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Digital traceability systems in multi-tier supply networks: an information integration perspective from the fashion industry

Laura Macchion
Department of Management and Engineering, Universita degli Studi di Padova, Padova, Italy

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Abstract

Purpose – This study investigates how digital traceability systems operate as inter-organisational information systems (IOS) enabling information integration, visibility, and coordination across multi-tier fashion supply networks. Focusing on how firms build digital traceability infrastructures in anticipation of forthcoming regulatory requirements, the study examines the strategic, institutional, and operational drivers, socio-technical mechanisms, and traceability configurations that shape data integration and governance across organisational tiers.

Design/methodology/approach – The study adopts an in-depth qualitative case study of an Italian luxury fashion supply network involving actors from raw material sourcing to final product distribution. Data were collected between September 2025 and January 2026 through semi-structured interviews, plant visits, and archival documentation. Data analysis followed an iterative Gioia-inspired coding process combining within-case and cross-tier analysis to examine how traceability systems are designed, integrated, and coordinated across organisational boundaries.

Findings – The findings show that traceability adoption is driven by sustainability pressures, quality management requirements, brand protection concerns, and coordination needs. From an information systems perspective, effective traceability depends on the interaction between data standardisation, information and communication technology (ICT) integration, digital platform architectures, and relational governance mechanisms that collectively enable distributed data generation, validation, and exchange across supply network actors. The study further introduces the concept of traceability depth, defined as the degree of informational granularity and cross-tier visibility embedded within traceability architectures. It demonstrates that firms balance batch-level and item-level traceability configurations to manage trade-offs between information visibility, operational complexity, and coordination requirements across supply chain tiers.

Originality/value – This study contributes to the literature on inter-organisational information systems and supply network digitalisation by conceptualising traceability as a distributed socio-technical information infrastructure rather than merely a compliance-oriented tracking mechanism. It extends existing traceability research beyond regulated contexts by explaining how digital platforms, governance practices, and information architectures enable multi-tier information integration and coordination across complex supply networks. It also introduces traceability depth as an information systems design dimension capturing variations in informational granularity and visibility across organisational tiers.

Keywords Digital traceability systems, Supply networks, Data integration, Sustainability, Inter-organisational information systems

Paper type Research article

1. Introduction

The collapse of the Rana Plaza building in 2013 starkly revealed the opacity of global fashion supply chains and triggered a decade-long debate on transparency and responsibility in the fashion industry. The event exposed how many brands lacked visibility over their extended supply networks, which often involve multiple subcontractors performing specialised

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production activities without direct control from focal firms. In response, growing societal expectations and institutional pressures have intensified demands for transparency and accountability within fashion supply networks (Mejías *et al.*, 2019; Karaosman *et al.*, 2020; Malik *et al.*, 2021; Viet *et al.*, 2023). These pressures have been further reinforced by regulatory developments such as the Corporate Sustainability Reporting Directive (CSRD), the Corporate Sustainability Due Diligence Directive (CSDDD), and the Ecodesign for Sustainable Products Regulation (ESPR), including the forthcoming Digital Product Passport (DPP). Together, these initiatives are progressively reshaping firms' requirements to collect, manage, and disclose detailed supply chain information, even though several sector-specific implementation measures and technical specifications were still under development during the period of this study (Hunka *et al.*, 2025; Latino *et al.*, 2022; Jackson *et al.*, 2020; Perano *et al.*, 2023).

In parallel, rapid advancements in digital technologies have expanded the opportunities for improving transparency across global supply networks. Firms are increasingly deploying digital systems to capture, store, and share data related to production processes, material flows, and supply chain actors across organisational boundaries (Sodhi and Tang, 2019; Goworek *et al.*, 2020; Malik *et al.*, 2021). Within this context, traceability has emerged as a critical mechanism enabling the identification and tracking of products, components, and processes throughout the supply chain (ISO 9001, 2015). In the fashion industry, digital technologies such as RFID, blockchain, and web-based platforms allow firms to generate and exchange real-time information about product origins and transformations, thereby supporting transparency, sustainability, and informed decision-making (Shou and Domenech, 2022; Liu *et al.*, 2023; Friedman and Ormiston, 2022; Khan *et al.*, 2023; Razak *et al.*, 2023; Zhou *et al.*, 2024; Horcea-Milcu *et al.*, 2024).

Traceability systems can be conceptualised as inter-organisational information systems (IOS) and distributed digital infrastructures enabling data integration, coordination, and visibility across heterogeneous supply network actors. Rather than merely supporting operational tracking, these systems facilitate the generation, standardisation, validation, and exchange of data throughout the network through shared digital platforms, interoperable information architectures, and governance mechanisms. In this sense, digital traceability systems represent socio-technical infrastructures that support coordination in complex multi-tier supply networks characterised by fragmented production structures and distributed information sources.

Despite the growing relevance of traceability in practice, the academic literature remains fragmented and largely sector-specific. Existing research has predominantly focused on compliance-driven traceability systems in regulated industries such as agri-food and pharmaceuticals (Kayikci *et al.*, 2022; Zhou *et al.*, 2023; İndap and Tanyaş, 2023; Bharathi *et al.*, 2025; Giri *et al.*, 2025), where traceability is primarily conceptualised as a regulatory tool for ensuring product safety. By contrast, limited attention has been devoted to understanding traceability in contexts where it is formally voluntary yet increasingly built in anticipation of regulation, as a strategic and digital capability. This gap is particularly evident in the fashion industry, characterised by fragmented, globally dispersed, and multi-tier supply networks. Prior studies have often focused on focal firms or downstream transparency initiatives, overlooking upstream sourcing stages and the inter-organisational information systems required to support coordination across supply chain tiers. Moreover, existing traceability research has paid limited attention to how digital traceability infrastructure function as inter-organisational information infrastructures enabling information integration and sharing across multiple organisational tiers. While prior studies have examined traceability technologies and transparency initiatives, less is known about how data architectures, platform-based coordination mechanisms, and governance structures collectively enable information integration and visibility across complex supply networks. As a result, important information systems questions concerning interoperability, data governance, cross-tier integration, and socio-technical coordination remain underexplored.

In such contexts, implementing traceability systems requires the integration of digital infrastructures, the standardisation of data across heterogeneous actors, and the establishment of governance practices that enable reliable information exchange. These challenges are particularly pronounced in fashion supply networks, where multiple actors operate across different countries and institutional environments (Saccani *et al.*, 2023). At the same time, traceability is increasingly viewed as a strategic capability for supporting sustainability, enhancing brand legitimacy, and enabling transparency towards stakeholders (Roy, 2021; Erhun *et al.*, 2021; Yavaprabhas *et al.*, 2023; Vazquez Melendez *et al.*, 2024). Against this background, this study investigates how fashion firms operationalise sustainability through digital traceability infrastructure within multi-tier supply networks. Specifically, the research examines the drivers, digital enabling mechanisms, and design choices that shape the implementation of traceability systems across supply chain tiers. Adopting an inter-organisational information systems perspective, the study conceptualises traceability systems as distributed socio-technical infrastructures supporting information integration, coordination, and visibility across organisational boundaries. Accordingly, the study addresses the following research questions: RQ1: How do fashion firms build digital traceability infrastructures in anticipation of forthcoming regulatory requirements (e.g. the EU's CSDDD, CSRD, and ESPR), and what strategic, institutional, and operational drivers shape the resulting depth of these infrastructures across multi-tier fashion supply networks?; RQ2: How do digital, informational, relational, and configurational mechanisms shape the design and effectiveness of traceability systems across organisational tiers, and what are the implications for inter-organisational information systems (IOS) design?

To answer these questions, the study adopts an in-depth qualitative case study of an Italian luxury fashion supply network, analysing how data flows, digital infrastructures, and governance mechanisms support traceability implementation across multiple tiers, from raw material sourcing to final product distribution. This study contributes to the literature on inter-organisational information systems and supply network digitalisation in three main ways. First, it extends traceability research beyond compliance-oriented perspectives by conceptualising digital traceability systems as inter-organisational information infrastructures enabling distributed information integration across multi-tier supply networks. Second, the study explains how socio-technical mechanisms—including data standardisation, ICT integration, digital platforms, and relational governance—collectively enable cross-tier coordination and information visibility across heterogeneous organisational actors. Third, the study introduces the concept of traceability depth as an information systems design dimension capturing variations in informational granularity and cross-tier visibility across supply network stages.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature, positioning the specific gap addressed by this study. Building on the research questions introduced above, Section 3 develops the analytical framework. Section 4 describes the research methodology and case study design. Section 5 presents the empirical findings, while Section 6 discusses the theoretical and managerial implications of the study. Finally, Section 7 concludes the paper by outlining the main contributions, limitations, and directions for future research.

2. Theoretical background

2.1 Digital traceability systems as inter-organisational information infrastructures

Traceability has long been recognised as a critical mechanism for ensuring visibility and control across supply chains. According to ISO 8402:1994, traceability refers to the ability to track the history, use, and location of a specific entity through identification systems. This definition was further extended in ISO 9001:2000 to include network traceability, which involves tracing the history, use, and location of products and processes throughout an entire supply network (Karlsen *et al.*, 2013). In practical terms, traceability requires the identification of all stages of purchasing, production, and distribution, where product units are appropriately labelled and information is exchanged among actors across the network (Hu *et al.*, 2013). Traceability can be conceptualised as a distributed inter-organisational system that enables the generation, standardisation, and exchange of data across multiple supply chain actors. In this view, traceability is not limited to tracking physical flows but also involves the management of information flows that connect heterogeneous organisations through shared data infrastructures. These systems rely on digital technologies to capture, store, and transmit data associated with products, processes, and actors, thereby enabling visibility and coordination throughout the network.

Inter-organisational information systems (IOS) literature provides an important theoretical lens for understanding how digital traceability systems support coordination across distributed supply network actors. IOS are commonly defined as shared information systems that enable information exchange, coordination, and collaboration across organisational boundaries (Johnston and Vitale, 1988; Kumar and van Dissel, 1996). Unlike internally focused enterprise systems, IOS connect multiple autonomous organisations through shared digital infrastructures, enabling the integration of heterogeneous data sources and the coordination of interdependent activities.

Within complex supply networks, IOS play a critical role in supporting cross-tier visibility, reducing coordination uncertainty, and enabling collaborative decision-making across organisational tiers (Robey *et al.*, 2008). These systems often emerge through the interaction between technological infrastructures, governance arrangements, and relational coordination mechanisms, reflecting the socio-technical nature of inter-organisational digital systems. In this context, digital traceability infrastrucutres can be conceptualised as IOS infrastructures that connect upstream and downstream actors through shared data architectures, interoperable standards, and platform-enabled information exchange mechanisms. This perspective shifts the understanding of traceability beyond operational tracking and compliance monitoring towards the management of distributed information flows across multi-tier supply networks. Traceability systems therefore operate not only as mechanisms for identifying physical products, but also as digital infrastructures enabling the generation, integration, validation, and exchange of information across heterogeneous organisational actors. While traceability and transparency are closely related, they are not conceptually equivalent. Traceability refers to the capability to identify, reconstruct, and track products, materials, and transformations across supply chain stages, whereas transparency concerns the extent to which such information is made visible and accessible to organisational actors and external stakeholders (Roy, 2021). In this sense, traceability systems represent enabling infrastructures through which different degrees of supply chain transparency can be achieved.

The concept of traceability is typically articulated through two complementary processes: tracing and tracking. Tracing refers to the ability to identify the origin and characteristics of a product within the supply network, while tracking refers to the ability to follow the downstream path of a product from suppliers to customers (Karlsen *et al.*, 2013). Furthermore, traceability can operate at different levels. Internal traceability refers to the ability to track and trace product batches within the boundaries of a single organisation, whereas network traceability involves the monitoring of product flows across multiple supply chain actors, from raw material sourcing to final distribution (Karlsen *et al.*, 2013). As supply chains become increasingly global and complex, network traceability has become particularly relevant for coordinating both material and information flows throughout the network. These developments are particularly relevant for the fashion sector, which is currently preparing for the implementation of the EU Digital Product Passport (DPP) under the Ecodesign for Sustainable Products Regulation (ESPR). Such regulatory initiatives aim to improve supply chain transparency by requiring companies to provide detailed, structured, and interoperable information about product origins, materials, and environmental impacts. In this context, traceability systems increasingly function as digital infrastructures supporting compliance, transparency, and circular economy practices, while enabling the integration and accessibility of data across supply networks (Abdelmeguid *et al.*, 2024; Sharma *et al.*, 2025).

Most of the existing literature on traceability has focused on agri-food supply chains (e.g. Regattieri *et al.*, 2007; Bendaoud *et al.*, 2012; Karlsen *et al.*, 2013; Bosona and Gebresenbet, 2013). In these contexts, traceability systems are primarily designed to ensure food safety and protect consumers from contamination risks. As a result, many studies have analysed traceability practices in perishable goods supply chains such as meat (Smith *et al.*, 2008), grain (Thakur and Hurburgh, 2009), fish (Thompson *et al.*, 2005), fruit (Canavari *et al.*, 2010), and vegetables (Hu *et al.*, 2013). Within these industries, traceability systems are often mandated by regulatory frameworks and focus on enabling rapid product recall and contamination management. However, in global industries such as fashion, the role of traceability extends beyond regulatory compliance and operational control.

In the fashion industry, traceability increasingly supports objectives related to ethical sourcing, sustainability assurance, product authenticity, and brand reputation. Due to the high level of internationalisation and fragmentation that characterises fashion supply chains, companies face increasing challenges in maintaining visibility and control over extended supplier networks. Consequently, traceability systems are gaining importance as mechanisms for identifying supply chain actors, monitoring production processes, and supporting country-of-origin strategies. This implies the need to integrate data across multiple tiers of the supply network and to ensure the interoperability of information systems across heterogeneous actors. The fashion industry plays a significant role in the European economy. As of 2021, the European fashion industry generated approximately €367 billion in sales and employed more than 2 million people (EURATEX, 2017). In Italy, the fashion industry generated around €95.5 billion in revenue in 2020, with exports representing nearly 70% of total production (Sistema Moda Italia, 2021). Given the economic relevance of the sector, improving supply chain transparency has become a priority for many fashion companies, particularly with regard to raw material sourcing. In recent years, several fashion companies have begun addressing traceability issues by increasing transparency in their supply chains. For example, Patagonia has introduced initiatives allowing customers to verify the origin of raw materials, while Arket and Everlane provide detailed information about suppliers and production processes. Adidas has also implemented initiatives such as the Better Cotton Initiative to improve sustainability and traceability within its supply chain. In parallel, the European Union has been developing policy initiatives aimed at improving traceability in the fashion industry. These include digital platforms enabling companies to report supply chain data and provide consumers with greater visibility regarding product origin and environmental impact, as well as due diligence regulations requiring firms to monitor social and environmental conditions across their supply chains (Saha *et al.*, 2021). These developments further reinforce the role of traceability as a data-driven mechanism supporting transparency and accountability.

Despite increasing attention from policymakers and industry actors, there are currently no universally accepted standards defining how traceability systems should be designed and implemented in fashion supply chains. As a result, companies often develop proprietary solutions or rely on third-party providers to support traceability initiatives. This lack of standardisation creates challenges for interoperability, data integration, and information sharing across supply networks. Furthermore, existing academic research remains limited and fragmented, often focusing on focal firms or downstream activities (Bottani and Rizzi, 2008; Moon and Ngai, 2010), while upstream sourcing stages and inter-organisational data integration mechanisms remain underexplored. Even recent fashion-specific traceability studies (e.g. Benstead *et al.*, 2024) have continued to emphasise operational and compliance-related aspects of traceability, leaving the inter-organisational information systems dimension of multi-tier fashion supply networks comparatively underexplored. This study addresses this gap; the related literature on Open Book Accounting, which focuses primarily on cost-information sharing rather than traceability-related data integration, is considered beyond the scope of the present analysis.

Addressing these challenges requires the development of digital architectures and governance practices capable of supporting traceability across complex, multi-tier supply networks (Reck *et al.*, 2022). By enabling the integration of information across multiple organisational layers, traceability systems have the potential to enhance transparency, support sustainability initiatives, and strengthen coordination among supply chain actors. This study contributes to this emerging research stream by examining how traceability systems operate as inter-organisational information systems within multi-tier fashion supply networks.

2.2 Information integration and platform-enabled coordination in multi-tier supply networks

Increasing fragmentation and global dispersion within supply networks have intensified the challenges associated with integrating information across firms, technologies, and operational processes. Multi-tier supply networks typically involve independent organisations operating different enterprise systems, governance structures, and data management practices, thereby increasing coordination complexity and limiting information visibility across supply chain stages (Sodhi and Tang, 2019). Under these conditions, information integration becomes a critical capability enabling firms to coordinate distributed activities and manage interdependent information flows across organisational boundaries. Within the information systems literature, integration extends beyond simple data exchange and involves the alignment of technological, semantic, and organisational dimensions of information sharing. Prior studies distinguish between syntactic integration, which concerns the compatibility of data formats and technical standards; semantic integration, which refers to the consistency of meanings and interpretations associated with shared information; and pragmatic integration, which concerns the coordinated use of information within organisational processes and decision-making activities (Barki and Pinsonneault, 2005). Achieving integration across these dimensions is particularly challenging in multi-tier supply networks characterised by fragmented governance structures, heterogeneous digital systems, and uneven technological capabilities among actors.

Recent IS research increasingly conceptualises digital platforms as coordination infrastructures enabling interoperability, visibility, and distributed collaboration across organisational actors (Tiwana, 2014; de Reuver *et al.*, 2018). Platform-based architectures allow multiple organisations to generate, validate, access, and exchange information through shared digital infrastructures, thereby facilitating coordination across supply network tiers. In supply chain contexts, such platforms support the integration of upstream and downstream information flows, enabling firms to reconstruct product histories, monitor operational activities, and improve decision-making across distributed organisational environments.

Within digital traceability systems, platform-enabled coordination mechanisms are particularly important because traceability depends on the continuity, reliability, and synchronisation of information across multiple transformation stages. Shared digital platforms support the alignment of product identifiers, transformation records, logistics information, and sustainability-related data across heterogeneous actors operating different technological systems. Through these mechanisms, traceability systems function as inter-organisational information infrastructures that connect physical product flows with distributed digital information flows across organisational boundaries. These digital platforms also create significant governance and interoperability challenges. The integration of traceability information across organisational tiers requires the establishment of shared standards, validation procedures, access rights, and coordination protocols capable of supporting trustworthy information exchange. Technological compatibility alone is therefore insufficient to ensure effective integration. Rather, interoperability depends on organisational alignment, governance arrangements, and relational coordination mechanisms capable of supporting continuous information sharing among distributed actors. Additional complexity emerges from asymmetries in visibility and control within platform-based environments. Focal firms frequently assume a central role in defining data standards, controlling information access, and orchestrating data flows, while smaller upstream suppliers may possess limited bargaining power and uneven digital capabilities. Digital traceability infrastructures should therefore be understood as socio-technical systems shaped by this interaction between digital architectures and governance arrangements, rather than as purely technological infrastructures.

