they originate from virtually anywhere." (Waste management company, Post-consumer Textiles Expert, 5.4.2023)

Another crucial value-adding element for Infinited Fiber Company was identified to lay in an external partner's, such as textile waste management company's, capability to devise specific sorting requirements tailored to the needs of a particular company. Given that the criteria for quality and composition can be customized based on the specific requirements of a client, this approach results in less waste generated compared to a scenario where the feedstock includes materials that cannot be utilized in the fiber production process. As Infinited Fiber Company's fiber manufacturing process utilizes cotton rich textile waste, textile waste management companies can create value by providing their client, such as Infinited Fiber Company, presorted waste according to their exact feedstock sourcing criteria. Traceability in this context would ideally help the textile waste management companies to speed up the process of sorting waste accurately, according to their different clients´ sourcing criteria.

In addition, notable value was identified in cooperations between Infinited Fiber Company and external partners that possessed the ability to provide instruments for verifying

the source of renewable energy used in Infinna™ fiber manufacturing processes. Currently, the primary method for verifying the use of renewable energy in fiber manufacturing processes involves the purchasing of EU Guarantee of Origin (GoO) certificates. These certificates ensure that a specific amount of power is generated at a particular power plant, constituting a voluntary certification scheme that traces the power back to its origin, answering questions about the type of plant used and its location. As electricity cannot be labeled with this information, the tracking occurs separately through certificates registered via a reliable electronic mechanism for every megawatt-hour (MWh) of power produced.

For Infinited Fiber Company, ensuring the origin of the renewable energy used could have manifold benefits. The first identified advantage lies in these certificates enhancing the innovative narrative by substantiating claims related to sustainability and green energy sources. The paramount importance of verified green energy compliance for innovative textile fiber companies was noted to lie in the ambition to comply with green claims and construct a coherent storyline with external certification schemes such as GoOs. They are the sole individuals capable of verifying the origin of green energy, except when considering an off-grid setup as explained by one informant:

> "An alternative to using (GoO) certificates is to establish what is commonly referred to as an "off-grid" setup, where you create your own means of production, such as constructing your own hydroelectric or wind power plant or acquiring one that generates all the electricity you require. In this scenario, your facility would be directly connected to the production facility via a cable, making it the sole viable option. Otherwise, they [GoOs] are the only means to verify the origin of green energy." (Energy company, Sales Manager, 13.4.2023)

For Infinited Fiber Company, this verification could entail, for instance, crafting a narrative that supports the idea of locally sourcing green energy from the Kemi River, as hydrogen power, to operate the upcoming Flagship Factory. In the market, electricity and renewable energy certificates are sold separately, and purchasing certificates alongside electricity provides businesses and suppliers with tangible proof of renewable energy, enabling them to act on their choices and meet sustainability and compliance targets. Internationally, consumers and companies can rely on International Renewable Energy Certificates (I-RECs), and market-based certificates to achieve the same goal. For Infinited

Fiber Company, GoOs could also serve as significant pathways for tax reliefs and governmental grants aimed at supporting the use of renewable energy in industrial production. An example is the Finnish government aid for electrification, where part of the additional cost resulting from emissions trading in electricity prices will be compensated for specific industrial sectors through electrification support. To be eligible for this aid, at least 30 percent of a company's electricity should be sourced and verified from renewable sources, supporting the use of GoOs.

Considering that logistics is a crucial stage in the textile and apparel value chain, traceability becomes essential for understanding the environmental and social impacts of transportation processes. It was observed that traceability could serve as a significant value-adding factor for Infinited Fiber Company, particularly as their clients prioritize assistance with reporting on environmental matters, such as emissions calculations per shipment. In this regard, Infinited Fiber Company is tasked with collecting comprehensive emissions data throughout its fiber manufacturing process, encompassing data from raw material and chemical shipments to actual fiber deliveries to brand clients. Therefore, having logistics partners capable of collecting such emissions data per shipment was deemed valuable.

Another recognized value-adding aspect was decision-making support, as access to more data on transportation impacts allows companies to make informed decisions, and address potential issues proactively, relying on the data and recommendations provided by logistics companies. Having more data could aid in decisions regarding consolidating shipments to lower shipping costs and minimize emissions by avoiding partially filled containers. Furthermore, choosing suppliers based on their compliance with existing logistics regulations, or carbon accounting initiatives such as the Science Based Targets, was acknowledged as a vital value-creating factor for Infinited Fiber Company:

> "We can bring value to you [Infinited Fiber Company] by providing data on what kind of emissions have the transports generated, and furthermore, if you or your customer were to participate in the Science Based Targets initiative, we would be able to align data to match with their environmental goals accordingly. Furthermore, various options could indeed be identified to mitigate emissions even before they occur." (Logistics company, National QSHE Manager, 19.4.2023)

Building on the findings on the value of traceability within the context of the commissioning company, the following chapter will provide a comprehensive overview of the findings and implications of identified value of traceability within the context of Infinited Fiber Company. The chapter also projects the previously identified findings from the literature review, and evaluates whether they are in line with the findings of the empirical research.

