

Article

Identifying Strategies for Balancing Profitability and Sustainability: An Exploratory Case from the Apparel Supply Chain

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Abstract

Business models have historically prioritized efficiency and profitability, often at the expense of environmental and social concerns. Balancing profitability and sustainability remain a central challenge in global apparel supply chains, amid increasing competitive, regulatory, and consumer scrutiny. This study explores how organizations navigate this tension through an interpretive case study of a South Asia-based apparel manufacturer that piloted multi-tier traceability technologies, combining physical and digital tracking to ensure a traceable chain of custody. In-depth interviews with senior decision-makers, guided by a deductive approach using strategic duality theory as a sensitizing device, identified four mechanisms for reconciling economic and environmental goals: (1) achieving economies of scale through digital platformization; (2) enhancing authentication and verification; (3) creating benchmarking matrices linking sustainability and performance; and (4) enabling data-driven decision making. The study contributes to theory and practice by demonstrating how traceability technologies position sustainability as a long-term driver of profitability, innovation, and ethical value creation.

Keywords: sustainability; profitability; digital technologies; traceability technology; strategic tensions; apparel supply chain; duality management strategies; sustainable development goals

1. Introduction

The progression of industrial revolutions has continually reshaped organizational operations. It began with mechanical production powered by water and steam, progressed to mass production through electricity and assembly lines, and was further enhanced by computers and electronics in the Third Industrial Revolution [1], which improved speed, flexibility, and precision [2]. Currently, with the rise of advanced technologies, industries are embracing the Fourth Industrial Revolution [3], with some suggesting that the Fifth is already on the horizon.

The apparel industry, being highly labour-intensive, thrived in these evolving conditions, resulting in the emergence of new business models such as mass production, which eventually gave rise to fast fashion and e-commerce [4]. While technologies and industries have evolved, the core focus of organizations has remained consistent for centuries: efficiency, productivity, and profitability, all of which have been shaped by the various industrial revolutions [5,6].



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Accordingly, the main focus of supply chains was to obtain materials at the best price in the quickest possible way, and this cycle led to spill-over effects such as overconsumption and significant environmental harm [7,8]. This, in turn, brought the concept of sustainability to the forefront, influencing the trajectory of Industry 4.0, where there is growing emphasis on using technology to mitigate environmental impact [9,10]. Despite this shift, many organizations find it difficult to allocate resources, modify entrenched processes, or transform organizational cultures that have long been focused on delivering profitability [11,12]. This tension between profit-driven operations and sustainability goals creates internal friction [13]. As a reaction, some organizations attempt to present a sustainable image through greenwashing, misleading stakeholders about their actual practices and contributing to numerous hazardous scandals over time [9]. This issue is highlighted by real-world incidents. For example, Mattel's 2007 toy recall exposed a major failure in traceability, as the source of hazardous paint from an unauthorized supplier could not be identified [14,15]. Similarly, the 2013 factory collapse in Bangladesh, which killed over 1000 garment workers, raised urgent concerns about the safety and transparency of working conditions in global supply chains [16]. Other examples include Volkswagen's emissions scandal [17] and H&M's misleading sustainability claims [18]. More recently, global scrutiny has increased over the use of forced labour involving Uyghur populations in China, along with the difficulty in tracing cotton sourced from that region, further emphasizing the lack of traceability in global sourcing practices [19]. Such cases demonstrate that managing uncertainty in supply chain conditions is essential not only for sustainable supply chain management (SSCM) but also for the economic performance of buying firms [15].

In response to these challenges, increasing pressure has emerged from consumers, regulators, and investors demanding greater transparency and accountability [20,21]. Central to these failures is the lack of transparency and the inability to trace the origin and journey of products. The fashion and apparel industry, in particular, faces intense scrutiny as one of the largest contributors to environmental pollution, resource waste, and social issues such as child labour and unsafe working conditions. To address this, the European Union has mandated the adoption of Digital Product Passports (DPPs) by 2027 for fashion and apparel products entering the EU market [22].

Although several certification schemes exist to verify specific sustainability aspects, such as GOTS, which focuses on organic fibres and sustainable processing; BCI, which promotes responsible cotton farming; OEKO-TEX, certifying textiles free from harmful substances; and FSC, ensuring products come from responsibly managed forests [23], these systems often operate in silos. The complexity of apparel supply chains leads to fragmentation, overlap, and inefficiencies, contributing to greenwashing, poor interoperability, and a lack of end-to-end visibility.