An IOS perspective further highlights how different forms of interdependence among supply network actors influence the complexity of traceability coordination and distributed information sharing. Classic IOS research distinguishes between pooled, sequential, and reciprocal interdependence structures, each associated with different coordination requirements and governance arrangements (Johnston and Vitale, 1988; Kumar and van Dissel, 1996; Robey *et al.*, 2008). In multi-tier fashion supply networks, traceability systems frequently operate under conditions of reciprocal interdependence, where upstream and downstream actors continuously exchange, validate, and update interconnected traceability information across multiple transformation stages; failures in syntactic or semantic integration under these conditions can reduce information visibility and undermine inter-organisational coordination (Cimino *et al.*, 2008; Engelseth, 2009; Guercini and Runfola, 2009; Sodhi and Tang, 2019). These challenges are particularly pronounced in the fashion industry due to the fragmentation, global dispersion, and multi-tier configuration of fashion supply networks, where specialised suppliers operate across different institutional and technological environments. Coordinating such reciprocal interdependence relies not only on interoperable technologies, but also on inter-organisational control mechanisms, which can be formal, such as contractual arrangements, performance monitoring systems, and standardised reporting procedures (Dekker, 2004; Van der Meer-Kooistra and Vosselman, 2000), or informal, relying on trust-based relationships and shared norms that reduce opportunistic behaviour (Langfield-Smith and Smith, 2003). In digital traceability systems, both formal and informal control mechanisms play complementary roles in ensuring data reliability, information continuity, and coordination effectiveness across partners.

Describing which information is shared across tiers is, however, only a first step towards an information systems contribution; a fuller account must also explain how the digital infrastructure itself reshapes the social and power dynamics of the network. Three complementary theoretical lenses are useful here. First, affordance theory suggests that a digital platform does not have fixed effects on practice, but offers specific action possibilities, such as real-time data entry, cross-tier visibility, and automated validation, that emerge from the interaction between the platform's material properties and the goals of the actors who use it (Zammuto *et al.*, 2007; Leonardi, 2011). Second, identification technologies such as RFID tags, digital identifiers, and shared records do not operate independently of organisational practices. Instead, their value emerges through continuous interaction with existing routines, production processes, and local operational constraints. These technologies enable new forms of coordination, such as real-time batch tracking and continuous information updating, while their implementation is simultaneously adapted to heterogeneous organisational contexts characterised by legacy systems, different levels of digital capability, and diverse operational practices (Orlikowski, 2007; Leonardi, 2011). Third, the shared traceability records analysed in this study function as boundary objects, artefacts that are flexible enough to be interpreted and used differently by actors with heterogeneous local practices, such as a supplier's paper-based batch record, an intermediate actor's ERP export, or the focal company's RFID-linked identifier, while retaining enough shared structure to enable translation and coordination across tiers (Star and Griesemer, 1989). It is precisely at this translation point that power asymmetries become visible: actors who define the structure of the boundary object retain greater interpretive control over the network's information architecture than actors who must adapt their local practices to fit it, a dynamic examined further in the Discussion.

2.3 Drivers and governance of digital traceability systems

Traceability systems are adopted for a variety of strategic, operational, and regulatory reasons across different industries. These drivers can be interpreted as pressures that require firms to develop capabilities for data generation, integration, and sharing throughout the network. Understanding these drivers is particularly important in industries such as fashion, where traceability initiatives are formally voluntary, but where, as discussed further below, forthcoming EU due-diligence and disclosure regulations are increasingly shaping their timing and design. In regulated sectors such as agri-food, traceability systems have historically emerged in response to major food safety crises, including the outbreak of Bovine Spongiform Encephalopathy (BSE) during the 1990s. These events led to the introduction of strict regulations requiring companies to implement systems capable of collecting, storing, and sharing real-time information about product batches across all actors involved in the supply network. Such systems enable contaminated products to be traced back to their origin and support rapid recall procedures, thereby ensuring consumer safety and regulatory compliance (Donnelly *et al.*, 2009). In this context, traceability systems function as information infrastructures designed to support data accuracy, reliability, and accessibility across organisational actors. Beyond regulatory requirements, traceability systems are increasingly adopted to support strategic and operational objectives that rely on enhanced visibility. One important driver relates to the prevention of market fraud and product counterfeiting (Merlano *et al.*, 2024). The expansion of global supply networks and digital marketplaces has increased the circulation of counterfeit goods, creating significant risks for both firms and consumers (Song *et al.*, 2021; Pun *et al.*, 2021). Traceability systems address this challenge by enabling the authentication and verification of product-related data across supply chain stages. Technologies such as RFID, barcodes, electronic product codes, and digital identifiers allow firms to create and manage unique data records associated with products, thereby strengthening information reliability and product authenticity (Li, 2013; Tan and Sidhu, 2022).

Although traceability adoption in the fashion industry remains formally voluntary, the timing and design of the analysed traceability initiative cannot be fully understood without considering the evolving European regulatory context in which it was developed. Data collection took place between September 2025 and January 2026, a period during which the regulatory framework governing sustainability reporting, supply chain due diligence, and product traceability was undergoing rapid development. While the Corporate Sustainability Reporting Directive (CSRD) had already entered its phased implementation and the Corporate Sustainability Due Diligence Directive (CSDDD) was progressively reshaping corporate due diligence expectations, the sector-specific implementation measures for the Ecodesign for Sustainable Products Regulation (ESPR)—including the Delegated Acts defining the Digital Product Passport (DPP) requirements for textile and fashion products—had not yet been adopted. Consequently, firms operated in a context characterised by increasing regulatory direction but considerable implementation uncertainty, requiring them to design digital traceability infrastructures capable of accommodating forthcoming regulatory obligations whose detailed technical specifications were still under development. Several informants explicitly linked the traceability initiative to these forthcoming regulatory developments rather than presenting it as a purely discretionary strategic choice. Rather than responding to fully defined legal requirements, firms were proactively preparing their information infrastructures for a regulatory environment whose implementation details and technical standards were still evolving. Accordingly, this study interprets the focal company's traceability initiative as an anticipatory organisational response to regulatory uncertainty, in which digital traceability infrastructures were designed ahead of the full implementation of the relevant regulatory framework. This perspective has important implications for the design of inter-organisational information systems (IOS). Under conditions of regulatory uncertainty, decisions concerning data granularity, platform architecture, governance arrangements, interoperability, and information integration cannot be regarded as fixed compliance choices; instead, they represent adaptive design decisions intended to provide sufficient flexibility for accommodating future regulatory requirements as the European framework and its sector-specific implementation measures become fully operational.

A second key driver concerns the need to improve coordination, communication, and control within increasingly complex supply networks. As supply chains become more fragmented and geographically dispersed, firms face growing challenges in managing information flows across multiple actors (Mathew and Spinelli, 2025). Traceability systems enable the integration of data across organisational tiers, supporting real-time information exchange and enhancing visibility over product flows. Improved data sharing can reduce information asymmetries, enhance operational efficiency, and support more effective decision-making across the supply network (Guercini and Runfola, 2009; Karlsen *et al.*, 2013). In this sense, traceability systems act as inter-organisational information platforms that facilitate coordination and alignment among supply chain partners. Traceability systems also support product quality management and process optimisation. By enabling the collection and analysis of data related to production processes and product attributes, these systems allow firms to identify defects, monitor performance, and improve quality control. For example, traceability enables companies to isolate defective batches and limit the scope of product recalls, thereby reducing operational disruptions. Moreover, the availability of shared data across supply chain actors can support collaborative innovation and continuous improvement of products and processes (Herrmann, 1999; Ermini *et al.*, 2024).

Another important driver relates to the increasing role of transparency as a source of competitive advantage. By providing access to detailed and verifiable information about product origins and production processes, firms can strengthen brand reputation and build consumer trust. This requires the development of digital interfaces and data-sharing mechanisms that allow information to be communicated effectively to external stakeholders. In the fashion industry, particularly in the luxury segment, traceability data associated with country-of-origin and production practices play a critical role in shaping customer perceptions of quality and authenticity (Diallo *et al.*, 2021; Holmqvist and Kowalkowski, 2023). Consequently, traceability systems are increasingly viewed as strategic information assets supporting differentiation and competitive positioning (Karlsen *et al.*, 2013; Garcia-Torres *et al.*, 2022). In addition to reputational benefits, traceability systems can generate valuable data-driven insights. By collecting information on product flows, production processes, and customer interactions, firms can analyse purchasing behaviours and improve market segmentation strategies. These data-driven capabilities allow firms to align product design and supply chain configurations with evolving consumer preferences (Karlsen *et al.*, 2013). In this sense, traceability systems contribute not only to operational transparency but also to strategic decision-making and data analytics.

Sustainability considerations represent another critical driver of traceability adoption. Global supply chains are increasingly scrutinised for their environmental and social impacts, and firms face growing pressure from regulators, non-governmental organisations, and consumers to demonstrate responsible sourcing practices. The fashion industry, in particular, is associated with significant environmental impacts and complex sourcing structures (De Brito *et al.*, 2008). Traceability systems support sustainability objectives by enabling the collection and integration of data related to material origins, resource consumption, and production conditions. By improving visibility over upstream supply chain activities, firms can monitor environmental performance, reduce waste, and promote sustainable practices (Fornasiero *et al.*, 2017; Hickmann *et al.*, 2024; Huemer and Flygansvær, 2025; Negri, 2025; Burini *et al.*, 2025; Ru *et al.*, 2026). Beyond enabling supply chain transparency and sustainability monitoring, digital traceability infrastrucutres increasingly support supply chain risk management and environmental performance objectives. By providing visibility over upstream sourcing activities, traceability systems allow firms to identify and assess environmental and social risks across supplier networks, including risks associated with unsustainable sourcing practices, non-compliant production conditions, and supply chain disruptions (Sodhi and Tang, 2019; Razak *et al.*, 2023). Furthermore, traceability data can support the monitoring and reporting of carbon emissions and environmental impacts across supply chain stages, thereby contributing to corporate climate objectives and regulatory compliance requirements emerging from initiatives such as the European Green Deal and the Corporate Sustainability Reporting Directive (CSRD). In this sense, digital traceability systems increasingly function as data infrastructures supporting not only operational transparency but also environmental risk governance and emissions accountability across distributed supply networks. Furthermore, traceability systems can help identify social issues within supply chains, such as child labour, forced labour, or unsafe working conditions, by providing access to verified information across supply network actors (Karlsen *et al.*, 2013; Kimbro *et al.*, 2018; Masterson *et al.*, 2019; Martínez and Poveda, 2022). This highlights the role of traceability as a data-driven mechanism supporting accountability and ethical decision-making across supply networks.

Beyond enabling transparency and sustainability, digital traceability infrastructures also create important governance challenges associated with inter-organisational information sharing. Prior studies on inter-organisational systems and supply chain transparency have shown that increased visibility may generate tensions concerning data ownership, selective disclosure, commercial confidentiality, and unequal supplier capabilities (Kumar and van Dissel, 1996; Egels-Zandén and Hansson, 2016; Hannibal and Kauppi, 2019). In multi-tier supply networks, focal firms often depend on upstream actors with heterogeneous technological capabilities and varying willingness to disclose operational information. Consequently, implementing traceability systems requires not only technological infrastructures, but also governance mechanisms capable of balancing transparency, coordination, and control across organisational actors. These coordination mechanisms include the definition of shared data standards, validation procedures, access rights, and coordination protocols regulating how information is generated, exchanged, and used across organisational tiers. As noted above, this interaction between technological integration and relational governance remains central to ensuring trustworthy information exchange across distributed actors.

Traceability systems generate multiple benefits for fashion supply networks, including improved operational control, enhanced collaboration, stronger product quality, and increased transparency. From an information systems perspective, these benefits emerge from the ability of traceability systems to integrate, standardise, and share data across distributed actors. As sustainability and transparency requirements continue to grow, traceability systems are becoming essential digital infrastructures supporting responsible production and consumption patterns (Li *et al.*, 2020).

2.4 Digital traceability architectures and information integration in supply networks

A network traceability system can be understood as a combination of technological, informational, and organisational components that enable product identification, data transmission, information sharing, and location tracking across supply networks (Regattieri *et al.*, 2007). Traceability systems operate as distributed digital infrastructures that integrate data across organisational boundaries, supporting both the tracking of physical flows and the management of information flows. Designing such systems therefore requires not only functional capabilities for tracing and tracking products, but also the development of information architectures that enable reliable data capture, storage, and exchange among heterogeneous supply chain actors (Hu *et al.*, 2013).

Within multi-tier supply networks, information integration represents a critical challenge because organisations often operate heterogeneous information systems, data standards, and technological infrastructures. As a result, digital traceability systems must support interoperability throughout the network by enabling the alignment of syntactic, semantic, and operational dimensions of information exchange (Barki and Pinsonneault, 2005). In this context, traceability systems function not merely as operational tracking tools, but as inter-organisational information architectures supporting coordination, visibility, and distributed decision-making across supply network actors.

Effective traceability requires interoperable inter-organisational information systems capable of aligning data across multiple actors. Supply networks typically involve organisations with different technological capabilities, data standards, and information management practices. As a result, traceability requires the implementation of interoperable digital systems that allow data to be collected, structured, and shared in a consistent manner across the network (Cimino *et al.*, 2008). Interoperability is achieved through the standardisation of data formats, coding systems, and information protocols, enabling actors to interpret and use shared data effectively. To ensure traceability across the network, each Traceability Resource Unit (TRU)—defined as the individual item or production batch subject to traceability—must be uniquely identified and monitored throughout the supply chain. TRUs can be associated with digital identifiers embedded in products or batches through technologies such as barcodes, RFID tags, or electronic product codes (Ngai *et al.*, 2007). These identifiers generate data records that are continuously updated as products move across supply chain stages. The reliability of traceability systems therefore depends on the accuracy, consistency, and completeness of data generated by each actor involved in the network. The identification and management of TRUs require firms to design appropriate data architectures defining how identifiers are generated, stored, and linked across supply chain stages. This includes defining data structures, establishing data validation procedures, and ensuring that information is consistently recorded at each transformation point. Because products often undergo multiple transformations during production processes, traceability systems must also manage data aggregation and disaggregation, ensuring continuity of information across different levels of granularity.

In inter-organisational information systems, maintaining continuity of data lineage across transformation stages represents a major architectural challenge. As products are aggregated, disaggregated, or transformed into new batches, digital traceability infrastructures must preserve the informational links connecting input materials, intermediate processes, and output products across multiple organisational tiers. This requires mechanisms for synchronising identifiers, validating data consistency, and coordinating information updates across distributed actors.

In the fashion industry, traceability practices are increasingly shaped by the need to integrate information across multiple supply chain actors and to provide visibility into production processes. Companies are adopting practices aimed at improving both internal data management and inter-organisational information exchange. One key practice involves establishing structured communication channels and shared digital platforms that enable actors to exchange data related to product origins, processing activities, and compliance with sustainability standards (Garcia-Torres *et al.*, 2022). These platforms support the coordination of supply chain activities and enable firms to monitor environmental and social performance across production networks.

Technological solutions play a central role in enabling digital traceability practices. RFID technologies, for example, allow products to be uniquely identified and tracked across supply chain stages, improving the accuracy and timeliness of data collection (Ozturk *et al.*, 2020). Similarly, blockchain technology has been proposed as a mechanism for enhancing data integrity and transparency in supply networks by creating decentralised and tamper-resistant records of transactions (de Boissieu *et al.*, 2021; Jimenez-Castillo *et al.*, 2024). Blockchain-based systems enable the secure storage and sharing of traceability data, allowing information about product origins, processing activities, and logistics movements to be accessed and verified by multiple actors (Hastig and Sodhi, 2020; Upadhyay *et al.*, 2021; Fan *et al.*, 2022; Shou and Domenech, 2022; Moretto and Macchion, 2022; Böhmecke-Schwafert *et al.*, 2022; Kumar *et al.*, 2022; Aloini *et al.*, 2023; Cole *et al.*, 2019; Dong *et al.*, 2025).

Recent studies have also highlighted significant barriers associated with the implementation of blockchain-enabled traceability systems, including scalability limitations, interoperability challenges, governance complexity, and unequal technological capabilities among supply chain actors (Kamath, 2018). These barriers are particularly relevant in fragmented and multi-tier industries such as fashion, where suppliers frequently operate heterogeneous legacy systems and possess uneven digital capabilities. Consequently, many firms adopt hybrid traceability architectures that combine multiple technologies and coordination mechanisms rather than relying on fully decentralised blockchain solutions.

Despite these advantages, the implementation of advanced digital traceability technologies presents several challenges. A major issue concerns the lack of standardisation and interoperability among different systems. Because supply chain actors may adopt heterogeneous digital infrastructures, ensuring seamless data exchange across organisations can be difficult (Manzoor *et al.*, 2022). Integrating traceability systems with existing enterprise systems often requires significant investments and organisational changes, particularly in complex industries such as fashion, where legacy systems and fragmented supply networks are common (Klöckner *et al.*, 2022; Tan and Salo, 2023). Cost considerations also represent a barrier to adoption, especially for small and medium-sized enterprises that may lack the resources to implement advanced digital infrastructures (Choi *et al.*, 2022). Additional challenges relate to data governance, privacy, and sustainability. Traceability systems must ensure that sensitive operational data are protected while enabling appropriate levels of information sharing across actors (Nygaard and Silkoset, 2023; Moretto and Macchion, 2022). Moreover, certain technologies, such as blockchain, are associated with high energy consumption, raising concerns about their environmental sustainability (Parmentola *et al.*, 2022; Khan *et al.*, 2021). Furthermore, recent critical perspectives have questioned whether traceability initiatives always generate substantive transparency improvements or whether, in some cases, they may also support symbolic transparency and greenwashing practices (Egels-Zandén and Hansson, 2016). The existence of digital traceability infrastructures does not automatically guarantee complete visibility across supply networks, as focal firms may selectively disclose information or prioritise specific sustainability indicators while obscuring others. This highlights the importance of governance mechanisms, data validation procedures, and inter-organisational accountability structures in ensuring the credibility and reliability of traceability systems.