4.3.3 Commissioning company perspective for value creation through traceability

As outlined in the literature review, scholars have recognized two principal viewpoints regarding value creation in business markets, which bear resemblance to the context of Infinited Fiber Company's value chains: the value of products, and the value of buyer-seller relationships (Lindgreen & Wynstra 2005, 732-733). A thorough investigation into the value engendered by traceability implementation within Infinited Fiber Company's value chain has yielded findings consistent with the notion of value identified and put into action within both contexts.

From a product value perspective, the study highlights the importance of traceability systems in facilitating the exchange of detailed data concerning Infinited Fiber Company's product, the Infinna™ fiber, thereby enhancing its overall value proposition (Nokelainen et al. 2022; Gereffi & Frederick 2010). As multinational textile and apparel brands, clients of Infinited Fiber Company, increasingly demand data from their suppliers on ESG topics, the establishment of comprehensive lifecycle traceability for Infinna™ becomes crucial. This involves gathering data throughout the fiber manufacturing process, starting from the sourcing and characteristics of textile waste used as feedstock, tracing the origin of chemicals and other raw materials, to tracking the origin of green energy, and emissions data corresponding to all logistics actions involved in manufacturing and shipping of the finished fiber.

In line with insights from the literature review, the study emphasized the vital role of collaborating with existing partners within the value chain to enhance the value of traceability (Cura et al. 2022). The necessity of collecting accredited data beyond the scope of the fiber manufacturing process underscored the significance of partnerships. Ecosystem partners such as waste management, energy, and logistics companies contribute to value creation by providing accredited ESG data, supporting Infinited Fiber Company's efforts

in achieving full lifecycle traceability for its fiber. These finding aligns with the theoretical framework, indicating that partnerships not only enhance individual companies' competitive advantage, but also foster growth within the community ecosystem.

Consistent with the theoretical framework, the study's results highlight that for Infinited Fiber Company, implementing traceability brings about various benefits such as increased visibility, operational efficiency, and enhanced reliability throughout the value chain. Achieving cost and operational efficiency involves optimizing resource usage, swiftly responding to market fluctuations, and improving order management. (Betti et al. 2021.) Moreover, companies like Infinited Fiber Company, can spot strategic opportunities within the traced value chain, encourage innovation, mitigate disruptions, ensure safety, and validate sustainability processes and products.

Expanding on these points, scholars emphasizing the significance of buyer-seller relationships argue that comprehensive traceability enables companies to track products across the value chain and gather precise data on supplier sourcing, production, and input origins (Silva & Mattos 2019; Betti et al. 2021). By adopting a traceability solution, Infinited Fiber Company can assist their clients' customers in understanding end-of-life solutions by transparently illustrating a product's lifecycle journey from production to disposal and regeneration back into fiber form. This not only fosters engagement and trust between the client and the customer, but also holds the potential for long-term value generation for Infinited Fiber Company. Within this framework, implementing a traceability solution could create value for Infinited Fiber Company by revealing current realities, and uncovering potential future collaboration opportunities with recyclers, sorters, second-hand platforms, and other relevant stakeholders in the industry. With the study's key findings presented, the subsequent section will summarize the study's conclusions and introduce the revised initial framework based on these findings.

5 Conclusions

This section presents the results of an empirical research study in conjunction with the academic literature and theoretical framework. The conclusions section is divided into two parts. Firstly, the theoretical contribution aligns the research findings with the revised initial framework. Additionally, this section explores the research implications for prior literature. The managerial implications section presents the findings in a managerial context, offering insights that may be valuable for the commissioning company, and other companies within the textile value chain, to better understand the aspect of value creation through traceability. Finally, the last section addresses the study's limitations and offers suggestions for future research.

5.1 Theoretical contribution

In recent years, traceability has emerged as a significant concern across various industries, policymakers, and regulators, particularly in the textile and apparel sector, where issues pertaining to social, environmental, and governmental aspects are prevalent (Quantis 2018; UNFCCC 2018). To aid organizations in their transition towards enhanced traceability, the development of a strategic framework is deemed crucial, emphasizing components that generate value and align with strategic objectives (Betti et al. 2021). This study developed an integrated framework for analysing value creation through traceability within textile and apparel value chains. Building upon existing literature, the integrated framework synthesizes comprehensive findings, addressing perceptions and the scope of traceability within target companies. Utilizing interview findings, the framework links key industry drivers, action points for facilitating traceability data flow, enablers, and components of value for a value-based implementation of traceability practices.

The initial framework, based on existing literature, theories, and findings, was presented in Chapter 2.5, incorporating the study's three sub-objectives: understanding key drivers for traceability, structuring traceability data flow facilitation, and establishing the linkage between traceability and business objectives within textile and apparel value chains. The study's findings complement existing literature, as illustrated in Figure 8, with modifications made to the initial framework based on empirical research findings. These deviations and additions are highlighted for clarity, demonstrating the refinement of the initial framework to incorporate empirical insights.