Emerging technologies offer promising solutions to these challenges by enabling enhanced authentication and traceability [24]. While some companies have begun piloting such technologies, adoption remains slow. A study by the UNECE [25] found that only 34% of companies in the garment and footwear sectors have implemented traceability practices, and among them, half can only trace their products to their immediate suppliers. This limited uptake shows the fragmented nature of current efforts and the significant gap in end-to-end visibility. One contributing factor is that sustainability is frequently treated as an add-on, rather than being integrated into the core business strategy, creating tension between sustainability intentions and profitability goals [26,27]. As a result, this study seeks to address a central question: *What are the salient strategies that organizations can employ to minimize the friction between the dual focus on profitability and sustainability?*

Although these problems are well documented, the scientific knowledge required to address them remains incomplete in three key respects. First, the profitability–sustainability

relationship is still largely framed as a trade-off to be optimized, with limited theoretical explanation of how organizations can hold these competing objectives in productive tension without subordinating one to the other. Second, while research on traceability technologies has examined their technical affordances—such as what blockchain, RFID, or digital identifiers can record—it has paid less attention to whether, and through which organizational mechanisms, these technologies reconcile economic and environmental goals in everyday practice. Third, firm-level empirical evidence from multi-tier apparel supply chains in developing-economy contexts remains limited, despite these being settings where the tension is especially acute. The cases discussed above—Mattel, Rana Plaza, Volkswagen, and sourcing controversies in Xinjiang—are therefore not merely examples of corporate failure; they represent breakdowns in tracing product origin, custody, and accountability. These failures directly motivate the solution examined in this study: where opacity enabled harm, verifiable end-to-end traceability may allow firms to protect margins while substantiating sustainability claims. They also shape the study's design. Because each failure occurred deep within a multi-tier chain rather than at the point of final sale, this study examines traceability across all five tiers of an apparel supply chain. It therefore selects an information-rich case in which precisely this type of traceability breakdown is being addressed in practice.

Accordingly, the objective of this study is twofold: (i) to identify the salient strategies through which an apparel manufacturer reconciles the competing demands of profitability and sustainability, and (ii) to explain how the combined use of digital and physical traceability technologies enables those strategies. The strategies are identified empirically rather than assumed. Drawing on in-depth interviews with senior decision-makers who were directly involved in a live traceability pilot, supplemented by system-generated traceability data and internal documents, the analysis applies deductive thematic coding sensitized by the strategic duality theory of Janssens and Steyaert [28]. Each interview account is mapped against the theory's duality-management strategies in order to surface the concrete mechanisms the organization uses to manage the structural duality of profitability versus sustainability. The procedure used to elicit and code these strategies is detailed in the Methodology section.

The dynamic between sustainability and profitability is often considered complex, featuring both collaborative potential and recognized trade-offs [29]. Emerging literature [30,31] and anecdotal commentary suggests that they can co-exist, and that technology plays a role in incorporating the notions of sustainability to corporate strategy, without compromising profitability [32].

2. Literature Review

The literature review will establish the context for understanding how sustainability evolved to become important in contemporary businesses, the real challenges they face, why efforts sometimes fall short, and the theoretical stance this study intends to build upon.

2.1. Importance of Sustainability for Contemporary Businesses

Sustainability has become an essential consideration in modern businesses, driven by stakeholder expectations, regulatory pressures, reputational concerns, and the pursuit of long-term value creation. In the past, sustainability was often viewed as a peripheral activity, sometimes portrayed as a CSR or PR initiative [33]. However, this perception has evolved, and modern organizations increasingly regard sustainability as a central element of their strategic positioning. Growing global awareness of climate change, resource depletion, and social inequality has placed pressure on organizations to adopt sustainable practices

across environmental, social, and economic domains [34]. Nevertheless, the motivations for adopting sustainability vary considerably [35].

For some companies, sustainability is primarily about regulatory compliance, focused on meeting minimum environmental or ethical standards imposed by governments and international bodies [36,37]. These motivations often depend on the industry and the countries in which the company operates. Other companies see sustainability as a market-driven necessity, responding to shifting consumer preferences, investor pressures, or reputational risks [38,39]. Increasingly, firms are also motivated by financial incentives such as tax breaks, carbon credits, and ESG-related investment flows or funding [40]. Additionally, certain businesses are proactively designed around sustainable business models that go beyond compliance or reactive motives. These companies embed sustainability into the core of their operations and strategy, aiming to create value not only for shareholders but also for broader stakeholder groups and the planet [41]. Such models integrate environmental and social considerations into product design, sourcing, supply chain management, and innovation [42]. Thus, while the importance of sustainability is widely recognized, the rationale for pursuing it differs based on organizational values, strategic priorities, and external pressures.