One of the most prominent initiatives exploring digital traceability in the luxury fashion sector is the Aura Blockchain Consortium, developed by LVMH. This platform operates as a permissioned blockchain network that enables authorised actors to record and access traceability data across the supply chain. By linking product information to digital records, the platform supports product authentication, transparency, and consumer engagement through verified data. Compared with fully blockchain-based approaches such as Aura, many fashion firms currently adopt hybrid traceability architectures that combine RFID systems, barcodes, enterprise platforms, web-based interfaces, and organisational and governance practices (Papetti *et al.*, 2019; Friedman and Ormiston, 2022; Ali *et al.*, 2021; Zhang *et al.*, 2025), providing greater operational flexibility and enabling gradual integration across partners while reducing implementation complexity and interoperability constraints. Digital traceability in fashion relies on the integration of identification technologies, interoperable information systems, and governance mechanisms that collectively support coordination and transparency across multi-tier supply networks.

2.5 Traceability depth and information visibility across supply chain tiers

Existing traceability literature has primarily conceptualised traceability granularity in operational terms, focusing on the degree to which products, batches, or materials can be individually identified, monitored, and reconstructed throughout supply chains (Regattieri *et al.*, 2007; Karlsen *et al.*, 2013). Prior studies have shown that different levels of traceability granularity influence operational control, recall efficiency, product authentication, and visibility across supply networks (Donnelly *et al.*, 2009; Roy, 2021). In regulated industries such as agri-food and pharmaceuticals, traceability systems have traditionally prioritised batch-level identification mechanisms designed to support compliance, product safety, and contamination management (Karlsen *et al.*, 2013; Kayikci *et al.*, 2022). However, in industries characterised by fragmented and globally distributed supply networks, such as fashion, traceability configurations increasingly shape broader data integration and coordination capabilities across organisational tiers (Mejías *et al.*, 2019; Sodhi and Tang, 2019).

Traceability configurations influence not only operational monitoring, but also the extent to which information can be generated, integrated, accessed, and validated across multi-tier supply networks. Digital traceability systems therefore affect cross-tier visibility, interoperability, and coordination among firms operating different technological systems and governance structures (Garcia-Torres *et al.*, 2022; Holmqvist and Kowalkowski, 2023). Despite the growing relevance of these issues, existing literature has provided limited conceptualisation of how varying traceability configurations shape information visibility and cross-tier integration within inter-organisational information systems. Building on this perspective, this study introduces the concept of traceability depth, defined as the degree of informational granularity, continuity, and cross-tier visibility through which products, materials, and transformations are digitally identifiable and linkable across supply network stages.

Traceability depth therefore reflects how extensively information associated with products, processes, and transformations can be reconstructed, integrated, and accessed across organisational boundaries (Cimino *et al.*, 2008; Sodhi and Tang, 2019). Traceability depth includes multiple interrelated dimensions. First, it involves informational granularity, referring to whether traceability is implemented at batch level or item level (Regattieri *et al.*, 2007). Second, it concerns information continuity, namely the ability to preserve data lineage and informational links across transformation stages and organisational transitions (Donnelly *et al.*, 2009; Karlsen *et al.*, 2013). Third, it relates to cross-tier visibility, indicating the extent to which information can be shared, integrated, and accessed across upstream and downstream actors within the supply network (Sodhi and Tang, 2019; Garcia-Torres *et al.*, 2022). Finally, traceability depth reflects the scope of digital integration across organisational tiers, information systems, and platform architectures (Tiwana, 2014; de Reuver *et al.*, 2018). Different levels of traceability depth create trade-offs between operational feasibility, visibility, and coordination complexity across supply network stages (Roy, 2021; Mejías *et al.*, 2019). Upstream actors operating large-scale material flows frequently adopt batch-level traceability configurations that support aggregation and operational efficiency while limiting informational granularity (Donnelly *et al.*, 2009). By contrast, downstream actors in industries such as fashion increasingly implement item-level traceability systems to support product authentication, customer-facing transparency, sustainability communication, and brand protection (Garcia-Torres *et al.*, 2022; Holmqvist and Kowalkowski, 2023). In luxury fashion networks, greater traceability depth can also strengthen country-of-origin strategies, reinforce brand legitimacy, and support sustainability-oriented communication toward consumers and stakeholders.

At the same time, increasing traceability depth also generates higher data management complexity and integration requirements. Capturing and validating highly granular traceability data across multiple organisational actors requires interoperable digital infrastructures, standardised identifiers, governance mechanisms, and coordinated information-sharing practices (Cimino *et al.*, 2008; Sodhi and Tang, 2019). Moreover, differences in supplier digital capabilities, data quality, and willingness to disclose operational information may constrain the achievable level of traceability depth across supply network tiers (Hannibal and Kauppi, 2019). Traceability depth can therefore be understood as a design dimension of digital traceability architectures reflecting different configurations of informational visibility, interoperability, and coordination across supply chain tiers. This perspective extends existing traceability and supply chain visibility literature by conceptualising traceability depth not merely as operational granularity, but as a socio-technical characteristic of inter-organisational information infrastructures supporting distributed interoperability across multi-tier supply networks (Mejías *et al.*, 2019; Sodhi and Tang, 2019).

Taken together, the literature reviewed in this section shows that prior traceability research has been dominated by two partial perspectives: a compliance- and operations-oriented view rooted in regulated sectors such as agri-food, and a growing but still fragmented information-systems view that has introduced relevant constructs, IOS, data integration, platform-enabled coordination, without yet integrating them into a single account of how traceability infrastructures are built and governed across multi-tier, non-regulated supply networks such as fashion. None of the reviewed studies simultaneously addresses the anticipatory regulatory logic of traceability adoption, the socio-technical and power dynamics of platform-mediated coordination, and the configurational variation of traceability depth across heterogeneous organisational tiers. This is the specific gap the present study addresses: rather than reviewing these three streams as separate bodies of work, the remainder of the paper uses them as an integrated analytical lens, developed into the research questions and framework presented next, and subsequently mobilised as tools of analysis in the Methodology, Findings, and Discussion sections, where the concept of traceability itself shifts function, from an object of prior scholarly inquiry here in Section 2, to an analytical and theoretical lens applied to the empirical case in Sections 3 to 6. Section 3 does not revisit the literature reviewed above but operationalises these theoretical insights into the analytical framework that guides the empirical investigation.

This gap also has methodological implications. Capturing how traceability infrastructures are built and governed across heterogeneous, multi-tier actors calls for a research design able to investigate contemporary phenomena within their real-life context and to generate in-depth insight into an emerging research area, for which case study research is particularly well suited (Voss *et al.*, 2002; Yin, 1994), and specifically an embedded, single-case design of the kind proposed by Eisenhardt (1989) and Eisenhardt and Graebner (2007), given the need to examine multiple organisational tiers within one network. Within this tradition, the Gioia *et al.* (2013) approach to qualitative rigour offers a transparent way of connecting informant-centric evidence to the theoretical constructs discussed above, namely IOS, distributed information sharing, affordances, boundary objects, and configurational logic, and is therefore adopted, in adapted form, as the analytical procedure detailed in Section 4.

3. Research objectives and analytical framework

Many studies have examined the development and implementation of traceability systems, particularly in regulated sectors such as the agri-food industry, where traceability is primarily driven by legislative requirements and food safety regulations (Karlsen *et al.*, 2013; Annosi *et al.*, 2021; dos Reis and Machado, 2022). In these contexts, traceability systems are typically designed to ensure compliance and to support product recall procedures. Consequently, much of the existing literature conceptualises traceability as a compliance-oriented monitoring mechanism aimed at managing operational risks and ensuring product safety. However, in other industrial contexts, traceability remains formally voluntary but is increasingly implemented as part of broader strategic initiatives related to sustainability, transparency, and supply chain coordination. In industries such as fashion, traceability is rarely mandated but is increasingly shaped by anticipation of forthcoming regulation, and is therefore implemented as a proactive managerial choice. This creates a distinct context in which traceability adoption is shaped not only by regulatory pressures, but also by strategic motivations, technological capabilities, and inter-organisational coordination mechanisms. Under these conditions, firms face the challenge of designing information infrastructures before detailed regulatory implementation measures are fully defined, making traceability design itself an anticipatory organisational capability rather than a purely compliance-oriented activity.

This shift highlights the need to understand traceability systems as digital infrastructures enabling data generation, integration, and exchange across distributed supply network actors

(Sodhi and Tang, 2019; Garcia-Torres *et al.*, 2022). Despite the growing relevance of such systems, existing research has provided limited insights into how traceability systems are designed and implemented as inter-organisational information systems across multi-tier supply networks. In particular, prior studies have often focused on specific supply chain segments or individual firms, overlooking the role of digital platforms, data standardisation, and information integration across multiple tiers. Furthermore, the absence of widely accepted traceability standards and reference models—particularly beyond blockchain-based solutions—creates additional challenges for data interoperability and coordination among heterogeneous actors (Reck *et al.*, 2022). As a result, there remains limited understanding of how traceability systems operate as distributed information systems that support coordination, transparency, and sustainability across complex supply networks.

Prior traceability research has only partially engaged with foundational inter-organisational information systems (IOS) literature explaining how digitally enabled coordination, reciprocal interdependence, coordination mechanisms, and interoperability challenges shape information integration throughout the network (Johnston and Vitale, 1988; Kumar and van Dissel, 1996; Robey *et al.*, 2008). Existing studies have frequently examined traceability technologies, sustainability practices, or transparency initiatives separately, while providing limited explanation of how platform-enabled architectures support the continuous generation, validation, and integration of traceability information across multiple organisational tiers. Consequently, important IS questions concerning distributed information sharing, data lineage continuity, governance complexity, and cross-tier coordination remain underexplored within digital traceability research. The literature also provides limited conceptualisation of how different traceability configurations influence information visibility and coordination across supply chain tiers. While prior studies have discussed traceability granularity primarily from an operational perspective (Regattieri *et al.*, 2007), less attention has been devoted to understanding how different levels of informational granularity, continuity, and cross-tier visibility shape inter-organisational coordination and digital infrastructure requirements within multi-tier supply networks.

Against this background, this study aims to investigate how fashion firms implement digital traceability systems across multi-tier supply networks, focusing on the interaction between strategic drivers, enabling mechanisms, and traceability practices. By adopting an information systems perspective, the study conceptualises traceability as a network-level digital infrastructure supporting data integration and coordination across organisational boundaries.

Accordingly, the study addresses the following research questions:

RQ1. How do fashion firms build digital traceability infrastructures in anticipation of forthcoming regulatory requirements (e.g. the EU's CSDDD, CSRD, and ESPR), and what strategic, institutional, and operational drivers shape the resulting depth of these infrastructures in multi-tier fashion supply networks?;

RQ2. How do digital, informational, relational, and configurational mechanisms shape the design and effectiveness of traceability systems across organisational tiers, and what are the implications for inter-organisational information systems (IOS) design?

To address these questions, the study develops an analytical framework (Figure 1) linking traceability drivers with enabling mechanisms and operational practices. The framework captures the interactions between sustainability pressures, digital infrastructures, and coordination mechanisms, highlighting how traceability systems support the integration of data and coordination of activities across supply network actors. Rather than functioning as a linear input-process-output model, the framework is used analytically in two complementary ways. First, drawing on the affordance, sociomateriality, and boundary-object perspectives introduced in Section 2.2, platform coordination, data standardisation, and governance mechanisms are treated not simply as inputs producing an information-integration output, but

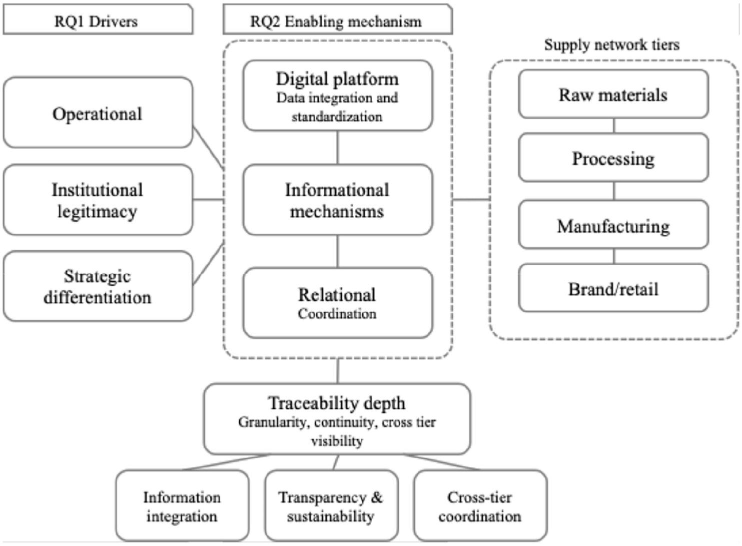

Figure 1. Conceptual framework of digital traceability systems as inter-organisational information infrastructures in multi-tier supply networks

as elements whose interaction reshapes the social and power dynamics of the network, a relationship examined explicitly in the Discussion. Second, following recent configurational and equifinality-based research in supply chain and sustainability management (Xi *et al.*, 2023; Feng and Sheng, 2023; Jiang *et al.*, 2024; Wang and Feng, 2026; Zhang *et al.*, 2026), the framework treats regulatory pressure, digitally-enabled coordination, data standardisation, and relational governance as potentially equifinal antecedents of traceability depth: different combinations of these conditions, rather than a single necessary pathway, may allow different actors in the network to reach comparable levels of traceability participation. Accordingly, the framework assumes that equivalent traceability outcomes may emerge from different combinations of technological capabilities, governance arrangements, regulatory conditions, and organisational practices, rather than from a single optimal implementation pathway. By considering multiple supply chain tiers, from raw material sourcing to final product distribution, the framework provides a basis for interpreting how such configurations vary across organisational tiers characterised by uneven digital capability and bargaining power. The framework also incorporates the concept of traceability depth to explain how different configurations of informational granularity and visibility shape coordination requirements and information integration across supply chain tiers. In doing so, the study responds to recent calls for stronger integration between traceability research and broader IS debates concerning digital platforms, affordances, configurational analysis, and inter-organisational coordination within distributed network environments.

The empirical analysis focuses on a multi-tier luxury fashion supply network, examining how data flows, digital platforms, and coordination mechanisms support traceability implementation throughout the network. Through this perspective, the study aims to provide insights into how traceability systems can support transparency, sustainability, and coordination in contemporary supply networks.

The following sections describe the research methodology adopted in the study and the empirical setting used to investigate traceability implementation across different supply chain tiers. Subsequently, the case study findings are presented and discussed in relation to the research questions and theoretical framework.

4. Methodology

Considering the exploratory nature of the research questions and the limited empirical evidence on traceability implementation within multi-tier fashion supply chains, and for the methodological reasons discussed in Section 2, this study adopts a qualitative, single embedded case study design. The selected case focuses on one of the leading and most representative companies in the luxury fashion industry in terms of turnover and number of employees. The focal company specialises in leather goods, footwear, clothing, and accessories, and has recently launched an extensive traceability initiative for its leather products, formally voluntary but explicitly developed in anticipation of forthcoming EU due-diligence and disclosure requirements (CSDDD, CSRD, ESPR). At the time of the empirical investigation, however, the detailed implementation requirements of the Digital Product Passport for the textile and fashion sector had not yet been formally specified, making the analysed initiative particularly suitable for examining how firms design digital traceability infrastructures under conditions of regulatory uncertainty. This project involves multiple actors across the supply network, from raw material sourcing to final product distribution. The focal company was selected because it represents an exemplary case of traceability implementation within the fashion sector and provides a unique opportunity to observe the coordination mechanisms and technological infrastructures required to implement traceability across multiple supply chain tiers (Eisenhardt, 1989; Eisenhardt and Graebner, 2007). The case is particularly suitable for investigating digital traceability as an inter-organisational information system because it involves multiple organisational actors operating interconnected digital infrastructures and continuously exchanging traceability information across transformation stages.

In particular, the case enables the investigation of traceability systems as inter-organisational information systems, allowing the analysis of how data are generated, standardised, and exchanged across organisational boundaries. The traceability project analysed in this research extends from third-tier suppliers to final consumers, allowing the investigation of traceability practices across upstream and downstream stages of the supply network. The inclusion of the Spanish farmer reflects the actual sourcing configuration of the analysed luxury fashion supply network rather than a sampling decision made by the researchers. The focal company sources bovine hides through cross-border supply relationships that are common within the European leather industry, where the Iberian Peninsula represents one of the principal livestock production areas supplying the type of hides used by Italian luxury leather manufacturers. Accordingly, the objective of the study was not to compare national agricultural systems, but to examine how digital traceability infrastructures operate across heterogeneous organisational actors participating in the same multi-tier European supply network.

As a small-scale operator with limited digital infrastructure, the farmer contributes comparatively little structured information directly to the shared platform. Rather than representing a weakness of the case design, this organisational tier provides an empirically informative illustration of the heterogeneous digital capabilities that characterise real multi-tier supply networks. It represents the point at which digital traceability infrastructures encounter their greatest constraints in terms of digital capability, interoperability, and organisational resources, thereby offering valuable insights into how information integration mechanisms, platform-enabled coordination, and governance arrangements accommodate actors with markedly different levels of technological maturity within the same supply network. These issues are examined further in Sections 5 and 6.

The unit of analysis of this research is the focal company's multi-tier supply network, encompassing all major organisational actors involved in the sourcing, transformation, and distribution of leather products, from raw material suppliers to retailers. The embedded case study design enables comparisons across organisational tiers and supports the identification of traceability mechanisms operating at both firm and network levels. This multi-tier perspective is particularly appropriate for analysing inter-organisational information systems because it captures how information flows, digital infrastructures, and governance arrangements operate across heterogeneous organisational layers characterised by different levels of digital capability and reciprocal interdependence. Although the study is based on a single embedded case, its objective is analytical rather than statistical generalisation (Yin, 1994), providing an appropriate setting for examining how digital traceability infrastructures operate within complex and distributed supply networks characterised by heterogeneous information systems, fragmented governance structures, and uneven organisational capabilities.

To ensure methodological rigour and reliability, a structured research protocol was adopted throughout the study (Voss *et al.*, 2002). The research began with an extensive review of the literature on traceability systems and supply chain transparency in order to develop the conceptual framework guiding the empirical investigation. Subsequently, data were collected through multiple qualitative methods in order to ensure triangulation and improve the robustness of the findings. Data collection was conducted between September 2025 and January 2026 and involved three main sources of evidence: semi-structured interviews, archival documentation, and direct observations during plant visits.