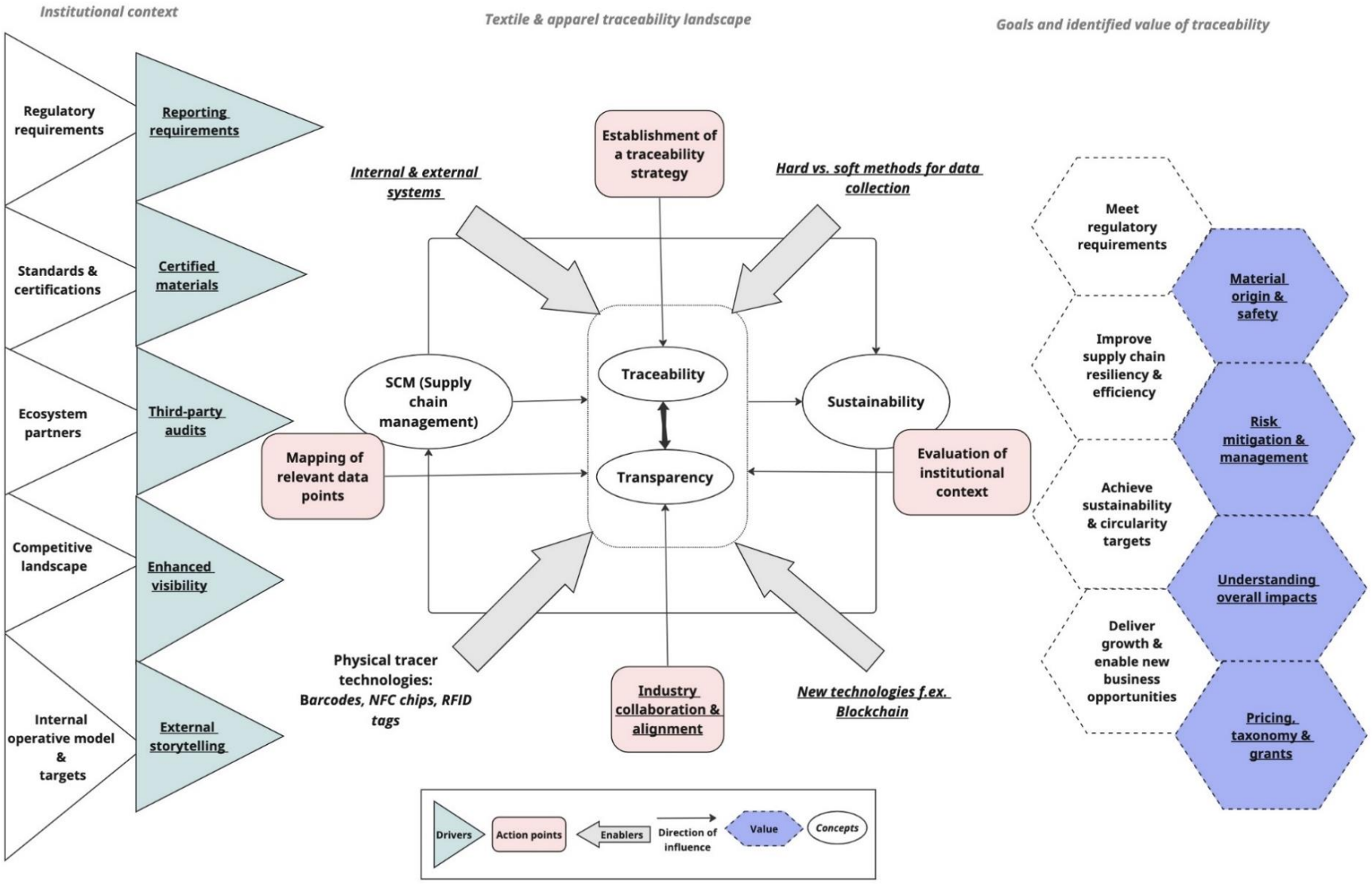

Figure 8 Revised initial framework

Existing literature underscores the pivotal role of the institutional context in propelling the adoption of traceability practices. Notably, regulatory initiatives, such as the EU strategy for textiles, are recognized as prominent drivers shaping strategies related to traceability (TrusTrace 2023, 13-18). The research findings further specify and highlight the paramount importance of institutional drivers identified in relevant literature. Further specifications arising from regulatory, normative, and cultural-cognitive drivers were included in the revised initial framework highlighting their noted importance and value to the informants.