2.2. Tensions Arising in Sustainability Initiatives

Despite its growing relevance, the pursuit of sustainability often generates internal and external tensions within organizations. These tensions are particularly pronounced when managing sustainability across multi-tier supply chains, where complexity can amplify existing challenges [43]. The literature commonly categorizes these tensions as paradoxes, dilemmas, and dialectics [44]. Sustainability was traditionally viewed as a trade-off. However, the introduction of the triple bottom line concept shifted this view, encouraging organizations to consider the economic, environmental, and social pillars of sustainability simultaneously [34]. Sustainable expectations are often societal and long term in nature [45], which can create friction with stakeholder demands that conflict with short-term organizational goals [46].

Modern supply chains typically span from developed to developing countries and involve partners with differing profit margins, organizational capacities, and operating conditions. These differences such as those between large and small businesses or between stable and unstable environments, make it difficult to balance competing priorities and implement sustainability principles consistently [47–51]. The literature also highlights temporal and spatial tensions. Bansal and DesJardine [52] discuss the temporal dimension, where short-term financial pressures often undermine long-term environmental and social goals. Spatial tensions arise when global supply chains involve geographies with differing regulatory frameworks, capabilities, and expectations, leading to inconsistencies in implementation and impact [53].

When tensions emerge due to constraints such as limited resources, insufficient expertise, or conflicting priorities, companies typically respond in one of three ways: adopting sustainability initiatives hastily, postponing action, or ignoring them altogether [54]. These reactive and inconsistent approaches can lead to serious unintended consequences. Pursuing sustainability without genuine commitment or sufficient internal capacity often results in superficial efforts focused more on appearance than impact. This opens the door to misleading practices such as overstating achievements or masking inaction, which ultimately undermine credibility and trust. Over time, misalignments between sustainability claims and actual practices can erode stakeholder confidence, compromise long-term performance, and increase the risk of reputational damage.

Synthesizing this body of work, two broad perspectives on the profitability–sustainability relationship can be distinguished. The first is a ‘trade-off perspective,’ which views economic and environmental–social goals as competing claims on finite organizational resources. From this perspective, gains in sustainability are often assumed to require sacrifices in profitability, efficiency, or short-term competitiveness. Scholars in this tradition emphasize compliance costs, capital-market short-termism, and the difficulty of recovering sustainability investments, thereby framing managerial choice as one of prioritization, compromise, and resource allocation (e.g., [29]).

The second is a ‘coexistence (or integrative) perspective,’ which contends that profitability and sustainability can be mutually reinforcing—only under the right conditions. This view encompasses the business-case and ‘win–win’ literature, the triple-bottom-line tradition, and, more recently, paradox and duality theories that treat the tension as a productive and enduring feature of organizational life rather than a problem to be eliminated (e.g., [31,34,54]). Digital and data-driven capabilities are increasingly positioned within this camp as enablers that lower the cost of pursuing both goals at once.

Although the coexistence perspective is now well represented conceptually, it remains comparatively thin on mechanism: it asserts that the two goals can be reconciled but offers limited fine-grained evidence of how organizations actually do so, particularly in geographically dispersed, multi-tier supply chains. This study contributes to the coexistence perspective in three ways. First, it specifies a concrete reconciling mechanism—multi-tier traceability—rather than treating reconciliation as an abstract possibility. Second, it identifies four duality-management strategies through which that mechanism operates in practice, grounding the coexistence claim in observable organizational behaviour. Third, by foregrounding the cost, interoperability, data-quality, and collaboration constraints discussed above, it specifies the boundary conditions under which coexistence is achievable, thereby qualifying the more optimistic ‘win–win’ readings.

2.3. Sustainability Fallacies

Despite the growing prominence of sustainability, many organizations fall short of meaningful implementation. While numerous companies claim to embrace sustainability, high-profile cases reveal a gap between intention and action, undermining stakeholder trust [55]. For instance, allegations of forced labour involving the Uyghur population in the Xinjiang province brought global attention to unethical practices embedded in supply chains, despite corporate commitments to sustainability and human rights [56]. Brands sourcing from the region, knowingly or unknowingly, have faced reputational backlash and legal scrutiny, exposing the failures of due diligence and traceability mechanisms [57].

Similarly, Volkswagen’s emissions scandal, where software was used to cheat environmental tests, highlights the dangers of greenwashing, which involves misleading stakeholders about a company’s environmental performance [58,59]. Even sustainability certifications and eco-labelling schemes have come under scrutiny for weak enforcement and lack of transparency, contributing to stakeholder distrust and confusion [60]. These are not isolated incidents. Numerous firms have been exposed for performative sustainability [61], where environmental or ethical claims are made to appeal to public sentiment but lack substantive evidence.