The use of multiple data sources strengthens the construct validity of the research by allowing evidence to be triangulated across different perspectives (Eisenhardt and Graebner, 2007; Yin, 1994). Semi-structured interviews were conducted with key informants from the focal company and its main supply chain partners directly involved in traceability implementation across the network. As reported in Table 1, eleven semi-structured interviews were conducted across the five organisational tiers of the supply network. Three interviews were conducted at the focal company involving the Chief Sustainability Officer, an ICT Specialist, and an Operations Manager. Two interviews were conducted at each of the remaining organisational tiers, including the tannery, hide collector, slaughterhouse, and farmer levels. Interviewees included CEOs, COOs, Owner-Managers, and Operations Managers responsible for traceability implementation and supply-chain coordination activities. The multi-informant design ensured that traceability practices were examined from different strategic, technological, and operational perspectives within each organisational tier, thereby supporting the cross-tier analytical perspective adopted in the study. Interviews lasted between approximately 60 and 120 min and were conducted in person during multiple visits to the participating organisations. This approach enabled the researchers to complement the interview data with direct observations of traceability practices, operational processes, and information systems within the companies' facilities. These actors were selected because of their direct involvement in the design, coordination, and operational implementation of the traceability system. In particular, the inclusion of ICT specialists was essential for capturing the technological and informational dimensions of the traceability

Table 1. Composition of the analysed supply chain

Company	Role in the supply chain	Country	Company size	Interviewees
Focal Company	Brand owner	Italy	Large Enterprise	Chief Sustainability Officer; ICT Specialist; Operations Manager
First-tier supplier	Tannery	Italy	Large Enterprise	CEO; Operations Manager
Second-tier supplier	Hide collector	Italy	Large Enterprise	CEO; Operations Manager
Third-tier supplier	Slaughterhouse	Italy	Large Enterprise	COO; Operation Manager
Fourth-tier supplier	Farmer	Spain	SME - Small and Medium-sized Enterprise	Owner; Operations Manager

architecture, including digital platforms, data management processes, interoperability mechanisms, and system functionalities supporting distributed information sharing across organisational tiers.

Interviewees were purposively selected, in collaboration with the focal company, on the basis of two criteria: direct operational responsibility for traceability-related activities within their organisation, and sufficient seniority or tenure to speak to how traceability practices had evolved over time. The number of interviews per tier reflects the size and internal differentiation of each organisation, three roles at the focal company given its more complex internal division of labour between sustainability, ICT, and operations functions, and two roles at each upstream and midstream actor, where responsibility for traceability activities was more concentrated. Data collection continued until the combined interview, observational, and documentary evidence no longer generated substantively new insights relevant to the research questions within the boundaries of the embedded case. The resulting judgement concerns the adequacy of the empirical evidence to support theory elaboration in this specific research setting rather than a claim of comprehensive saturation across all organisational tiers. Given the embedded single-case design, the adequacy of the evidence was assessed holistically by considering the convergence of multiple sources of evidence—including interviews, plant visits, direct observations, and archival documentation—rather than through the number of interviews conducted within each individual tier. This judgement is necessarily bounded by the selected case and is acknowledged as a limitation of the study in Section 7.

Each interview followed a semi-structured protocol designed to explore the drivers, challenges, and operational mechanisms associated with traceability implementation within the supply network. Additional questions were included to investigate how data are captured, standardised, and shared across systems, as well as how digital platforms support inter-organisational coordination. Interviews were recorded and subsequently transcribed to facilitate systematic analysis (Yin, 1994). To complement the interviews, the researchers collected and analysed internal documents provided by the participating organisations, including process maps, traceability procedures, system documentation, and sustainability reports. These documents were also used to analyse the information architecture of the traceability system, including data structures, coding systems, and information flows across supply chain actors. In addition, plant visits were conducted at the facilities of the focal company and its main suppliers. These visits allowed the researchers to observe traceability practices and information management systems directly, thereby improving the contextual understanding of the processes being studied. The data collection process was iterative and continued until data saturation was reached, meaning that additional interviews did not generate substantially new insights (Eisenhardt, 1989; Voss *et al.*, 2002). The extended duration of the data collection phase allowed researchers to refine emerging interpretations, validate preliminary findings with informants, and compare perspectives across organisational tiers. The composition of the analysed supply chain is summarised in Table 1.

To guide the interviews, a semi-structured interview protocol was developed based on the research questions and the literature on traceability systems (Voss *et al.*, 2002). The interview protocol included questions regarding the role of the interviewee within the company, the motivations for implementing traceability practices, the challenges encountered during implementation, and the technologies used to track products and materials across the supply chain. In addition, the protocol explicitly addressed information systems aspects, including data generation processes, system integration, data validation mechanisms, and platform-based information exchange.

The interview protocol addressed the following topics:

(1) Role of the interviewee within the company and involvement in traceability practices;

(2) Drivers motivating the company to implement traceability systems, including external pressures such as regulations or customer demands;

(3) Challenges and barriers encountered during traceability implementation;

(4) Technologies and tools used to track materials and products across the supply chain;

(5) Mechanisms used to ensure the accuracy and completeness of traceability data;

(6) Communication of traceability information to customers and stakeholders.

Following data collection, interview transcripts, observational notes, and archival documentation were analysed through a theory-informed abductive coding process drawing on the data-structuring principles proposed by Gioia *et al.* (2013). The Gioia approach was used as a transparent procedure for organising and communicating the progression from informant-level evidence to theoretically informed interpretations, rather than as a basis for claiming unconstrained inductive theory generation. Analysis proceeded iteratively between the IOS and information-integration framework, the empirical material, and emerging cross-tier interpretations. The resulting structure includes informant-centric first-order concepts, theoretically informed second-order themes, and aggregate analytical dimensions, as represented in Figure 2.

In the first analytical stage, the researchers coded the interview transcripts while remaining as close as possible to the language and experiences reported by the informants. Although this stage retained informant-centric labels, coding was conducted within the broad domains already reflected in the theoretically informed interview protocol, including traceability drivers, data generation, system interoperability, governance, and cross-tier information exchange. First-order concepts therefore captured participants' own expressions concerning issues such as the need to "understand where materials come from", the difficulty of "ensuring that all suppliers manage information consistently", the use of common codes, the adaptation of manual records to platform requirements, and the unequal operational effort required across organisational tiers.

In the second stage, these first-order concepts were iteratively compared across interviews, organisational tiers, and complementary data sources, and subsequently interpreted through

Informant-centric first-order concepts (*Illustrative quotations*)	**Theory-informed second-order themes** (Interpretive categories)	**Aggregate analytical dimensions** (Higher-order constructs)
• "We need to understand where materials come from." • "Customers ask for more transparent information."	→ **Strategic and regulatory drivers** Pressures from customers, sustainability goals and regulations that motivate traceability.	→ **Strategic and institutional drivers** Institutional and strategic forces that legitimise digital traceability initiatives.
• "Suppliers use different codes." • "The challenge is linking data between stages."	→ **IOS enabling mechanisms** Technologies and organisational mechanisms that enable data exchange and interoperability.	→ **IOS enabling mechanisms** The sociotechnical infrastructure and enablers that support information flow across the network.
• "Not all suppliers manage information in the same way." • "Upstream we still rely on manual records."	→ **Information sharing processes** Processes through which information is created, shared and interpreted across heterogeneous actors.	→ **Distributed information sharing** Cross-tier information processes shaped by different capabilities, routines and digitalisation levels.
• "The focal company sets the formats we must follow." • "Without trust, suppliers do not share complete data."	→ **Governance and control** Rules, roles and relational mechanisms that shape data quality, access, trust and decision rights.	→ **Platform governance** Governance arrangements and interpretive control that structure data sharing across tiers.
• "Item-level tracking is too costly upstream." • "Batch tracking works upstream, item tracking downstream."	→ **Traceability configurations** Tier-specific choices on data granularity and traceability depth based on feasibility and cost.	→ **Traceability depth configurations** Gonfiguratioce of granularity and traceability depth across tiers.
• "Integrated information improves decision making." • "Traceability supports sustainability reporting."	→ **Outcomes** Benefits at the supply network level in terms of visibility, coordination and sustainability performance.	→ **System-level outcomes** Network-level outcomes in visibility, coordination, compliance and sustainability performance.

Note: First-order concepts are informant-centric quotations. Second-order themes are theory-informed interpretations. Aggregate dimensions represent higher-order analytical constructs.

Figure 2. Theory-informed abductive data analytical process

the study's theoretical framework to develop second-order themes. These themes included strategic and regulatory drivers, IOS enabling mechanisms, syntactic, semantic, and pragmatic information integration (Barki and Pinsonneault, 2005), platform-enabled coordination, governance arrangements, and traceability-depth configurations. In the final stage, the second-order themes were organised into broader aggregate analytical dimensions explaining how digital traceability infrastructures are designed, implemented, enacted, and governed across multi-tier supply networks. These aggregate dimensions comprised strategic and institutional drivers, IOS enabling mechanisms, distributed information-sharing processes, traceability configurations and depth, and system-level outcomes. The Gioia-inspired data structure was therefore used as a transparent analytical device to organise the progression from informant-centric evidence to theoretically informed interpretation, rather than as evidence of unconstrained inductive theory generation.

It should be acknowledged that the semi-structured interview protocol was itself developed from the inter-organisational information systems (IOS) and information integration framework established during the literature review. Consequently, the first-order concepts inevitably reflect the broad domains explored during data collection rather than emerging independently of the researchers' prior theoretical commitments. The analytical process is therefore more accurately characterised as theory-informed and abductive from the outset, moving iteratively between the theoretical framework, the empirical material, direct observations, and archival documentation. Consistent with this positioning, the purpose of the Gioia-inspired methodology was not to generate entirely new theory from an unconstrained empirical starting point, but to provide a rigorous and transparent procedure for organising empirical evidence and elaborating existing theoretical concepts. Accordingly, the study is positioned as an exercise in theory elaboration, extending and refining existing IOS, information integration, and digital traceability literature through rich empirical evidence drawn from an embedded multi-tier case study, rather than as an exercise in unconstrained inductive theory building.

To enhance the reliability of the analysis, two researchers independently coded selected interview transcripts and subsequently compared their interpretations. Discrepancies were discussed until consensus was reached, thereby ensuring consistency in the coding process and strengthening the credibility of the analysis. This double-coding and consensus procedure served as a form of investigator triangulation and peer debriefing throughout the study. Coding was conducted manually using structured coding tables that systematically linked each informant quotation to its corresponding first-order concept, theory-informed second-order theme, and aggregate analytical dimension, thereby maintaining a transparent chain of evidence throughout the analytical process rather than relying on dedicated qualitative data analysis software. Accordingly, Figure 2 should be interpreted as a transparent representation of this theory-informed abductive analytical process rather than as evidence of a purely emergent coding structure independent of the underlying theoretical framework. The figure illustrates how informant-centred empirical evidence was progressively interpreted through the IOS and information integration framework to develop higher-order analytical dimensions. Finally, cross-tier comparison deliberately preserved, rather than smoothed over, divergent patterns across organisational tiers, including the more limited and differently structured data contribution of the upstream farmer tier. These differences were treated as analytically informative evidence that contributed to the interpretation developed in the Findings and Discussion rather than as inconsistencies to be eliminated.

In addition, a chain of evidence was maintained throughout the research process to allow external readers to trace the analytical steps linking empirical observations to conclusions (Yin, 1994). The analysis combined within-case analysis and cross-tier analysis (Table A1 - Appendix 1). Within-case analysis was used to examine traceability practices implemented by each actor within the focal supply network, while cross-tier analysis enabled the identification of patterns and differences across supply chain stages. This analytical approach also allowed the identification of how data flows, digital infrastructures, and inter-organisational information systems operate across different tiers of the supply network. To provide a structured overview of how traceability systems operate across different levels of the supply network, Table A2 - Appendix 2 presents a cross-tier analysis highlighting the main differences and complementarities among upstream, midstream, and downstream actors. This analysis supports the interpretation of the findings by identifying systematic patterns in traceability objectives, data characteristics, and information system configurations across supply chain tiers.

Although the study focuses on a single luxury fashion network, the multi-tier embedded design and the analytical orientation of the research provide relevant theoretical insights into how digital traceability infrastructures operate as inter-organisational information infrastructures within complex and distributed supply networks. Building on this cross-tier overview, the following section presents the empirical findings, structured around the key drivers, enabling mechanisms, and traceability practices identified in the case study.

5. Findings

The empirical analysis of the traceability system implemented within the analysed fashion supply network provides insights into how traceability is developed and coordinated across multiple supply chain tiers from an information systems perspective. By examining the activities and interactions among supply chain actors, the study highlights the drivers motivating the adoption of traceability systems, the digital and organisational mechanisms that support their implementation, and the operational practices through which traceability is achieved across the network. More specifically, the findings illustrate how traceability systems operate as inter-organisational digital infrastructures that enable the generation, standardisation, and exchange of data across distributed actors. The results show that traceability implementation within the analysed fashion supply network, while formally voluntary, is substantially anticipatory of forthcoming regulation and is driven by a combination of strategic, regulatory, and operational motivations, which shape the design of the traceability system and influence the depth of traceability achieved across different supply chain tiers. In addictio, the implementation of traceability depends on enabling mechanisms that facilitate information integration, interoperability, and coordination across heterogeneous actors. These mechanisms include digital platforms, shared identifiers, data standardisation processes, validation procedures, governance arrangements, and relational coordination practices that collectively support the continuity and reliability of information flows across the supply network. Through these mechanisms, firms operationalise traceability by implementing differentiated traceability configurations and information-sharing practices across upstream, midstream, and downstream stages of the network.

Accordingly, the findings are presented in three main sections. The first section examines the strategic and operational drivers motivating the adoption of digital traceability systems across the supply network. The second section analyses the digital, informational, and organisational mechanisms enabling traceability implementation and inter-organisational data sharing. The third section explores the traceability practices and information architectures implemented across different supply network tiers, highlighting how varying levels of traceability depth emerge across upstream, midstream, and downstream stages of the network.

5.1 Drivers of digital traceability systems adoption

The empirical findings show that the adoption of traceability systems within the analysed fashion supply network is driven by a combination of strategic, operational, institutional, and relational motivations. These drivers create pressures for firms to develop capabilities for data generation, information integration, and coordination across distributed organisational actors. Rather than functioning solely as compliance-oriented monitoring mechanisms, traceability systems emerge as inter-organisational information infrastructures supporting visibility, coordination, and governance across multiple supply chain tiers.

One of the primary drivers identified in the case study is the increasing importance of sustainability. The focal company has progressively recognised the need to improve visibility over its supply network in order to monitor environmental and social impacts associated with production processes. This requires the collection and integration of data related to raw material origins, production activities, and supplier practices across multiple supply chain tiers. As highlighted by one interviewee, *"we needed to understand where our materials come from and how they are processed, otherwise it is impossible to manage sustainability properly"* (Focal Company – Chief Sustainability Officer). In addition, *"customers increasingly ask for transparency, and without traceability data we cannot provide credible information"* (Focal Company – Sustainability Officer). In this context, traceability systems are implemented as digital infrastructures that enable firms to access and manage such information, thereby supporting sustainability objectives and compliance with emerging regulatory requirements. These findings suggest that sustainability pressures do not simply increase the demand for transparency, but also intensify the need for integrated inter-organisational information systems capable of supporting cross-tier information visibility. Moreover, traceability systems support the identification and mitigation of environmental risks across upstream supply chain stages. By enabling visibility over raw material sourcing and production processes, firms can monitor carbon footprint data, identify high-risk suppliers, and demonstrate compliance with emerging regulatory requirements concerning supply chain emissions and environmental due diligence emerging from initiatives such as the European Green Deal and the *CSRD*. In this context, traceability systems function as digital infrastructures enabling the generation, validation, and exchange of sustainability-related information across distributed supply network actors.

A second key driver relates to product quality management and operational control. Traceability systems allow companies to capture and analyse data associated with production processes, enabling the identification of defects and the monitoring of product quality across the supply network. By linking product information to specific batches and processing stages, firms can trace quality issues back to their origin and implement corrective actions more effectively. As noted by a supplier, "*traceability allows us to identify exactly where a problem originates, which is essential for managing quality issues*" (Tannery – Production Manager). Furthermore, "*if there is a defect, we can trace it back to a specific batch and isolate the issue immediately*" (Focal Company – Operations Manager). From an IOS perspective, these findings highlight how traceability systems support coordination under conditions of reciprocal interdependence, where information generated by one actor directly affects operational decisions and visibility across other organisational tiers. Effective quality management therefore depends not only on local monitoring practices, but also on the continuity and reliability of information flows across the network.

Brand protection and product authenticity represent another critical driver of traceability adoption, particularly in the luxury fashion segment. The ability to provide verifiable and structured information about product origins and manufacturing processes is essential for safeguarding brand reputation and maintaining consumer trust. Traceability systems enable firms to create digital records associated with products, which can be used to authenticate items and support country-of-origin claims. As emphasised by one respondent, "*in the luxury segment, being able to demonstrate where a product comes from is fundamental for protecting the brand*" (Focal Company – Brand Manager). Another interviewee noted that "*traceability data support our 'Made in' claims and help us maintain customer trust"* (Focal Company – Marketing Director). The findings indicate that traceability systems increasingly operate as strategic information infrastructures supporting the management and communication of product-related information toward external stakeholders. This reinforces the role of digital traceability systems not only as operational monitoring tools, but also as mechanisms supporting legitimacy, differentiation, and customer-facing transparency.

Another critical driver concerns the growing complexity of coordination across fragmented supply networks. The analysed supply chain involves multiple actors operating across different organisational and technological environments, creating significant challenges related to visibility and coordination. Traceability systems address these challenges by enabling the integration of information flows across supply chain tiers and by supporting the alignment of operational activities among actors. As highlighted by one supplier, "*without shared data, coordination across suppliers becomes extremely difficult*" (Tannery – Operations Manager). Similarly, "*the system helps us align information across all actors involved in the production process*" (Focal Company – ICT Specialist). These findings are consistent with IOS literature emphasising how increasing interdependence among actors intensifies the need for interoperable digital infrastructures and shared coordination mechanisms (Kumar and van Dissel, 1996; Robey *et al.*, 2008). In the analysed case, traceability systems support coordination not only through information exchange, but also through the continuous validation, synchronisation, and updating of interconnected traceability information across organisational boundaries.

A further driver concerns the need to enhance transparency towards consumers and other stakeholders. Increasingly, customers demand access to reliable information about product origins, sustainability practices, and production conditions. Traceability systems enable firms to respond to these demands by providing structured and accessible information through digital interfaces, thereby supporting customer engagement and strengthening brand positioning (Diallo *et al.*, 2021; Holmqvist and Kowalkowski, 2023). As noted by one manager, "*consumers want to know the story behind the product, and traceability allows us to provide that information*" (Focal Company – Sustainability Manager). These findings indicate that traceability systems increasingly operate as strategic information infrastructures supporting the management and communication of product-related information towards external stakeholders. From an IOS perspective, transparency therefore depends not only on the availability of traceability data, but also on the capability to integrate, validate, and communicate information consistently across organisational tiers.