In literature, regulatory drivers are highlighted as predominant influencers of traceability implementation (OECD 2022, 5-7; Adisorn et al. 2021, 13-18; European Commission 2023). Informants further supported this view by highlighting the sense of urgency in implementing traceability solutions to prepare for reporting requirements based on company size, certification schemes like B-Corp, and overall sustainability reporting obligations such as the CSDR. Similarly, industry standards and certifications were noted as a significant normative driver, as indicated in literature (Garcia-Torres et al. 2022, 358; Moretto & Macchion 2022, 1477-1478; Stranieri et al. 2018, 51). Informants agreed with the role of industry standards and certifications as being key drivers for traceability implementation, but further specified especially the importance of material certification schemes as a pivotal driver for traceability related to sourcing practices. Some informants even stated that their represented company would not be able to utilize some materials in the case they did not have a needed certificate, thus highlighting their paramount importance.

Consistent with the initial framework, ecosystem partners were also identified as a crucial normative driver for traceability, aligning with Scott's (1995) perspective on individuals conforming to universal norms for appropriate behaviour in a specific context (Scott 1995). Early adoption by other ecosystem partners or competitors was identified as a significant driver for traceability (Moretto & Macchion 2022, 1478-1479). However, in this context a notable contradiction was made in terms of identified sense of urgency to implement traceability solutions if a competitor was seen to do so. In line with the study’s findings companies with headquarters based in the EU market were noted to have a more severe sense of urgency to implement solutions when seeing a competitor do so, whereas

companies based outside of Europe felt less of an urgency. However, according to the findings of the study, third party audits were especially seen as a key driver for traceability with lack of such ultimately seen as a weakening the competitive position of the company.

The pursuit of more data and increased visibility into the value chain has been identified as a driving force compelling companies to adopt traceability solutions, aiming to gain a competitive advantage by, for example, mitigating risks associated with their production processes or overall value chain (Özkan et al. 2021, 4-5; Shih & Agrafiotis 2015, 1035). In line with the initial framework, companies are recognizing traceability as a competitive edge, attributing it to enhanced visibility into their value chains and improved supplier selection. Furthermore, linked with internal drivers and company-specific motivators for traceability, external storytelling based on verified and accredited data emerged as a significant driver for traceability stated by informants. This aligns with existing literature, indicating a shift in companies' focus from merely supporting the collection of ESG data to specifically bolstering claims related to ESG topics. Consequently, companies now find it crucial to possess data supporting their communication and claims on ESG-related matters, marking a substantial cultural-cognitive driver for traceability.

Connected to internal drivers and company-specific motivations for traceability, the utilization of verified and accredited data for external storytelling emerged as a significant driver (Henninger 2015, 6026; TrusTrace 2023; Johansson & Månsson 2013, 25). Companies are experiencing a transition from actively supporting the collection of ESG data to focusing on substantiating claims related to ESG topics. Consequently, for effective communication on ESG-related matters, companies must already possess data substantiating these communications and claims. This shift was highlighted by informants as a major cultural-cognitive driver for traceability.

The research aligns with relevant studies on traceability data flow, revealing the utilization of various systems and tools to support traceability practices, consistent with existing literature. The revised initial framework underscores the importance of both external and internal systems in collecting and storing traceability data effectively. While external solution providers are available, most target companies are still transitioning to full-scale utilization, opting for pilot phases to identify suitable use cases and solutions based on traceability objectives. Contrary to initial findings, the use of physical tracers is minimal due to cost and utilization constraints; however, emerging technologies like blockchain

are seen as potential future tools, incorporated into the revised framework. Additionally, the study identifies two main methods for collecting traceability data: the hard and soft approaches. Most target companies employ the hard method, involving the systematic collection of tangible data using predetermined structured tools, while others opt for the soft approach, validating supplier claims on a less structured basis.

In line with Lindgreen and Wynstra's (2005) research streams on value creation, the study identifies value generated within the textile and apparel value chains, both in product evaluation and buyer-seller relationships. The revised framework focuses on pinpointing components of traceability that align with existing goals. Firstly, traceability enhances the value of goods and services by ensuring product safety and compliance with regulations like REACH. Moreover, it aids in improving supply chain resilience and efficiency, mitigating risks associated with supply chain management. This resonates with the emphasis on relationships in Lindgreen and Wynstra's (2005) work, particularly in selecting suppliers based on ESG performance. Achieving sustainability goals through traceability is a key objective, enabling companies to understand and manage their environmental impacts effectively. Furthermore, traceability investments offer growth opportunities and enhanced returns by enabling updated pricing, accessing grants, and tax benefits through verified sustainability performance.

The study reaffirms the importance of implementing traceability based on key action points identified in relevant literature for value creation at the company level. It establishes a clear link between traceability and achieving strategic business objectives, particularly in areas like risk management and supply chain efficiency. Prioritizing and determining relevant traceability targets within the institutional context is crucial, aligning with existing literature on the subject. Developing a traceability strategy involves addressing essential data points and systematically collecting relevant data, in line with established frameworks. Collaborative efforts are deemed essential for expanding traceability implementation across textile and apparel value chains, as indicated in prior research. Moreover, industry alignment is emphasized for establishing common frameworks and structures to enhance information disclosure and enable unified data exchange on traceability topics.