The findings indicate that traceability systems can generate additional value by enabling data-driven decision-making. By collecting and integrating information across the supply network, firms can analyse product flows, identify inefficiencies, and improve supply chain performance. As highlighted by one respondent, "*having access to integrated data allows us to better understand our processes and improve decision-making*" (Focal Company – ICT Specialist). In this sense, traceability systems generate value not only through transparency and monitoring, but also through the creation of integrated information resources supporting analytics and managerial decision-making across distributed supply network actors. At the same time, the findings reveal that traceability adoption also creates governance challenges associated with information sharing across organisational actors. The implementation of the traceability system required the focal company to define shared standards, validation procedures, and access rules regulating how information is generated and exchanged across the network. Informants highlighted that not all actors possessed the same technological capabilities or willingness to disclose operational information. In particular, upstream actors with lower levels of digital maturity often experienced difficulties in adapting to new information requirements. As noted by one respondent, "the challenge is not only collecting the data, but ensuring that all suppliers manage and share information consistently" (Focal Company – ICT Specialist). These findings suggest that digital traceability adoption involves not only technological implementation, but also governance and relational coordination challenges. The effectiveness of traceability systems therefore depends on the ability to align partners through shared standards, interoperable information structures, and trust-based coordination mechanisms capable of supporting reliable information exchange across supply chain tiers.

This highlights the role of traceability systems not only as tools for monitoring and transparency, but also as inter-organisational digital infrastructures supporting analytics and strategic decision-making. The results show that their adoption is driven by a combination of interrelated strategic, operational, and institutional factors, reflecting firms' increasing need to manage distributed data, integrate heterogeneous information sources, and develop inter-organisational capabilities that enhance information integration, visibility, coordination, and sustainability across multi-tier supply networks.

5.2 Digital and information mechanisms enabling traceability implementation

The implementation of traceability systems within the analysed fashion supply network is enabled by a set of interconnected digital, informational, and organisational mechanisms that support data integration and coordination across supply chain actors. These mechanisms allow firms to generate, standardise, and exchange data across organisational boundaries, ensuring the continuity and reliability of information flows throughout the network.

A first enabling mechanism concerns data standardisation. The traceability system requires the adoption of shared coding structures and data formats that allow different actors to record and interpret information consistently. Standardised identifiers are used to link raw materials, intermediate products, and finished goods across production stages, enabling the alignment of data across heterogeneous organisations. One respondent noted "*we had to define common codes and data formats, otherwise each supplier would manage information differently*" (Focal Company – ICT Specialist). This standardisation is essential for ensuring interoperability among systems and for maintaining the integrity of traceability data as products move across the supply network (Bevilacqua *et al.*, 2009). Another respondent noted that "*without standardisation, data cannot be integrated across the different stages of the supply chain"* (Focal Company – IT Manager). From an information integration perspective, these findings highlight the importance of syntactic integration mechanisms enabling heterogeneous actors to exchange and interpret traceability information consistently across organisational tiers. Shared identifiers, coding structures, and data protocols therefore function as foundational IOS mechanisms supporting interoperability and cross-tier coordination.

A second mechanism relates to ICT integration. The traceability system relies on the integration of digital technologies that support data capture, storage, and transmission across supply chain actors. In the analysed case, web-based platforms and identification technologies such as RFID enable the collection of data at different stages of the production process and allow information to be shared in near real time. As explained by one manager, "*the platform is essential because it connects all actors and allows data to be shared continuously*" (Focal Company – IT Manager). These technologies support the synchronisation of information flows and enhance visibility over product movements and transformations across the network. The integration of heterogeneous legacy systems across organisational tiers is achieved through a combination of technical and organisational mechanisms. At the upstream tiers, where suppliers such as the slaughterhouse and hide collector operate basic digital systems or partially paper-based records, data are transferred to the shared platform primarily through structured manual data-entry procedures and simplified web-based interfaces designed to accommodate actors with limited digital capabilities. At the midstream tier, the tannery's ERP system is partially connected to the shared traceability platform through data export mechanisms enabling the periodic synchronisation of batch-level production records. At the downstream tier, the focal company's integrated ERP and RFID systems are more tightly coupled with the platform, enabling near real-time data exchange and automated updating of traceability records. This hybrid integration configuration reflects the heterogeneous digital maturity of actors across the supply network and highlights the trade-offs between full system integration and operational feasibility within fragmented multi-tier environments. The traceability system operates as a shared digital platform that connects multiple actors and enables the exchange of structured information across organisational tiers. Through this platform, each actor can access relevant traceability data and update information related to production activities, thereby contributing to a distributed information infrastructure that supports coordination and transparency. As noted by a supplier, "*without the system, we would not be able to manage the flow of information across the supply chain*" (Tannery – Operations

Manager). These findings reinforce the role of digital platforms as coordination infrastructures supporting reciprocal interdependence among supply network actors. Rather than functioning merely as repositories of traceability data, the platform enables the continuous synchronisation, validation, and updating of interconnected information flows throughout the network. From an affordance perspective, the shared platform enables different action possibilities across organisational tiers rather than producing uniform effects. While downstream actors exploit real-time integration and automated data updating, upstream actors mainly use simplified interfaces and manual data-entry procedures because of their more limited digital capabilities. Consequently, the same digital infrastructure affords different forms of participation and coordination depending on the organisational context and technological maturity of each actor.

Another key enabling mechanism concerns data governance and relational coordination. The effectiveness of the traceability system depends on the willingness and ability of supply chain actors to share accurate and timely information. This requires the establishment of governance paractices that define roles, responsibilities, and data-sharing rules across the network. As highlighted by one respondent, "*data sharing only works if there is trust between partners*" (Hide Collector – CEO). Trust-based relationships among actors facilitate the exchange of information and reduce the risk of opportunistic behaviour, while formal agreements help ensure data consistency and reliability across organisational boundaries. In addition, "*we need to be sure that the data entered by suppliers are accurate and reliable*" (Focal Company – Quality Manager). The findings also reveal important governance tensions associated with information sharing across heterogeneous actors. While focal firms seek greater visibility and standardisation across supply chain tiers, upstream actors may possess uneven technological capabilities and different levels of willingness to disclose operational information.

These tensions are not distributed symmetrically across the supply network. In the analysed case, the focal company largely defines the standards, reporting formats, validation procedures, and data structures that govern the traceability platform, requiring smaller and less digitally mature upstream actors to adapt their existing routines and information systems. Consequently, adaptation costs fall disproportionately on these actors, even where they recognise the benefits of participating in the traceability initiative.

At the same time, the strategic value generated by the traceability infrastructure is also distributed unevenly. The focal company benefits from system-wide visibility, enhanced coordination capabilities, improved sustainability reporting, and greater preparedness for an evolving regulatory environment. By contrast, upstream actors derive benefits that are primarily operational rather than strategic, consisting mainly of continued participation within the supply network, improved information consistency, and access to shared traceability processes. These findings also illustrate that the digital traceability infrastructure is continuously shaped through its interaction with existing organisational routines. Rather than replacing local practices, the platform is progressively adapted to heterogeneous operational contexts, allowing paper-based records, ERP systems, RFID technologies, and manual procedures to coexist within the same inter-organisational architecture. Consequently, the effectiveness of the infrastructure depends not only on its technical capabilities, but also on its ability to accommodate the diverse operational practices and digital capabilities of participating organisations.

Governance mechanisms therefore operate not only as control structures but also as coordination mechanisms that support trust, relational alignment, and the reliability of information exchange across organisational actors. At the same time, these governance arrangements shape how responsibilities, adaptation efforts, information visibility, and decision-making authority are distributed across organisational tiers. The traceability system enables greater visibility over product origins, processing stages, and supplier activities, thereby supporting decision-making and operational control. However, the findings indicate that collaboration within digital traceability systems should not be interpreted as implying equal benefits or equal responsibilities across participating actors. Rather, collaborative information exchange is enabled through governance arrangements that simultaneously facilitate coordination while distributing strategic value, operational effort, and decision-making responsibilities unevenly across the network.

Cross-tier data integration represents another critical capability underpinning effective traceability implementation. The traceability system connects upstream and downstream actors by linking data generated at different stages of the production process. This integration allows firms to reconstruct the history of products and to monitor the transformation of materials across the supply network. As noted by one interviewee, "*the main challenge is linking data coming from different stages of the process into a coherent system*" (Focal Company – ICT Specialist). By ensuring the continuity of information across tiers, the system supports both tracing and tracking functionalities and enables a comprehensive view of supply chain activities. These findings illustrate how traceability effectiveness depends on maintaining semantic and pragmatic integration across organisational tiers. Beyond technical interoperability, actors must share common interpretations of traceability information and coordinate the operational use of data within organisational processes and decision-making activities. The implementation of traceability systems is supported by organisational alignment and capability development. Firms must invest in developing the technical and organisational capabilities required to manage traceability data, including training personnel, adapting internal processes, and integrating traceability systems with existing enterprise systems. As highlighted by one respondent, "*implementing traceability requires not only technology but also organisational changes and new skills*" (Focal Company – Operations Manager). This suggests that traceability implementation should be understood as a socio-technical transformation process involving the alignment of digital infrastructures, organisational routines, governance arrangements, and inter-organisational coordination practices.

5.3 Traceability practices and information architecture across supply network tiers

The empirical findings show that traceability within the analysed fashion supply network is operationalised through a set of practices that enable the identification, tracking, and tracing of products across multiple supply chain tiers. These practices are supported by a digital information architecture that enables the generation, storage, and exchange of data across organisational boundaries. As one interviewee explained "traceability is not only about tracking products, but about managing the data associated with each transformation" (Focal Company – ICT Specialist). Traceability practices vary across supply chain tiers and reflect differences in production processes, organisational roles, and information requirements.

In upstream stages, such as slaughterhouses, hide collectors, and tanneries, traceability is primarily implemented at the batch level, where groups of materials are identified and tracked through shared identifiers. In this sense, traceability records operate as shared artefacts that allow heterogeneous actors to exchange and interpret information despite relying on different operational routines and technological systems. These identifiers are associated with digital records that capture information about product origin, processing activities, and transformations. As noted by one supplier, "upstream we work with batches because handling individual items would be too complex and costly" (Tannery – Production Manager). These findings illustrate how upstream actors prioritise operational feasibility and aggregation efficiency within traceability configurations characterised by lower informational granularity. Batch-level traceability enables actors to manage large material flows while preserving continuity between physical product flows and digital information flows across transformation stages.

As products move downstream, traceability practices become more granular. In manufacturing and distribution stages, traceability is increasingly implemented at the item level, where individual products are assigned unique identifiers. Technologies such as RFID tags enable the creation of item-level digital records, allowing firms to track products individually across production and distribution processes. As explained by one manager, "downstream we need item-level traceability because each product must be uniquely identifiable" (Focal Company – Operations Manager). The transition from batch-level to item-level traceability reflects variations in traceability depth across organisational tiers. Downstream actors require higher informational granularity and visibility to support product authentication, customer-facing transparency, sustainability communication, and brand protection. In this sense, traceability depth emerges as a configurable characteristic of the digital traceability architecture rather than a uniform system property across the supply network.

The traceability system relies on a shared digital platform that connects supply chain actors and enables the exchange of traceability data across organisational tiers. Each actor is responsible for generating and uploading data related to its activities, including information on product transformations, processing stages, and logistics movements. As highlighted by one respondent, "each actor inputs data into the platform, so information is continuously updated along the supply chain" (Focal Company – ICT Specialist). These data are stored in a centralised or federated system, allowing authorised actors to access and update information as products move through the supply network. As noted by a supplier, "the platform allows us to access information from other actors, which improves coordination and transparency" (Tannery – Operations Manager). From an IOS perspective, the platform operates as a coordination infrastructure enabling reciprocal information exchange among organisational actors. The system supports not only the storage of traceability information, but also the continuous synchronisation and validation of interconnected data across supply chain tiers. Consequently, information visibility emerges through the interaction between shared digital infrastructures, standardised identifiers, and coordinated organisational practices.

A key feature of the traceability system is the continuity of information across transformation stages. As materials are processed and transformed, traceability data are updated and linked to new identifiers, ensuring that the history of each product can be reconstructed across multiple stages. This requires the implementation of data aggregation and disaggregation mechanisms that maintain the connection between input materials and output products. The system maintains data lineage by linking input and output batches through shared identifiers and transformation records stored within the digital platform. As emphasised by one interviewee, "we need to maintain the link between raw materials and final products across all transformations" (Tannery – Operations Manager). These findings highlight the importance of data lineage continuity within inter-organisational traceability systems. Maintaining informational continuity across transformations represents a critical integration challenge because products frequently change form, ownership, and organisational context throughout the supply network. Effective traceability therefore depends on the capability to preserve interoperable informational links across multiple transformation stages and organisational boundaries. The findings also highlight the importance of data validation and consistency. To ensure the reliability of traceability information, firms implement procedures to verify the accuracy of data entered into the system. These procedures include standardised data entry protocols, cross-checking of information, and monitoring of data completeness. As highlighted by one respondent, "if the data are not correct, the entire traceability system loses its value" (Focal Company – Quality Manager). Ensuring data quality is essential for maintaining trust among supply chain actors and for enabling effective use of traceability data. This suggests that data validation mechanisms play a critical governance role within digital traceability systems by supporting semantic consistency and reducing information asymmetries across organisational tiers. The reliability of traceability systems therefore depends not only on technological infrastructures, but also on governance arrangements capable of ensuring the credibility and consistency of distributed information flows. In addition, traceability practices support supply network visibility and communication towards external stakeholders. Selected traceability data are made accessible to consumers through digital interfaces, allowing them to verify product origins and production processes. This enhances transparency and supports brand positioning, particularly in the luxury fashion segment. As noted by one manager, "traceability allows us to communicate the product story directly to the customer through digital tools" (Focal Company – Operations Manager). The findings therefore show that digital traceability systems simultaneously support operational coordination, inter-organisational information integration, and customer-facing transparency. Traceability practices should consequently be understood not merely as operational monitoring activities, but as socio-technical mechanisms enabling information visibility and coordination across distributed supply network actors.

The configuration of traceability practices across supply chain tiers is summarised in Figure 3, which illustrates the interaction between physical flows, data flows, and digital infrastructures within the supply network.

6. Discussion

The findings of this study provide important theoretical and managerial implications for understanding traceability systems in complex, multi-tier fashion supply networks. The discussion interprets the findings through an inter-organisational information systems perspective, explaining how digital traceability systems support information integration, coordination, and visibility across organisational boundaries. Building on the empirical analysis, it highlights how these systems operate as inter-organisational information infrastructures that integrate heterogeneous information flows and enable coordination across distributed supply network actors.

6.1 Digital traceability systems as inter-organisational information infrastructures

The empirical analysis indicates that digital traceability systems are better understood as inter-organisational information systems (IOS) than stand-alone tracking technologies. While prior research has largely examined traceability within regulated sectors such as agri-food supply chains, where systems are primarily designed to ensure compliance and product safety, the findings demonstrate that in the fashion industry traceability, while formally voluntary, is

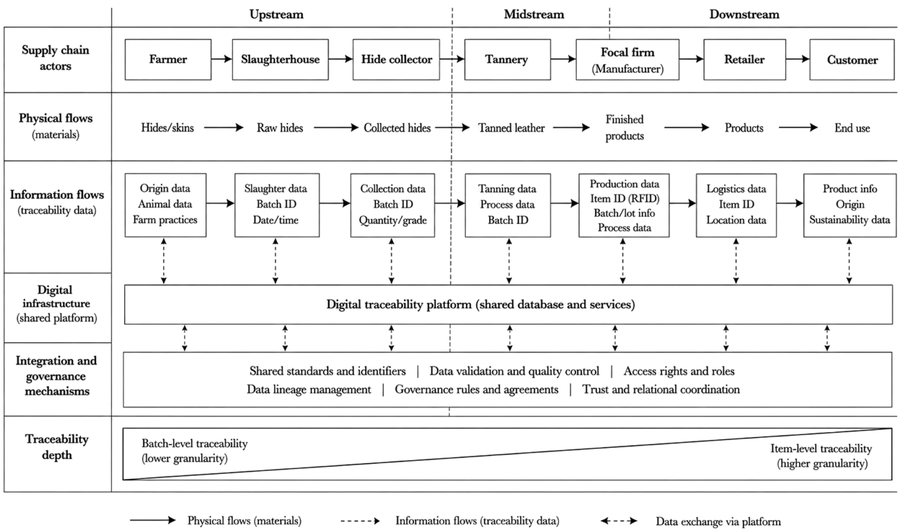

Figure 3. Empirical architecture of digital traceability integration across multi-tier supply networks

increasingly built in anticipation of forthcoming regulation, functioning as a strategic digital infrastructure enabling cross-tier integration among supply chain actors. The empirical evidence indicates that traceability systems operate under conditions of reciprocal interdependence, where information generated by one organisational actor continuously influences the visibility, coordination, and operational decisions of other actors across the supply network. This finding extends IOS literature (Johnston and Vitale, 1988; Kumar and van Dissel, 1996; Robey *et al.*, 2008) by showing how platform-enabled traceability systems support coordination not only through information exchange, but also through the continuous validation, synchronisation, and reconstruction of interconnected traceability information across multiple organisational tiers.

The analysed traceability system connects heterogeneous actors through shared digital platforms, interoperable standards, and governance arrangements, confirming that such systems are best understood as distributed socio-technical infrastructures rather than purely technological tools, consistent with the affordance and boundary-object perspective introduced in Section 2.2. The empirical evidence further suggests that digital traceability infrastructures do not determine organisational behaviour directly. Rather, they create differentiated possibilities for action that are realised according to actors' digital capabilities, organisational routines, and governance arrangements. Consequently, the same digital infrastructure supports different forms of participation, coordination, and information integration across organisational tiers, depending on how individual actors appropriate and enact its functionalities within their local operational context.

6.2 Information integration and platform-enabled coordination across supply network tiers

A second contribution concerns the role of information integration within digital traceability systems. Existing traceability literature has often focused on tracking technologies while paying limited attention to the mechanisms through which information is integrated across heterogeneous organisational actors and digital systems. The empirical analysis demonstrates that effective traceability implementation depends on the combined operation of complementary socio-technical mechanisms, rather than on any single mechanism in isolation. In this sense, data integration emerges as the core capability of digital traceability systems, enabling firms to coordinate distributed activities through shared and interoperable information infrastructures. The study shows that traceability effectiveness relies on the alignment of the syntactic, semantic, and pragmatic dimensions of information integration (Barki and Pinsonneault, 2005). At the syntactic level, firms standardise identifiers, coding systems, and data formats across organisational actors. At the semantic level, actors develop shared interpretations of traceability information across supply chain tiers. At the pragmatic level, such information becomes embedded within operational coordination, sustainability monitoring, and managerial decision-making processes across the network.