In conclusion, the empirical findings of the study align and further specify the initial framework presented in section 2 of this thesis. Any contradictions observed between the

results and the theoretical framework do not invalidate the literature; rather, they serve to specify and clarify it, as demonstrated in this section.

5.2 Managerial implications

This thesis provides insights into how companies operating within textile and apparel value chains—such as fiber, yarn, and fabric producers, garment makers, brands, and retailers—can derive value from implementing traceability. The growing concern for sustainability considering the impact of fast fashion on the clothing lifecycle, coupled with the demand for credible claims due to limited visibility into value chains, has sparked a noticeable interest in enhancing traceability (Krause et al. 2009, 20). Like with any new initiative, the question arises: How will this new practice or investment in new technological solutions generate value for my organization? This is why the study focused on the relevance of value creation—to deepen understanding of how traceability can benefit textile and apparel companies.

The study's findings suggest that the revised initial framework can lead to success for textile and apparel companies in several ways. This framework aids in identifying key drivers for traceability within a company's institutional context. By delineating legislative, normative, and cultural-cognitive drivers, organizations can gain a deeper understanding of the legal basis for traceability and potential consequences for non-compliance. This understanding can help companies establish a long-term vision for traceability and align short-term goals with that vision. Successful implementation of a traceability strategy also requires the formation of a cross-functional team comprising experts in various business functions such as sales, marketing, finance, and procurement, in which the framework can be of help.

The study found that legislative drivers are the most influential, prompting organizations to prioritize traceability implementation to avoid sanctions. Normative drivers help establish industry guidelines and norms for traceability implementation, while cultural-cognitive drivers provide valuable benchmarks for internal traceability goals, as noted by the study's participants. For companies based in the European Union, compliance with forthcoming EU regulations is mandatory. Therefore, preparing for the disclosure of product-specific data, and identifying key data points from material origin to ESG data collected during manufacturing and logistics processes is crucial.

Preparation for forthcoming legislations such as ESPR, DPP, and AGEC laws can commence with a comprehensive understanding of the traceability data flow process, covering data collection, storage, and exchange procedures. With an improved grasp of the value chains' extent and tools for facilitating data exchange, organizations can identify relevant data points tailored to their unique processes. Subsequently, they can establish structures to facilitate traceability data flow among these identified data points. By delving deeper into existing technological and physical solutions for data exchange, companies can select options that best align with their internal objectives and yield optimal value for their specific goals. A thorough understanding of pertinent traceability data enables companies to recognize synergies among collected data and utilize it effectively to meet business targets. Understanding relevant data points also simplifies the development of standardized, industry-wide processes, ensuring uniform collection of pertinent data and reducing subjective interpretations.

In concluding the managerial implications of this study, the study provided insights into how a fiber producer, such as the commissioning company, can engage in traceability to generate value for its organization. Equipped with an understanding of the components that contribute to value in traceability, the commissioning company can develop its own traceability implementation strategy. This strategy, outlined in Figure 4, begins with defining targets and core foundations for traceability based on identified key drivers. At this stage, the core technology, whether applied to internal or external system, is also selected. The second step involves addressing stakeholders' expectations, ensuring security, privacy, and scalability of traceability practices among value chain partners. The third step includes defining a scaling strategy and onboarding suppliers, coordinating IT resources, and initiating supplier training sessions to ensure successful implementation. Subsequently, an internal readiness analysis is conducted, evaluating ecosystem partners' readiness, and identifying key enablers and drivers, followed by the execution of the traceability strategy. This execution begins with testing and fine-tuning processes, leading to the active utilization of a traceability program, followed by ongoing follow-up and regular reviews. Finally the study’s limitations and suggestions for future research are discussed in the following chapter.

5.3 Limitations and suggestions for future research

This study offers a new perspective on the value of traceability by directly querying actors within textile and apparel value chains about their perceptions and motivations regarding traceability, then synthesizing these insights to gain a deeper understanding of the phenomenon. While this research provides both theoretical and managerial implications, it is not without limitations. The study primarily focused on gathering data from stakeholders of the commissioning company, Infinited Fiber Company, considering their relevance in their respective roles within the textile and apparel value chain. As most of these companies were headquartered in Europe and thus subject to EU regulations, the findings regarding key drivers may not be universally applicable. Informants primarily discussed institutional drivers within the context of European countries. Although the target companies operate globally, results may have varied with more representation from Asian, American, Australian, and African company representatives. Therefore, the lack of geographic diversity and examination of legislative initiatives outside the European Union context could be potential avenues for further research, allowing for exploration of differences in institutional drivers for traceability and perceptions of value creation in more diverse contexts.

While this research contributed to a deeper understanding of traceability's value for a fiber producer, such as the commissioning company, its findings may not be universally applicable to all fiber producers worldwide. Certain aspects of the findings, such as the value chain map comprising key stakeholders, can be generalized; however, the scope of traceability and relevant data points may vary depending on the type of fiber. For instance, Infinited Fiber Company's fiber, derived from post-consumer textile waste, places importance on the origin and composition of the waste used as feedstock for full lifecycle traceability, unlike other fibers.

Additionally, it's important to recognize that the pursuit of enhanced traceability, and the identified themes such as key implementation drivers and methods for data flow facilitation, are relatively new concepts introduced to the industry. Therefore, they are subject to ongoing evolution and development. It's noteworthy that this study evaluated key drivers, including regulatory initiatives, as of the time of conducting the research (year 2023-2024), which may have progressed and changed over time.

This study suggests that there are also notable further research needs for a more in-depth exploration of the value-generating aspects of current technological solutions to facilitate traceability data flow. It would be particularly interesting to investigate the primary technologies and platforms that contribute value to companies in the textile and apparel value chains, especially when the upcoming EU legislative initiatives, aiming to standardize the process, are fully implemented.

The final limitation of this study is the sample size of the pilot study. The next steps of this study would be to further test the revised internal framework's accuracy by extending to assessing the value creation theme in more brands context that use innovative textile fibers, which can be tracked through all the value chain stages. Although beyond the scope of this paper, there is also an opportunity in future research to include a quantitative component based on specific issues that participants identify. Finally, the methodology does not consider issues such as financial stability and financial flows, all of which impact how value is captured, and could be considered in future research.

6 Summary

In recent years, the global textile and apparel industry has undergone a significant transformation due to environmental and social concerns. This has led various stakeholders, including consumers, suppliers, regulators, and policymakers, to advocate for increased transparency and access to traceability data, encompassing product origin, composition, and production methods. Concurrently, companies are navigating a volatile business environment, necessitating enhanced value chain resilience to ensure material supply. Although traceability's importance is recognized, its implementation remains limited. This study affirms that improved visibility, operational efficiency, and strategic opportunities are key drivers for companies exploring new investment avenues around traceability.

The study's primary objective was to investigate how traceability can enhance value creation in the textile and apparel sector, with sub-objectives focusing on drivers for traceability, practical data flow facilitation, and alignment with business objectives. The literature review examined the current state of traceability in textile and apparel value chains, identified key drivers using an institutional context framework, elucidated tools for facilitating traceability data exchange, and established a link between traceability and value creation. This process synthesized the literature findings into an initial framework comprising essential building blocks relevant to the research topic.

The empirical research employed a qualitative approach, utilizing open-ended semi-structured interview questions derived from the theoretical framework. Sixteen informants, representing stakeholders from textile and apparel companies within the commissioning company's value chain, were selected for interviews. Data analysis involved predefined themes from the operationalization table and emergent themes from the results. The research closely aligned with existing literature, identifying key drivers for traceability and elucidating tools and methods for traceability data exchange. Regulative drivers were found to be the primary force behind traceability implementation, with European companies exhibiting more advanced practices than their US counterparts. Informants exhibited diverse perceptions of urgency and response to normative drivers, particularly regarding company-specific initiatives for enhanced value chain visibility. Consistently with the literature, traceability drivers were recognized across all three pillars of institutional theory.

The study concluded that traceability offers multifaceted value across organizations. It serves as a tool for mitigating and managing risks by providing visibility into external risks related to supply chain management, while also enhancing understanding of social, environmental, and governmental impacts for reporting purposes. Traceability enables informed decision-making by evaluating suppliers based on shared values and goals related to ESG and compliance issues. Moreover, traceability supports growth and unlocks new business opportunities by facilitating the exchange of accredited data for potential tax benefits, grants, and enhanced pricing of traced products. Additionally, it aids in coherent and verified storytelling, meeting consumers' increasing demand for sustainability and circularity performance communication.

These findings provide valuable insights for textile and apparel companies, guiding their participation in traceability practices that generate company value. For instance, the commissioning company of this study gained insights into traceability drivers, tools for effective traceability data flow, and understanding of traceability as a strategic tool, benefiting key stakeholders throughout their value chain.

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Appendices

Appendix 1 Cover Letter

Dear Mr./Mrs.

I hope all is well.

I am contacting you regarding a master's thesis, that I am conducting for Infinited Fiber Company with the aim at investigating how value is created through traceability within textile- and apparel value chains.

Comprehension for the aim of this study is sought by gaining understanding of three sub-questions:

1) What are the key drivers for traceability implementation?
2) How is traceability data flow facilitated in practice?
3) How is traceability linked to business objectives?

With this said, I kindly ask when anyone from your company working within sustainability/traceability solutions, would be available for a (45min -1 hour) interview around the topic of traceability in the context of your company? With permission, interviews will be recorded and stored temporarily, but data in final thesis is anonymized (see attached). You will be also given a chance to get acquainted with the interview questions beforehand (see attached).