The analysis also highlights the role of digital platforms as coordination infrastructures that facilitate interoperability, information visibility, and continuous information exchange across distributed supply networks. Rather than functioning merely as repositories of traceability data, these platforms support the synchronisation, validation, and updating of interconnected information flows across organisational boundaries. By doing so, they integrate heterogeneous data generated at different supply chain stages while preserving the continuity of traceability records throughout transformation processes. This extends platform and IOS literature by showing how shared digital infrastructures facilitate distributed information sharing within fragmented multi-tier supply networks characterised by heterogeneous enterprise systems, uneven digital capabilities, and distributed governance structures. The empirical evidence further indicates that these coordination mechanisms are essential for managing reciprocal interdependence among organisational actors, since traceability information generated by one actor directly influences the visibility, coordination, and operational activities of other participants across the network. At the same time, digital platforms also generate governance tensions associated with information sharing, visibility, and control. Their implementation requires focal firms to define shared standards, validation procedures, and access rules regulating how traceability data are generated, verified, and exchanged across organisational tiers. In addition, upstream actors frequently possess uneven digital capabilities and varying willingness to disclose operational information, thereby generating asymmetries in visibility and coordination across the supply network. Viewed through the boundary-object perspective introduced in Section 2.2, shared traceability records facilitate coordination across organisational tiers while accommodating differences in local operational practices. At the same time, because the focal company defines identifiers, reporting formats, validation rules, and data structures, these shared traceability artefacts also become mechanisms through which interpretive control is exercised across the network. Consequently, the same information infrastructure simultaneously enables cross-tier coordination while reinforcing asymmetric responsibilities and adaptation efforts among organisational actors.

These findings further suggest that the costs and benefits associated with digital traceability infrastructures are distributed asymmetrically across organisational tiers. While the focal company derives greater strategic value through enhanced network visibility, information integration, governance capabilities, and preparedness for an evolving regulatory environment, upstream actors primarily experience increased operational responsibilities associated with data generation, validation, compliance with platform requirements, and the adaptation of existing routines to externally defined standards. This asymmetry does not imply unequal commitment to the traceability initiative; rather, it reflects the different organisational roles, digital capabilities, and strategic positions occupied by actors within the multi-tier supply network.

Effective information integration therefore depends not only on technological interoperability, but also on governance arrangements and trust-based relationships capable of supporting reliable information exchange across organisational actors. Governance practices should therefore be understood as constitutive components of digital traceability systems rather than merely complementary managerial practices, since they directly shape information reliability, interoperability, coordination effectiveness, and the distribution of responsibilities across organisational tiers. These findings further reinforce the socio-technical nature of digital traceability systems, demonstrating that effective cross-tier integration emerges from the combined interaction of technological infrastructures, governance arrangements, and relational coordination mechanisms rather than from technological interoperability alone.

6.3 Traceability depth as an information systems design dimension

A third contribution concerns the introduction of traceability depth as an information systems design dimension. Prior literature has generally conceptualised traceability granularity in operational terms, focusing on tracking precision and product identification. By contrast, the findings of this study show that traceability depth also shapes information visibility, integration complexity, and coordination capabilities across supply network tiers. The empirical analysis demonstrates that traceability depth varies systematically across organisational stages. Upstream actors frequently adopt batch-level traceability configurations supporting aggregation efficiency and operational feasibility, while downstream actors implement item-level traceability systems supporting product authentication, customer-facing transparency, and brand protection.

The findings therefore suggest that traceability depth should be understood as a configurable characteristic of digital traceability architectures rather than a uniform property of the traceability system itself. Traceability depth encompasses variations in informational granularity, data lineage continuity, and cross-tier visibility across organisational tiers. The study further indicates that traceability depth is shaped not only by operational constraints, but also by digital capabilities, governance arrangements, coordination requirements, and transparency expectations. This highlights how different traceability configurations generate different trade-offs between informational visibility, operational complexity, and integration requirements across supply network stages. This contribution extends existing traceability and supply chain visibility literature by conceptualising traceability depth as a socio-technical characteristic of inter-organisational information infrastructures rather than merely as an operational tracking parameter. Accordingly, traceability depth should not be interpreted merely as a technical tracking configuration, but as a strategic information systems design choice influencing visibility, coordination complexity, and data integration across multi-tier supply networks.

Read through a configurational lens, the findings suggest that traceability depth does not emerge through a single implementation pathway across the supply network. Rather, comparable traceability outcomes are achieved through different, tier-specific combinations of regulatory pressure, digitally enabled coordination, data standardisation, relational governance, and organisational capabilities. This perspective recognises that equivalent levels of traceability participation may arise from alternative socio-technical pathways rather than from a single optimal organisational or technological arrangement (Xi *et al.*, 2023; Feng and Sheng, 2023; Jiang *et al.*, 2024; Wang and Feng, 2026; Zhang *et al.*, 2026).

The empirical evidence reveals three distinct organisational configurations. At the downstream focal-company tier, strong regulatory exposure combines with advanced digital capabilities, high platform integration, and centralised governance to support item-level traceability. At the midstream tannery tier, partial platform integration together with externally defined data requirements enables batch-level traceability through periodic synchronisation rather than continuous connectivity. By contrast, upstream actors—including the hide collector, slaughterhouse, and farmer—participate through a configuration characterised by limited digital capability, simplified interfaces designed by the focal company, and greater reliance on relational trust to sustain information exchange. Rather than representing less advanced versions of a single ideal model, these alternative pathways constitute complementary and internally coherent arrangements that collectively enable network-level traceability.

This configurational interpretation extends existing traceability research by suggesting that traceability depth should be understood as the outcome of multiple, equally viable socio-technical and governance configurations rather than as the consequence of a single dominant combination of organisational or technological conditions. Importantly, these configurations should not be interpreted solely as alternative technological arrangements. They also reflect different distributions of responsibilities, strategic benefits, operational burdens, and adaptation effort across organisational tiers, highlighting that participation in digital traceability infrastructures is inherently shaped by actors' organisational roles, digital capabilities, governance position, and regulatory exposure.

This perspective also reveals governance implications that would remain less visible under a purely functional interpretation of information integration. Because the focal company defines the shared traceability platform, its data structures, identifiers, reporting formats, and validation rules, it retains greater influence over how traceability is implemented across the network, whereas upstream actors are required to adapt their existing practices, often at proportionally greater operational effort, to an information architecture that they did not design. Although the available data do not allow a systematic assessment of how strategic benefits and implementation costs are distributed among participating organisations, they clearly indicate that both adaptation effort and interpretive control are unevenly distributed across organisational tiers. Consequently, governance arrangements that appear collaborative at the network level may still be experienced asymmetrically by individual actors. This asymmetry does not undermine the effectiveness of the traceability system; rather, it demonstrates that participation, coordination, and digital integration are shaped by different combinations of technological capability, governance arrangements, organisational resources, and institutional responsibilities across the supply network.

6.4 Digital traceability and sustainability-oriented visibility

The findings also contribute to research on sustainability and supply network transparency by showing how digital traceability systems support sustainability-oriented visibility across multi-tier supply networks. By enabling greater visibility over upstream sourcing and production activities, traceability systems support sustainability monitoring, responsible sourcing practices, and communication of sustainability-related information towards stakeholders and consumers. At the same time, the study suggests that the existence of digital traceability infrastructures does not automatically guarantee complete transparency across supply networks. Effective transparency depends on the quality, consistency, accessibility, and governance of traceability information across organisational actors. This highlights the importance of considering governance complexity, information asymmetries, and data validation mechanisms when analysing digital transparency initiatives within multi-tier supply networks.

The findings demonstrate that digital traceability systems create value not only through operational monitoring and compliance, but also through the generation of integrated information infrastructures supporting coordination, visibility, sustainability, and strategic decision-making across distributed supply network actors.

Table 2 summarises the main theoretical implications emerging from the empirical findings, highlighting how digital traceability systems operate as inter-organisational information infrastructures enabling information integration, coordination, and visibility across multi-tier supply networks.

7. Conclusions

This study investigated how traceability systems are implemented within multi-tier fashion supply networks and how they support sustainability, transparency, and coordination across organisational actors. By adopting an information systems perspective, the study conceptualises traceability systems as inter-organisational digital infrastructures that enable the generation, integration, and exchange of data across distributed supply network actors. The analysis indicates that the adoption of digital traceability systems is driven by a combination of sustainability pressures, quality management requirements, brand protection strategies, transparency expectations, and coordination needs. In response to these pressures, firms increasingly develop digital infrastructures capable of integrating information across multiple organisational tiers and enabling visibility across fragmented supply network environments.

The study also demonstrates that the effectiveness of traceability implementation depends on the interaction between digital platforms, data standardisation mechanisms, governance arrangements, and relational coordination practices. In particular, the findings highlight how platform-enabled coordination mechanisms support information integration across heterogeneous organisational actors by enabling the synchronisation, validation, and continuous updating of interconnected traceability information across supply chain stages.

A key insight emerging from the study concerns the concept of traceability depth, which reflects variations in informational granularity, cross-tier visibility, and data lineage continuity across organisational stages. The findings show that firms balance batch-level and item-level traceability configurations according to operational requirements, visibility needs, digital capabilities, and coordination complexity. Accordingly, traceability depth should be understood as a strategic information systems design dimension shaping visibility, coordination complexity, and data integration across multi-tier supply networks rather than merely as an operational tracking parameter.

From a theoretical perspective, this study contributes to the inter-organisational information systems (IOS) and information integration literature by extending the understanding of digital traceability beyond compliance-oriented monitoring mechanisms and conceptualising traceability systems as inter-organisational information infrastructures that support coordination, visibility, and distributed information integration across multi-tier

Table 2. Theoretical implications of digital traceability systems as inter-organisational information infrastructures

Dimension	Empirical evidence	Theoretical interpretation	IS implications
Traceability as IOS infrastructure	Traceability system connects multiple organisational actors through a shared digital platform enabling continuous generation and exchange of traceability information across supply chain tiers	Digital traceability systems operate as inter-organisational information infrastructures rather than stand-alone tracking technologies	Extends IOS literature by conceptualising traceability systems as distributed socio-technical infrastructures enabling multi-tier coordination and information visibility
Information integration	Data standardisation, shared identifiers, and interoperable coding structures enable actors to exchange and interpret traceability information consistently across organisational tiers	Information integration depends on syntactic, semantic, and pragmatic alignment across heterogeneous organisational actors	Highlights the multi-dimensional nature of information integration within digital traceability systems
Platform-enabled coordination	Digital platforms support continuous synchronisation, validation, and updating of interconnected information flows across organisational boundaries	Platform-enabled coordination supports reciprocal interdependence among distributed supply network actors	Extends platform and IOS literature by showing how digital platforms operate as coordination infrastructures within multi-tier supply networks
Governance mechanisms	Governance mechanisms regulate data validation, information access, and coordination among actors with heterogeneous digital capabilities	Effective traceability depends on the interaction between technological interoperability and relational governance mechanisms	Reinforces the socio-technical nature of inter-organisational information systems and highlights governance complexity within distributed digital infrastructures
Traceability depth	Upstream actors implement batch-level traceability while downstream actors increasingly adopt item-level traceability systems	Traceability depth represents a configurable design dimension shaping informational granularity, data lineage continuity, and cross-tier visibility	Extends traceability literature by conceptualising traceability depth as an information systems design characteristic rather than merely an operational tracking parameter
Sustainability-oriented visibility	Traceability systems support sustainability monitoring, responsible sourcing, and customer-facing transparency across organisational tiers	Digital traceability systems enable sustainability-oriented visibility across distributed supply networks	Connects IOS and information integration literature with sustainability and transparency research streams

supply networks. The study further advances IOS research by explaining how platform-enabled coordination, interoperable information exchange, and governance arrangements support reciprocal interdependence among heterogeneous organisational actors operating across different supply chain tiers.

The paper also contributes to the traceability and supply chain visibility literature by introducing the concept of traceability depth as an information systems design dimension that captures variations in informational granularity, data lineage continuity, and cross-tier visibility within digital traceability architectures. Rather than representing a fixed system characteristic, traceability depth emerges from different organisational configurations balancing digital capabilities, governance arrangements, operational practices, and regulatory conditions. In doing so, the study extends configurational perspectives within the information systems literature by showing that comparable levels of traceability participation can be achieved through multiple, equally viable socio-technical configurations rather than through a single optimal implementation pathway.

The study also demonstrates that digital traceability infrastructures reshape inter-organisational coordination not simply by increasing information availability, but by creating differentiated opportunities for coordination, governance, and cross-tier translation through which heterogeneous actors interact, exchange information, and coordinate activities across organisational boundaries. This perspective further highlights that digital infrastructures influence not only information exchange, but also the distribution of interpretive control, adaptation efforts, and governance responsibilities across organisational tiers.

From a managerial perspective, the findings suggest that firms should approach digital traceability as a strategic inter-organisational capability rather than merely as a compliance-oriented technology. Effective implementation requires investments not only in digital infrastructures, but also in interoperable standards, governance mechanisms, and organisational capabilities supporting information integration across supply network actors. Effective implementation requires investments not only in digital infrastructures, but also in interoperable standards, governance mechanisms, and organisational capabilities supporting information integration across supply network actors. The findings further indicate that traceability systems should be configured according to the informational and operational requirements of different supply chain tiers, balancing the benefits of increased visibility against the complexity associated with more granular traceability architectures. Rather than applying a single, undifferentiated data-entry standard across the network, focal firms are encouraged to calibrate platform requirements to the digital maturity of each tier: providing simplified, low-burden interfaces and manual or semi-automated data-entry routes for upstream actors with limited digital infrastructure, such as farmers, hide collectors, and slaughterhouses, while reserving fuller ERP and RFID-based platform integration for midstream and downstream actors with the technical capability to sustain it. This tiered approach can reduce the disproportionate adaptation burden documented among smaller upstream suppliers without compromising the integrity of the traceability chain. The study also highlights the importance of governance and relational coordination mechanisms in enabling effective information exchange across heterogeneous organisational actors. The findings suggest that governance practices should be considered constitutive components of digital traceability systems, as they directly influence information reliability, interoperability, and coordination effectiveness across organisational tiers. Firms implementing digital traceability systems should therefore establish shared standards, validation procedures, and collaborative governance arrangements capable of supporting trustworthy and interoperable information exchange across multi-tier supply networks.

Despite these contributions, the study presents some limitations. First, the analysis is based on a single case study within the luxury fashion sector, which may limit the generalisability of the findings. However, the objective of the study was analytical generalisation and theory development rather than empirical representativeness. Second, while the study adopts a multi-tier perspective, it focuses primarily on organisational and informational mechanisms rather than on the technical performance of specific digital technologies. Third, the study does not directly examine how consumers interpret and use traceability information communicated through digital interfaces. Fourth, because the interview protocol was itself structured around the study's inter-organisational information systems framework, the first-order concepts identified in the analysis closely track the protocol's topics; the empirical account is therefore more accurately characterised as a theory-informed, abductive reconstruction than as a purely inductive, ground-up theory-building exercise, as clarified in Section 4. Accordingly, the empirical account and the Gioia-inspired data structure should be interpreted as a theory-informed abductive elaboration of the case rather than as evidence of unconstrained inductive theory generation. Fifth, while the study documents governance tensions and uneven digital capabilities across tiers, the available data do not allow a systematic assessment of who benefits most from the traceability system and who bears disproportionate operational burden. The comparatively limited digitalisation and modest direct data contribution of the upstream livestock farmer illustrate this asymmetry, but establishing its full distributional implications would require dedicated data collection focused on upstream actors' own experience of the system, which falls outside the scope of the present study.

Future research could extend the analysis to other industries and geographical contexts in order to compare how digital traceability systems operate across different supply network configurations and institutional environments. Additional studies could also investigate how different technological architectures influence interoperability, information integration, governance complexity, and operational performance across organisational actors. Finally, future research could further examine the economic and organisational implications of traceability depth configurations, including their effects on coordination complexity, information-processing costs, consumer trust, and long-term competitive advantage. Future studies could also examine more systematically the distributional consequences of digital traceability systems, investigating who benefits from network-wide visibility and who bears disproportionate data-entry and adaptation burdens, particularly among smaller and less digitally mature upstream suppliers. Particular attention should be devoted to understanding how different organisational actors perceive the fairness of platform governance, the allocation of data-entry responsibilities, the distribution of strategic value generated by digital traceability infrastructures, and the evolving balance between coordination benefits and operational burdens across organisational tiers.