Kindly let me know your thoughts on the matter.

With kind regards,
Maria Ervast

Appendix 2 Operationalization table

Research question	Sub-research questions	Themes	Concepts	Related interview questions
How is value created through traceability within textile- and apparel value chains?	*What are the key drivers for traceability implementation?*	Institutional drivers	Normative drivers	2, 3
			Regulative drivers	3,4
			Cultural-cognitive drivers	5
	How is traceability data flow facilitated in practice?	Traceability data flow	Data points	6
			Data collection	7, 9, 10
			Data storage	8, 10
			Data exchange	11
	How is traceability linked to business objectives?	Value creation	Derivates of traceability implementation	12
			Relevant data points in fiber production	13
			Value for commissioning company	12, 13

Appendix 3 Interview Guide

This interview covers topics around traceability within the textile and apparel value chains.

INTRODUCTION & BACKGROUND:

1. How would you describe your personal experience and represented company's role within the textile and apparel industry?

INSTITUTIONAL DRIVERS FOR TRACEABILITY IMPLEMENTATION:

2. Has your company established some minimum data requirements for collecting traceability data from your value chain?
    - What are these requirements based on?
3. Do you have or follow any regulatory guidelines for collecting or storing traceability data?
    - If yes, which ones and why?
    - If not, why?
4. How have you prepared for the implementation of the EU Digital Product Passport?
    - How do you continue to do this?
    - What challenges may lie in this?
5. Has your company established any company specific targets for traceability implementation?

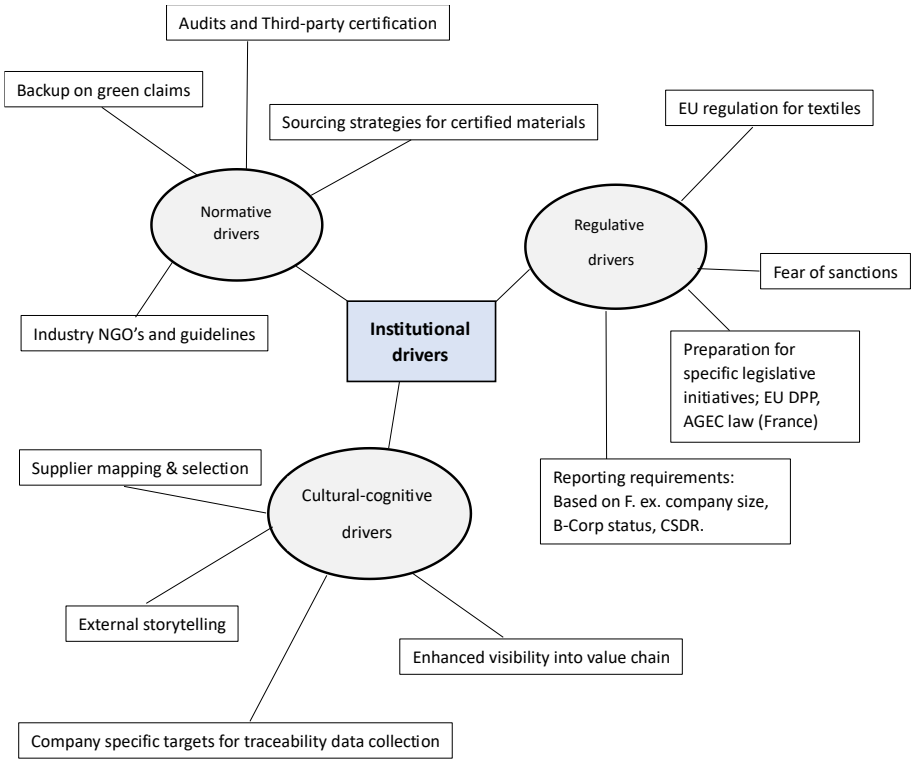
TRACEABILITY DATA FLOW:

6. What traceability data do you collect?
    - How do you identify which data is relevant to you?
7. How do you collect traceability data?
8. How do you store traceability data?
9. Have you used a physical tracker to facilitate traceability data flow?
    - If yes, which one and why?
    - If not, why?
10. Have you used a technological (digital platform) solution to implement traceability practices?
    - If yes, which one and why?
        - If not, why?
11. Does your company communicate externally on traceability topics?
        - If not, why?
        - If yes, which topics and why?