Appendix 1

Table A1. Within case analysis

Dimension	Focal company (brand owner)	First-tier supplier (Tannery)	Second-tier supplier (Hide collector)	Third-tier supplier (slaughterhouse)	Fourth-tier supplier (farmer)
Country	Italy	Italy	Italy	Italy	Spain
Company size	Large Enterprise	Large Enterprise	Large Enterprise	Large Enterprise	SME
Core activities	Product design, brand management, retail coordination	Leather processing and transformation	Collection and classification of hides	Animal processing and hide extraction	Animal breeding
Strategic role in traceability	System orchestrator; defines architecture and standards	Transformation node linking raw materials to manufacturing	Data aggregation node	Primary data generation node	Origin data provider
Traceability practices	Item-level tracking; integration of upstream data; product authentication	Batch tracking of hides and processing stages	Batch identification and origin tracking	Identification of animals and hides	Initial animal identification
Traceability level	Item-level (downstream)	Batch-level	Batch-level	Batch-level	Batch-level (origin)
Data generated	Product ID, supplier data, sustainability data, production data	Batch ID, transformation data, quality data	Origin data, classification data	Animal ID, processing data	Animal ID, farm data
Data granularity	High (item-level)	Medium (batch-level)	Medium	Medium	Low–medium
Identification mechanisms	RFID tags, product codes	Batch codes	Batch codes	Animal IDs, batch codes	Ear tags, manual records
Digital systems/ ICT tools	RFID system, ERP, traceability platform	ERP, traceability software	Basic digital systems	Local IS and databases	Limited digitalisation
Information integration mechanisms	Integration of multi-tier data through shared identifiers, platform coordination, and validation rules	Linking input/output batches through transformation records and shared identifiers	Aggregation and transmission of supplier-origin data across tiers	Generation of primary traceability records connected to downstream batch identifiers	Limited integration; reliance on upstream actors for digital information transfer
Platform interaction	Central node; collects and distributes data	Uploads and retrieves data	Transfers data upstream	Transfers data to collectors	Indirect participation

(*continued*)

Table A1. Continued

Dimension	Focal company (brand owner)	First-tier supplier (Tannery)	Second-tier supplier (Hide collector)	Third-tier supplier (slaughterhouse)	Fourth-tier supplier (farmer)
Data lineage continuity	Maintains item-level continuity between final products and upstream batches	Preserves informational continuity during aggregation/disaggregation processes	Maintains continuity between sourcing and classification stages	Preserves linkage between animal origin and hide extraction	Provides origin-level traceability information
Data governance and control	Defines standards, validates data, controls quality	Ensures data accuracy and compliance	Ensures origin data reliability	Ensures primary data accuracy	Limited governance
Governance tensions/ constraints	Need to coordinate heterogeneous actors with different digital capabilities and incentives	Pressure to maintain data consistency across transformations	Dependence on upstream data reliability	Operational burden associated with traceability requirements	Limited bargaining power and digital maturity
Information visibility	Full visibility across tiers and to consumers	Visibility upstream/ downstream	Limited visibility	Limited visibility	Very limited visibility
Coordination mechanisms	Defines protocols; orchestrates network	Coordinates with suppliers and manufacturer	Connects upstream and downstream	Compliance-based coordination	Minimal coordination
Validation mechanisms	Cross-checking procedures, standardised protocols, and platform validation rules	Verification of transformation and quality records	Validation of origin and supplier data	Validation of primary animal and batch records	Basic validation through upstream actors
Key challenges	Integration complexity; data consistency	Managing transformation data	Data consistency from multiple sources	Data accuracy at source	Low digital capability
Contribution to system	Enables system-wide integration and visibility	Connects raw materials to production	Ensures traceability continuity	Generates primary traceability data	Provides origin data

Appendix 2

Table A2. Cross case analysis

Dimension	Upstream actors (farmer, slaughterhouse, Hide collector)	Midstream actor (Tannery)	Downstream actors (manufacturer and focal firm)	Cross-tier interpretation
Role in traceability system	Generation of origin data and initial identification of materials	Transformation and linking of input and output batches	Integration and orchestration of traceability data across tiers	Traceability operates as a layered system combining data generation, transformation, and integration
Primary objective of traceability	Ensure origin identification and traceability of raw materials	Maintain continuity of traceability across transformation processes	Enable transparency, product-level visibility, and coordination across the network	Objectives evolve from operational traceability to system-level visibility and coordination
Traceability level	Batch-level traceability	Batch-level traceability with transformation linking	Item-level traceability for finished products	Traceability depth increases downstream, reflecting different information requirements
Type of data generated	Origin data (animal identification, location, supplier)	Transformation data (processing activities, quality, batch linkage)	Product-level traceability data and integrated supply chain information	Data evolve from raw origin attributes to integrated and structured traceability information
Data granularity	Low to medium (batch-level)	Medium (batch-level with transformation detail)	High (item-level)	Increasing granularity reflects trade-offs between operational feasibility and visibility
Degree of system integration	Limited (data transferred through intermediaries)	Partial (integration between upstream and downstream data)	High (central integration across tiers)	System integration is uneven and increases towards the focal firm
Interaction with digital platform Indirect participation through data passed to downstream actors	Interaction with digital platform Indirect participation through data passed to downstream actors	Interaction with digital platform Indirect participation through data passed to downstream actors	Interaction with digital platform Indirect participation through data passed to downstream actors	Interaction with digital platform Indirect participation through data passed to downstream actors
Active participation through data upload and retrieval	Active participation through data upload and retrieval	Active participation through data upload and retrieval	Active participation through data upload and retrieval	Active participation through data upload and retrieval

(*continued*)

Table A2. Continued

Dimension	Upstream actors (farmer, slaughterhouse, Hide collector)	Midstream actor (Tannery)	Downstream actors (manufacturer and focal firm)	Cross-tier interpretation
Central role in managing, validating, and accessing traceability data	Central role in managing, validating, and accessing traceability data	Central role in managing, validating, and accessing traceability data	Central role in managing, validating, and accessing traceability data	Central role in managing, validating, and accessing traceability data
Key challenges	Data capture at source and limited digital capabilities	Ensuring consistency of data across transformations	Integrating heterogeneous data across multiple supply chain tiers	Challenges differ across tiers but are interdependent
Contribution to traceability system	Provide origin and initial traceability data	Ensure continuity and linkage of traceability information	Enable system-wide visibility, integration, and transparency	Effective traceability depends on complementary roles across tiers

References

Abdelmeguid, A., Afy-Shararah, M. and Salonitis, K. (2024), “Towards circular fashion: management strategies promoting circular behaviour along the value chain”, *Sustainable Production and Consumption*, Vol. 48, pp. 143-156, doi: 10.1016/j.spc.2024.05.010.

Ali, M.H., Chung, L., Kumar, A., Zailani, S. and Tan, K.H. (2021), “A sustainable blockchain framework for the halal food supply chain: lessons from Malaysia”, *Technological Forecasting and Social Change*, Vol. 170, 120870, doi: 10.1016/j.techfore.2021.120870.

Aloini, D., Benevento, E., Stefanini, A. and Zerbino, P. (2023), “Transforming healthcare ecosystems through blockchain: opportunities and capabilities for business process innovation”, *Technovation*, Vol. 119, 102557, doi: 10.1016/j.technovation.2022.102557.

Annosi, M.C., Brunetta, F., Bimbo, F. and Kostoula, M. (2021), “Digitalization within food supply chains to prevent food waste. Drivers, barriers and collaboration practices”, *Industrial Marketing Management*, Vol. 93, pp. 208-220, doi: 10.1016/j.indmarman.2021.01.005.

Barki, H. and Pinsonneault, A. (2005), “A model of organizational integration, implementation effort, and performance”, *Organization Science*, Vol. 16 No. 2, pp. 165-179, doi: 10.1287/orsc.1050.0118.

Bendaoud, M., Lecomte, C. and Yannou, B. (2012), “A methodological framework to design and assess food traceability systems”, *International Food and Agribusiness Management Review*, Vol. 15 No. 1, pp. 103-125.

Benstead, A.V., Mwesiumo, D., Moradlou, H. and Boffelli, A. (2024), “Entering the world behind the clothes that we wear: practical applications of blockchain technology”, *Production Planning and Control*, Vol. 35 No. 9, pp. 947-964, doi: 10.1080/09537287.2022.2063173.

Bevilacqua, M., Ciarapica, F.E. and Giacchetta, G. (2009), “Business process reengineering of a supply chain and a traceability system: a case study”, *Journal of Food Engineering*, Vol. 93 No. 1, pp. 13-22, doi: 10.1016/j.jfoodeng.2008.12.020.

Bharathi, S.V., Perdana, A., Vivekanand, T.S., Venkatesh, V.G., Cheng, Y. and Shi, Y. (2025), “From ocean to table: examining the potential of blockchain for responsible sourcing and sustainable seafood supply chains”, *Production Planning and Control*, Vol. 36 No. 7, pp. 950-969, doi: 10.1080/09537287.2024.2321291.

Böhmecke-Schwafert, M., Wehinger, M. and Teigland, R. (2022), “Blockchain for the circular economy: theorizing blockchain’s role in the transition to a circular economy through an empirical investigation”, *Business Strategy and the Environment*, Vol. 31 No. 8, pp. 3786-3801, doi: 10.1002/bse.3032.

Bosona, T. and Gebresenbet, G. (2013), "Food traceability as an integral part of logistics management in food and agricultural supply chain", *Food Control*, Vol. 33 No. 1, pp. 32-48, doi: 10.1016/j.foodcont.2013.02.004.

Bottani, E. and Rizzi, A. (2008), "Economical assessment of the impact of RFID technology and EPC system on the fast-moving consumer goods supply chain", *International Journal of Production Economics*, Vol. 112 No. 2, pp. 548-569, doi: 10.1016/j.ijpe.2007.05.007.

Burini, G., Xu, J., Pero, M. and Sandberg, E. (2025), "Reverse supply chain configurations in the fashion and textile industry", *Sustainable Production and Consumption*, Vol. 56, pp. 504-518, doi: 10.1016/j.spc.2025.04.016.

Canavari, M., Centonze, R., Hingley, M. and Spadoni, R. (2010), "Traceability as part of competitive strategy in the fruit supply chain", *British Food Journal*, Vol. 112 No. 2, pp. 171-186, doi: 10.1108/00070701011018851.

Choi, T.M., Dolgui, A., Ivanov, D. and Pesch, E. (2022), "OR and analytics for digital, resilient, and sustainable manufacturing 4.0", *Annals of Operations Research*, Vol. 310 No. 1, pp. 1-6, doi: 10.1007/s10479-022-04536-3.

Cimino, M., Marcelloni, F. and Tomasi, A. (2008), "Patterns and technologies for enabling supply chain traceability through collaborative e-business", *Information and Software Technology*, Vol. 50, pp. 342-359.

Cole, R., Stevenson, M. and Aitken, J. (2019), "Blockchain technology: implications for operations and supply chain management", *Supply Chain Management: International Journal*, Vol. 24 No. 4, pp. 469-483, doi: 10.1108/scm-09-2018-0309.

de Boissieu, E., Kondrateva, G., Baudier, P. and Ammi, C. (2021), "The use of blockchain in the luxury industry: supply chains and the traceability of goods", *Journal of Enterprise Information Management*, Vol. 34 No. 5, pp. 1318-1338, doi: 10.1108/jeim-11-2020-0471.

De Brito, M.P., Carbone, V. and Blanquart, C.M. (2008), "Towards a sustainable fashion retail supply chain in Europe: organisation and performance", *International Journal of Production Economics*, Vol. 114 No. 2, pp. 534-553, doi: 10.1016/j.ijpe.2007.06.012.

de Reuver, M., Sørensen, C. and Basole, R.C. (2018), "The digital platform: a research agenda", *Journal of Information Technology*, Vol. 33 No. 2, pp. 124-135, doi: 10.1057/s41265-016-0033-3.

Dekker, H.C. (2004), "Control of inter-organizational relationships: evidence on appropriation concerns and coordination requirements", *Accounting, Organizations and Society*, Vol. 29 No. 1, pp. 27-49, doi: 10.1016/s0361-3682(02)00056-9.

Diallo, M.F., Ben Dahmane Mouelhi, N., Gadekar, M. and Schill, M. (2021), "CSR actions, brand value, and willingness to pay a premium price for luxury brands: does long-term orientation matter?", *Journal of Business Ethics*, Vol. 169 No. 2, pp. 241-260, doi: 10.1007/s10551-020-04486-5.

Dong, X., Hao, X., Cai, C., Li, X., Wang, K. and Zhang, J. (2025), "The impact of blockchain adoption in supply chain systems on corporate performance: a technology–organization–environment framework", *Production Planning and Control*, Vol. 36 No. 11, pp. 1431-1452, doi: 10.1080/09537287.2024.2364814.

Donnelly, K., Karlsen, K. and Olsen, P. (2009), "The importance of transformations for traceability. - a case study of lamb and lamb products", *Meat Science*, Vol. 83 No. 1, pp. 68-73, doi: 10.1016/j.meatsci.2009.04.006.

dos Reis, J.G.M. and Machado, S.T. (2022), "The role of logistics management in food supply chains", in *New Perspectives in Operations Research and Management Science: Essays in Honor of Fusun Ulengin* (pp. 551-582), Springer International Publishing, Cham.

Egels-Zandén, N. and Hansson, N. (2016), "Supply chain transparency as a consumer or corporate tool: the case of Nudie Jeans Co", *Journal of Consumer Policy*, Vol. 39 No. 4, pp. 377-395, doi: 10.1007/s10603-015-9283-7.

Eisenhardt, K.M. (1989), "Building theories from case study research", *Academy of Management Review*, Vol. 14 No. 4, pp. 532-550, doi: 10.2307/258557.

Eisenhardt, K.M. and Graebner, M.E. (2007), "Theory building from cases: opportunities and challenges", *Academy of Management Journal*, Vol. 50 No. 1, pp. 25-32, doi: 10.5465/amj.2007.24160888.

Engelseth, P. (2009), "Food product traceability and supply network integration", *Journal of Business and Industrial Marketing*, Vol. 24 Nos 5/6, pp. 421-430, doi: 10.1108/08858620910966291.

Erhun, F., Kraft, T. and Wijnsma, S. (2021), "Sustainable triple-a supply chains", *Production and Operations Management*, Vol. 30 No. 3, pp. 644-655, doi: 10.1111/poms.13306.

Ermini, C., Visintin, F. and Boffelli, A. (2024), "Understanding supply chain orchestration mechanisms to achieve sustainability-oriented innovation in the textile and fashion industry", *Sustainable Production and Consumption*, Vol. 49, pp. 415-430, doi: 10.1016/j.spc.2024.07.008.

EURATEX (2017), *Annual Report 2017: EU Textile and Fashion Industry*, European Apparel and Textile Confederation, available at: https://euratex.eu/about-euratex/annual-reports

Fan, Z.P., Wu, X.Y. and Cao, B.B. (2022), "Considering the traceability awareness of consumers: should the supply chain adopt the blockchain technology?", *Annals of Operations Research*, Vol. 309 No. 2, pp. 1-24, doi: 10.1007/s10479-020-03729-y.

Feng, T. and Sheng, H. (2023), "Identifying the equifinal configurations of prompting green supply chain integration and subsequent performance outcome", *Business Strategy and the Environment*, Vol. 32 No. 8, pp. 5234-5251, doi: 10.1002/bse.3414.

Fornasiero, R., Brondi, C. and Collatina, D. (2017), "Proposing an integrated LCA-SCM model to evaluate the sustainability of customisation strategies", *International Journal of Computer Integrated Manufacturing*, Vol. 30 No. 7, pp. 768-781, doi: 10.1080/0951192x.2016.1268716.

Friedman, N. and Ormiston, J. (2022), "Blockchain as a sustainability-oriented innovation?: opportunities for and resistance to blockchain technology as a driver of sustainability in global food supply chains", *Technological Forecasting and Social Change*, Vol. 175, 121403, doi: 10.1016/j.techfore.2021.121403.

Garcia-Torres, S., Rey-Garcia, M., Sáenz, J. and Seuring, S. (2022), "Traceability and transparency for sustainable fashion-apparel supply chains", *Journal of Fashion Marketing and Management: An International Journal*, Vol. 26 No. 2, pp. 344-364, doi: 10.1108/jfmm-07-2020-0125.

Gioia, D.A., Corley, K.G. and Hamilton, A.L. (2013), "Seeking qualitative rigor in inductive research: notes on the Gioia methodology", *Organizational Research Methods*, Vol. 16 No. 1, pp. 15-31, doi: 10.1177/1094428112452151.

Giri, V., Madaan, J., Chan, F.T. and Varma, N. (2025), "A methodological framework to analyze the impact of blockchain affordances on sustainable–resilient pharmaceutical supply chain performance", *Journal of Enterprise Information Management*, Vol. 39 No. 4, pp. 1-33, doi: 10.1108/jeim-10-2024-0567.

Goworek, H., Oxborrow, L., Claxton, S., McLaren, A., Cooper, T. and Hill, H. (2020), "Managing sustainability in the fashion business: challenges in product development for clothing longevity in the UK", *Journal of Business Research*, Vol. 117, pp. 629-641, doi: 10.1016/j.jbusres.2018.07.021.

Guercini, S. and Runfola, A. (2009), "The integration between marketing and purchasing in the traceability process", *Industrial Marketing Management*, Vol. 38 No. 8, pp. 883-891, doi: 10.1016/j.indmarman.2009.03.016.

Hannibal, C. and Kauppi, K. (2019), "Third party social sustainability assessment: is it a multi-tier supply chain solution?", *International Journal of Production Economics*, Vol. 217, pp. 78-87, doi: 10.1016/j.ijpe.2018.08.030.

Hastig, G.M. and Sodhi, M.S. (2020), "Blockchain for supply chain traceability: business requirements and critical success factors", *Production and Operations Management*, Vol. 29 No. 4, pp. 935-954, doi: 10.1111/poms.13147.

Herrmann, D. (1999), "Tracking systems as a catalyst for incremental innovation", *Management Decision*, Vol. 37 No. 10, pp. 786-791, doi: 10.1108/00251749910302881.

Hickmann, T., Biermann, F., Sénit, C.A., Sun, Y., Bexell, M., Bolton, M., . . . and Weiland, S. (2024), "Scoping article: research frontiers on the governance of the Sustainable Development Goals", *Global Sustainability*, Vol. 7, p. e7, doi: 10.1017/sus.2024.4.

Holmqvist, J. and Kowalkowski, C. (2023), "Traceability in luxury: harnessing B2B relationships to enhance ethical practices in the luxury industry", *Industrial Marketing Management*, Vol. 111, pp. 257-267, doi: 10.1016/j.indmarman.2023.04.008.

Horcea-Milcu, A.I., Dorresteijn, I., Leventon, J., Stojanovic, M., Lam, D.P., Lang, D.J. and Zimmermann, S., Stålhammar, S. and Weiser, A. (2024), "Transformative research for sustainability: characteristics, tensions, and moving forward", *Global Sustainability*, Vol. 7, e14.s, doi: 10.1017/sus.2024.12, available at: https://auraluxuryblockchain.com/

Hu, J., Zhang, X., Moga, L. and Neculita, M. (2013), "Modeling and implementation of the vegetable supply chain traceability system", *Food Control*, Vol. 30 No. 1, pp. 341-353, doi: 10.1016/j.foodcont.2012.06.037.

Huemer, L. and Flygansvær, B. (2025), "Increasing circularity: the importance of resource interactions when adapting from waste management to resource management", *Industrial Marketing Management*, Vol. 125, pp. 118-130, doi: 10.1016/j.indmarman.2024.12.010.

Hunka, A.D., Daniel, A.M., Bour, A. and Boyer, R.H. (2025), "Is transparency a good business strategy? Consumer preferences and willingness to pay for information about the chemical content of reused and recycled clothing", *Sustainable Production and Consumption*, Vol. 56, pp. 128-141, doi: 10.1016/j.spc.2025.03.020.

İndap, Ş. and Tanyaş, M. (2023), "Blockchain applications for traceability and food safety in agri-food supply chain: cherry product application", *Journal of Enterprise Information Management*.

Jackson, G., Bartosch, J., Avetisyan, E., Kinderman, D. and Knudsen, J.S. (2020), "Mandatory non-financial disclosure and its influence on CSR: an international comparison", *Journal of Business Ethics*, Vol. 162 No. 2, pp. 323-342, doi: 10.1007/s10551-019-04200-0.

Jiang, Y., Feng, T. and Huang, Y. (2024), "Antecedent configurations toward supply chain resilience: the joint impact of supply chain integration and big data analytics capability", *Journal of Operations Management*, Vol. 70 No. 2, pp. 257-284, doi: 10.1002/joom.1282.

Jimenez-Castillo, L., Sarkis, J., Saberi, S. and Yao, T. (2024), "Blockchain-based governance implications for ecologically sustainable supply chain management", *Journal of Enterprise Information Management*, Vol. 37 No. 1, pp. 76-99, doi: 10.1108/jeim-02-2022-0055.