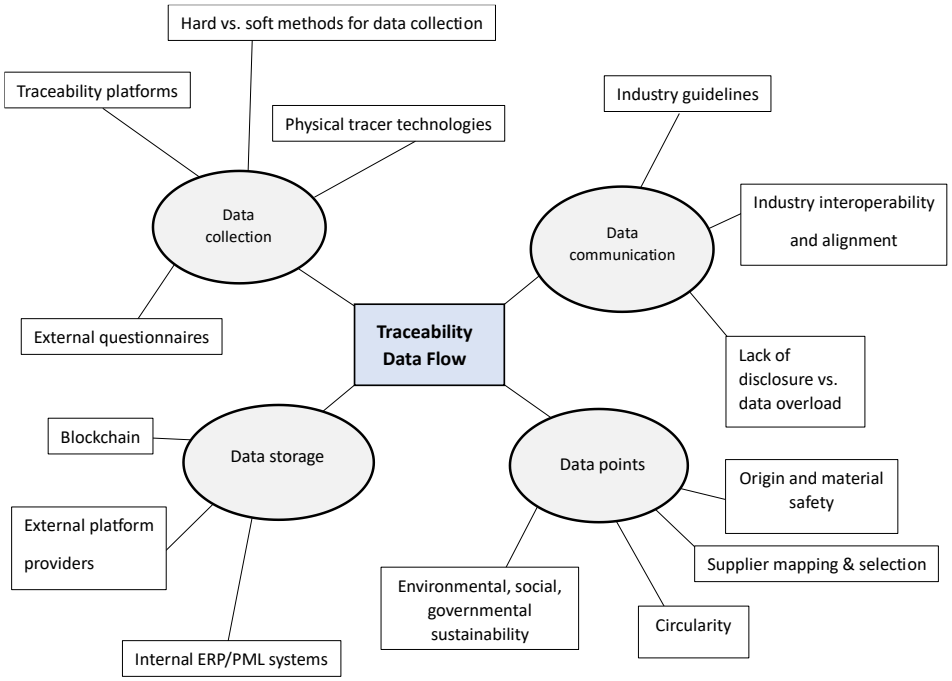
VALUE CREATION:

12. How do you see value being created by fostering traceability within your organization?
13. What traceability information is relevant to your company regarding Infinna™ fiber manufacturing process?
    - Why?

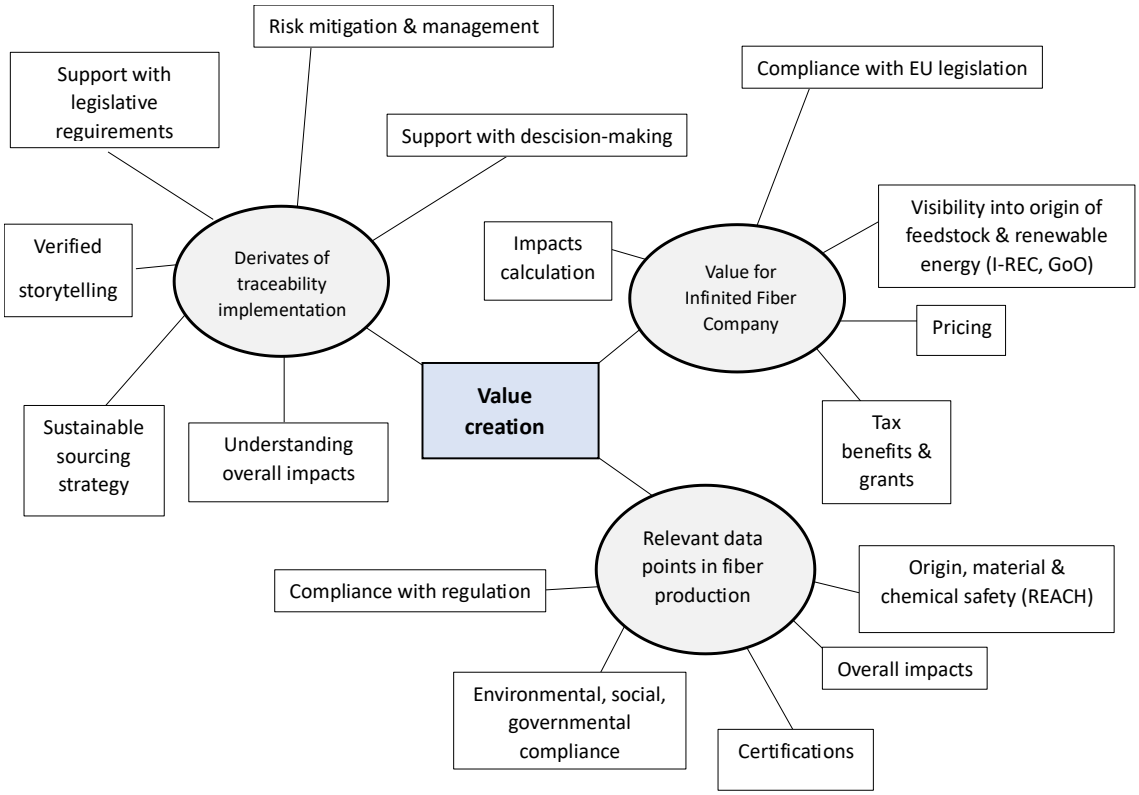
Appendix 4 Thematic Networks



Institutional drivers identified from interview data



Traceability Data Flow based on interview data



Perceptions of value creation through traceability