Johnston, H.R. and Vitale, M.R. (1988), "Creating competitive advantage with interorganizational information systems", *MIS Quarterly*, Vol. 12 No. 2, pp. 153-165, doi: 10.2307/248839.

Kamath, R. (2018), "Food traceability on blockchain: Walmart's pork and mango pilots with IBM", *The Journal of the British Blockchain Association*, Vol. 1 No. 1, pp. 1-12, doi: 10.31585/jbba-1-1-(10)2018.

Karaosman, H., Perry, P., Brun, A. and Morales-Alonso, G. (2020), "Behind the runway: extending sustainability in luxury fashion supply chains", *Journal of Business Research*, Vol. 117, pp. 652-663, doi: 10.1016/j.jbusres.2018.09.017.

Karlsen, K.M., Dreyer, B., Olsen, P. and Elvevoll, E.O. (2013), "Literature review: does a common theoretical framework to implement food traceability exist?", *Food Control*, Vol. 32 No. 2, pp. 409-417, doi: 10.1016/j.foodcont.2012.12.011.

Kayikci, Y., Subramanian, N., Dora, M. and Bhatia, M.S. (2022), "Food supply chain in the era of Industry 4.0: blockchain technology implementation opportunities and impediments from the perspective of people, process, performance, and technology", *Production Planning and Control*, Vol. 33 Nos 2-3, pp. 301-321, doi: 10.1080/09537287.2020.1810757.

Khan, S.A.R., Godil, D.I., Jabbour, C.J.C., Shujaat, S., Razzaq, A. and Yu, Z. (2021), "Green data analytics, blockchain technology for sustainable development, and sustainable supply chain practices: evidence from small and medium enterprises", *Annals of Operations Research*, Vol. 350 No. 2, pp. 1-25, doi: 10.1007/s10479-021-04275-x.

Khan, S.J., Badghish, S., Kaur, P., Sharma, R. and Dhir, A. (2023), "What motivates the purchasing of green apparel products? A systematic review and future research agenda", *Business Strategy and the Environment*, Vol. 31 No. 7, pp. 4183-4201.

Kimbro, M.B., Abraham, A.T., Lambe, C. and Jones, V. (2018), "Corporate social responsibility: the efficacy of matched between not-for-profits and multinational enterprises in developed and emerging markets", *Journal of Management for Global Sustainability*, Vol. 6 No. 1, p. 8, doi: 10.13185/2244-6893.1078.

Klöckner, M., Schmidt, C.G. and Wagner, S.M. (2022), "When blockchain creates shareholder value: empirical evidence from international firm announcements", *Production and Operations Management*, Vol. 31 No. 1, pp. 46-64, doi: 10.1111/poms.13609.

Kumar, K. and van Dissel, H.G. (1996), "Sustainable collaboration: managing conflict and cooperation in interorganizational systems", *MIS Quarterly*, Vol. 20 No. 3, pp. 279-300, doi: 10.2307/249657.

Kumar, S., Raut, R.D., Agrawal, N., Cheikhrouhou, N., Sharma, M. and Daim, T. (2022), "Integrated blockchain and internet of things in the food supply chain: adoption barriers", *Technovation*, Vol. 118, 102589, doi: 10.1016/j.technovation.2022.102589.

Langfield-Smith, K. and Smith, D. (2003), "Management control systems and trust in outsourcing relationships", *Management Accounting Research*, Vol. 14 No. 3, pp. 281-307, doi: 10.1016/s1044-5005(03)00046-5.

Latino, M.E., Menegoli, M., Lazoi, M. and Corallo, A. (2022), "Voluntary traceability in food supply chain: a framework leading its implementation in Agriculture 4.0", *Technological Forecasting and Social Change*, Vol. 178, 121564, doi: 10.1016/j.techfore.2022.121564.

Leonardi, P.M. (2011), "When flexible routines meet flexible technologies: affordance, constraint, and the imbrication of human and material agencies", *MIS Quarterly*, Vol. 35 No. 1, pp. 147-167, doi: 10.2307/23043493.

Li, L. (2013), "Technology designed to combat fakes in the global supply chain", *Business Horizons*, Vol. 56 No. 2, pp. 167-177, doi: 10.1016/j.bushor.2012.11.010.

Li, G., Lim, M.K. and Wang, Z. (2020), "Stakeholders, green manufacturing, and practice performance: empirical evidence from Chinese fashion businesses", *Annals of Operations Research*, Vol. 290 No. 1, pp. 961-982, doi: 10.1007/s10479-019-03157-7.

Liu, N., Lin, J., Guo, S. and Shi, X. (2023), "Fashion platform operations in the sharing economy with digital technologies: recent development and real case studies", *Annals of Operations Research*, Vol. 329 No. 1, pp. 1175-1195, doi: 10.1007/s10479-022-04544-3.

Malik, M., Ghaderi, H. and Andargoli, A. (2021), "A resource orchestration view of supply chain traceability and transparency bundles for competitive advantage", *Business Strategy and the Environment*, Vol. 30 No. 8, pp. 3866-3881, doi: 10.1002/bse.2845.

Manzoor, R., Sahay, B.S. and Singh, S.K. (2022), "Blockchain technology in supply chain management: an organizational theoretic overview and research agenda", *Annals of Operations Research*, Vol. 348 No. 3, pp. 1-48, doi: 10.1007/s10479-022-05069-5.

Martínez, C.I.P. and Poveda, A.C. (2022), "Strategies to improve sustainability: an analysis of 120 microenterprises in an emerging economy", *Global Sustainability*, Vol. 5, e3, doi: 10.1017/sus.2022.3.

Masterson, V.A., Vetter, S., Chaigneau, T., Daw, T.M., Selomane, O., Hamann, M., Wong, G.Y., Mellegård, V., Cocks, M., Tengö, M. and Tengö, M. (2019), "Revisiting the relationships between human well-being and ecosystems in dynamic social-ecological systems: implications for stewardship and development", *Global Sustainability*, Vol. 2, e8, doi: 10.1017/sus.2019.5.

Mathew, M. and Spinelli, R. (2025), "Decoding sustainable drivers: a systematic literature review on sustainability-induced consumer behaviour in the fast fashion industry", *Sustainable Production and Consumption*, Vol. 55, pp. 132-145, doi: 10.1016/j.spc.2025.02.011.

Mejías, A.M., Bellas, R., Pardo, J.E. and Paz, E. (2019), "Traceability management systems and capacity building as new approaches for improving sustainability in the fashion multi-tier supply chain", *International Journal of Production Economics*, Vol. 217, pp. 143-158, doi: 10.1016/j.ijpe.2019.03.022.

Merlano, E.F., Frei, R., Zhang, D., Murzacheva, E. and Wood, S. (2024), "Consumer perspectives on interventions to combat fraudulent product returns in omnichannel fashion retail", *International Journal of Physical Distribution and Logistics Management*, Vol. 54 No. 10, pp. 969-1001, doi: 10.1108/ijpdlm-02-2024-0082.

Moon, K.L. and Ngai, E.W. (2010), "R&D framework for an intelligent fabric sample management system: a design science approach", *International Journal of Operations and Production Management*, Vol. 30 No. 7, pp. 721-743.

Moretto, A. and Macchion, L. (2022), "Drivers, barriers and supply chain variables influencing the adoption of the blockchain to support traceability along fashion supply chains", *Operations Management Research*, Vol. 15 Nos 3-4, pp. 1-20, doi: 10.1007/s12063-022-00262-y.

Negri, P. (2025), "Innovators and transformers: enhancing supply chain sustainability: a methodology combining dynamic simulation and case studies", *International Journal of Physical Distribution and Logistics Management*, Vol. 55 No. 4, pp. 409-425, doi: 10.1108/ijpdlm-01-2024-0003.

Ngai, E.W.T., Cheng, T.C.E., Lai, K.H., Chai, P.Y.F., Choi, Y.S. and Sin, R.K.Y. (2007), "Development of an RFID-based traceability system: experiences and lessons learned from an aircraft engineering company", *Production and Operations Management*, Vol. 16 No. 5, pp. 554-568, doi: 10.1111/j.1937-5956.2007.tb00280.x.

Nygaard, A. and Silkoset, R. (2023), "Sustainable development and greenwashing: how blockchain technology information can empower green consumers", *Business Strategy and the Environment*, Vol. 32 No. 6, pp. 3801-3813.

Orlikowski, W.J. (2007), "Sociomaterial practices: exploring technology at work", *Organization Studies*, Vol. 28 No. 9, pp. 1435-1448, doi: 10.1177/0170840607081138.

Ozturk, E., Cinperi, N.C. and Kitis, M. (2020), "Improving energy efficiency using the most appropriate techniques in an integrated woolen textile facility", *Journal of Cleaner Production*, Vol. 254, 120145, doi: 10.1016/j.jclepro.2020.120145.

Papetti, A., Marconi, M., Rossi, M. and Germani, M. (2019), "Web-based platform for eco-sustainable supply chain management", *Sustainable Production and Consumption*, Vol. 17, pp. 215-228, doi: 10.1016/j.spc.2018.11.006.

Parmentola, A., Petrillo, A., Tutore, I. and De Felice, F. (2022), "Is blockchain able to enhance environmental sustainability? A systematic review and research agenda from the perspective of Sustainable Development Goals (SDGs)", *Business Strategy and the Environment*, Vol. 31 No. 1, pp. 194-217, doi: 10.1002/bse.2882.

Perano, M., Cammarano, A., Varriale, V., Del Regno, C., Michelino, F. and Caputo, M. (2023), "Embracing supply chain digitalization and unphysicalization to enhance supply chain performance: a conceptual framework", *International Journal of Physical Distribution and Logistics Management*, Vol. 53 Nos 5-6, pp. 628-665, doi: 10.1108/ijpdlm-06-2022-0201.

Pun, H., Swaminathan, J.M. and Hou, P. (2021), "Blockchain adoption for combating deceptive counterfeits", *Production and Operations Management*, Vol. 30 No. 4, pp. 864-882, doi: 10.1111/poms.13348.

Razak, G.M., Hendry, L.C. and Stevenson, M. (2023), "Supply chain traceability: a review of the benefits and its relationship with supply chain resilience", *Production Planning and Control*, Vol. 34 No. 11, pp. 1114-1134, doi: 10.1080/09537287.2021.1983661.

Reck, R., Castagna, A.C., Shuqair, S. and Pinto, D.C. (2022), "The transparency paradox: when transparency cues helps or backfires for brands?", *Journal of Cleaner Production*, Vol. 372, 133381, doi: 10.1016/j.jclepro.2022.133381.

Regattieri, A., Gamberi, M. and Manzini, R. (2007), "Traceability of food products: general frame work and experimental evidence", *Journal of Food Engineering*, Vol. 81 No. 2, pp. 347-356, doi: 10.1016/j.jfoodeng.2006.10.032.

Robey, D., Im, G. and Wareham, J. (2008), "Theoretical foundations of empirical research on interorganizational systems: assessing past contributions and guiding future directions", *Journal* *of the Association for Information Systems*, Vol. 9 No. 9, pp. 497-518, doi: 10.17705/1jais.00171.

Roy, V. (2021), "Contrasting supply chain traceability and supply chain visibility: are they interchangeable?", *The International Journal of Logistics Management*, Vol. 32 No. 3, pp. 942-972, doi: 10.1108/ijlm-05-2020-0214.

Ru, X., Schandl, H. and Lu, Y. (2026), "Consumer psychology in the circular economy: network evidence from sustainable clothing disposal in China", *Sustainable Production and Consumption*.

Saccani, N., Bressanelli, G. and Visintin, F. (2023), "Circular supply chain orchestration to overcome circular economy challenges: an empirical investigation in the textile and fashion industries", *Sustainable Production and Consumption*, Vol. 35, pp. 469-482, doi: 10.1016/j.spc.2022.11.020.

Saha, K., Dey, P.K. and Papagiannaki, E. (2021), "Implementing circular economy in the textile and clothing industry", *Business Strategy and the Environment*, Vol. 30 No. 4, pp. 1497-1530, doi: 10.1002/bse.2670.

Sharma, R., Samad, T.A., Chiappetta Jabbour, C.J. and de Queiroz, M.J. (2025), "Leveraging blockchain technology for circularity in agricultural supply chains: evidence from a fast-growing economy", *Journal of Enterprise Information Management*, Vol. 38 No. 1, pp. 32-67, doi: 10.1108/jeim-02-2021-0094.

Shou, M. and Domenech, T. (2022), "Integrating LCA and blockchain technology to promote circular fashion–A case study of leather handbags", *Journal of Cleaner Production*, Vol. 373, 133557, doi: 10.1016/j.jclepro.2022.133557.

SMI - Sistema Moda Italia (2021), available at: http://www.sistemamodaitalia.com (accessed May 2023).

Smith, G., Pendell, D., Tatum, J., Belk, K. and Sofos, J. (2008), "Post-slaughter traceability", *Meat Science*, Vol. 80 No. 1, pp. 66-74, doi: 10.1016/j.meatsci.2008.05.024.

Sodhi, M.S. and Tang, C.S. (2019), "Research opportunities in supply chain transparency", *Production and Operations Management*, Vol. 28 No. 12, pp. 2946-2959, doi: 10.1111/poms.13115.

Song, L., Meng, Y., Chang, H., Li, W. and Tan, K. (2021), "How counterfeit dominance affects luxury fashion brand owners' perceptions: a cross-cultural examination", *Journal of Business Research*, Vol. 130, pp. 1-13, doi: 10.1016/j.jbusres.2021.02.046.

Star, S.L. and Griesemer, J.R. (1989), "Institutional ecology, 'translations' and boundary objects: amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39", *Social Studies of Science*, Vol. 19 No. 3, pp. 387-420, doi: 10.1177/030631289019003001.

Tan, T.M. and Salo, J. (2023), "Ethical marketing in the blockchain-based sharing economy: theoretical integration and guiding insights", *Journal of Business Ethics*, Vol. 183 No. 4, pp. 1113-1140, doi: 10.1007/s10551-021-05015-8.

Tan, W.C. and Sidhu, M.S. (2022), "Review of RFID and IoT integration in supply chain management", *Operations Research Perspectives*, Vol. 9, 100229, doi: 10.1016/j.orp.2022.100229.

Thakur, M. and Hurburgh, C. (2009), "Framework for implementing traceability system in the bulk grain supply chain", *Journal of Food Engineering*, Vol. 95 No. 4, pp. 617-626, doi: 10.1016/j.jfoodeng.2009.06.028.

Thompson, M., Sylvia, G. and Morrissey, M. (2005), "Seafood traceability in the United States: current trends, system design and potential applications", *Comprehensive Reviews in Food Science and Food Safety*, Vol. 1, pp. 1-7, doi: 10.1111/j.1541-4337.2005.tb00067.x.

Tiwana, A. (2014), *Platform Ecosystems: Aligning Architecture, Governance, and Strategy*, Morgan Kaufmann.

Upadhyay, A., Mukhuty, S., Kumar, V. and Kazancoglu, Y. (2021), "Blockchain technology and the circular economy: implications for sustainability and social responsibility", *Journal of Cleaner Production*, Vol. 293, 126130, doi: 10.1016/j.jclepro.2021.126130.

Van der Meer-Kooistra, J. and Vosselman, E.G. (2000), "Management control of interfirm transactional relationships: the case of industrial renovation and maintenance", *Accounting, Organizations and Society*, Vol. 25 No. 1, pp. 51-77, doi: 10.1016/s0361-3682(99)00021-5.

Vazquez Melendez, E.I., Bergey, P. and Smith, B. (2024), "Blockchain technology for supply chain provenance: increasing supply chain efficiency and consumer trust", *Supply Chain Management: An International Journal*, Vol. 29 No. 4, pp. 706-730.

Viet, N.Q., de Leeuw, S. and van Herpen, E. (2023), "The impact of social vs environmental sustainability information disclosure on consumer choice of delivery time with varying sustainability concerns", *International Journal of Physical Distribution and Logistics Management*, Vol. 53 No. 11, pp. 26-52, doi: 10.1108/ijpdlm-09-2021-0392.

Voss, C., Tsikriktsis, N. and Frohlich, M. (2002), "Case research in operations management", *International Journal of Operations and Production Management*, Vol. 22 No. 2, pp. 195-219, doi: 10.1108/01443570210414329.

Wang, J. and Feng, T. (2026), "Approaching environmentalism for high ESG ratings: evidence from dynamic multi-signal interpretation", *Long Range Planning*, Vol. 59 No. 1, 102608, doi: 10.1016/j.lrp.2026.102608.

Xi, M., Fang, W., Feng, T. and Liu, Y. (2023), "Configuring green intellectual capital to achieve ambidextrous environmental strategy: based on resource orchestration theory", *Journal of Intellectual Capital*, Vol. 24 No. 5, pp. 1184-1205, doi: 10.1108/jic-07-2022-0154.

Yavaprabhas, K., Pournader, M. and Seuring, S. (2023), "Blockchain as the 'trust-building machine' for supply chain management", *Annals of Operations Research*, Vol. 327 No. 1, pp. 49-88, doi: 10.1007/s10479-022-04868-0.

Yin, R.K. (1994), *Case Study Research: Design and Methods*, 2nd ed., Sage, Thousand Oaks, CA.

Zammuto, R.F., Griffith, T.L., Majchrzak, A., Dougherty, D.J. and Faraj, S. (2007), "Information technology and the changing fabric of organization", *Organization Science*, Vol. 18 No. 5, pp. 749-762, doi: 10.1287/orsc.1070.0307.

Zhang, T., Jia, F. and Chen, L. (2025), "Blockchain adoption in supply chains: implications for sustainability", *Production Planning and Control*, Vol. 36 No. 5, pp. 699-722, doi: 10.1080/09537287.2023.2296669.

Zhang, Q., Yang, R. and Feng, T. (2026), "Unveiling the equifinal configurations driving business model design ambidexterity: based on TOE framework", *Journal of Business and Industrial Marketing*, Vol. 41 No. 7, pp. 975-994, doi: 10.1108/jbim-11-2024-0907.

Zhou, X., Lu, H. and Xu, Z. (2023), "A balance of economic advancement and social needs via improving supply chain traceability for future food sustainability: an empirical study from China", *Production Planning and Control*, pp. 1-21, doi: 10.1080/09537287.2023.2240751.

Zhou, X., Lu, H. and Kumar Mangla, S. (2024), "The impact of digital traceability on sustainability performance: investigating the roles of sustainability-oriented innovation and supply chain learning", *Supply Chain Management: An International Journal*, Vol. 29 No. 3, pp. 497-522.

Corresponding author
Laura Macchion can be contacted at: laura.macchion@unipd.it