Such examples illustrate the fallacy of superficial sustainability, where companies adopt sustainability language, certifications, or campaigns without addressing underlying systemic issues. In these cases, sustainability is treated as a branding exercise rather than a strategic, measurable commitment [58,62]. Without mechanisms for traceability, transparency, and accountability, these efforts risk becoming tools of reputation management rather than genuine transformation.

In light of these challenges, this study argues that sustainability cannot be achieved through image management alone. The tensions organizations face, including those between profit and purpose and between global pressures and local realities, must be actively managed through integrative mechanisms. Properly designed and implemented traceability systems offer a potential pathway to bridge these tensions by enhancing transparency, enabling informed decision making, and holding supply chain actors accountable. Rather than avoiding tension, organizations must learn to navigate it, moving beyond sustainability as rhetoric toward sustainability as reality.

2.4. Traceability Technologies: Affordances and Limitations

Because traceability is central to the argument advanced here, it warrants closer scrutiny than the sustainability literature has typically afforded it. Traceability technologies span barcodes and RFID, enterprise resource planning (ERP) systems, Internet-of-Things sensors, distributed-ledger (blockchain) platforms, digital product identifiers, and emerging physical markers such as embedded tracers and pigment or DNA tagging [20,21]. In principle, these tools render the chain of custody visible, substantiate ethical-sourcing claims, and deter greenwashing by replacing self-declaration with verifiable records [63]. A recurring weakness in the literature, however, is that the technology is presented as an unqualified good, with its enabling conditions and failure modes left underexamined.

Several limitations qualify this optimism. First, implementing traceability is costly, requiring distributed-ledger infrastructure, integration middleware, sensors, and supplier process redesign, costs that smaller upstream suppliers may be unable to absorb [21]. Second, multi-tier apparel chains are technologically fragmented: legacy ERP systems, spreadsheets, and proprietary platforms rarely interoperate, making end-to-end visibility dependent on data standards and integration work often beyond the control of any single firm [20]. Third, traceability systems are only as reliable as the data entered at each node; blockchain can make records immutable, but it cannot ensure the accuracy of information captured at source, leaving systems vulnerable to the ‘garbage-in, garbage-out’ problem and deliberate misreporting. Finally, adoption is organizational as well as technical, as data-sharing concerns, disputes over cost and value distribution, and supplier resistance can impede implementation. These constraints explain the slow diffusion of traceability and caution against treating technology as a self-executing solution.

This more critical reading sharpens the relevance of the present study by shifting attention from the assumed value of traceability technologies to their practical enactment. Rather than asking whether such technologies can, in principle, support sustainability, the study examines how an organization mobilizes them under real operating, cost, interoperability, and data-quality constraints to manage the profitability–sustainability duality. It also considers what organizational conditions, collaborative arrangements, and managerial practices are required for traceability to function effectively in practice. In doing so, the study connects a largely technical literature on traceability with an organizational-theory account of duality management, an integration that remains underdeveloped and that the following section sets out.

3. Theoretical Foundation

Organizations often have to navigate competing demands, a challenge that has long been a feature of organizational life. In recent years, however, the conflict between profitability and sustainability has become more pronounced, particularly within global supply chains. Organizations are frequently expected to deliver financial returns while concurrently fulfilling environmental and social responsibilities. Rather than treating these objectives as mutually exclusive, a growing body of organizational theory suggests that

such tensions are best understood as dualities, interdependent yet contradictory forces that coexist within organizational life [64,65]. Dualities can be structural, cultural, or personal; however, for the purpose of this study, the focus will be on structural dualities, as the phenomenon under investigation is the tension between profitability and sustainability [28].

Janssens and Steyaert [28] extend this notion by introducing the concept of trialectic thinking, which encourages a shift away from binary decisions toward a more integrative perspective. In their view, organizational contradictions, such as those between economic logic and environmental values, should not be ‘solved’ in the traditional sense but rather embraced as productive tensions. Their framework proposes a ‘third way out,’ a mediating space that allows organizations to hold opposing forces in dynamic balance through structural, cultural, or technological means.

These theoretical lenses are especially apposite to the empirical setting of this study because the constitutive features of multi-tier apparel supply chains instantiate precisely the conditions under which organizational dualities become intensified, spatially dispersed, and resistant to resolution through simple optimization. First, such chains are extended across multiple jurisdictions and institutional environments: cotton may be cultivated in one region, ginned and spun in another, and assembled elsewhere. Consequently, the profitability–sustainability tension is not located within a single organizational boundary, where one managerial actor might simply privilege one pole over the other, but is distributed across a constellation of legally independent yet operationally interdependent firms. A duality perspective is therefore more analytically appropriate than a trade-off logic, because it conceptualizes the tension as an enduring relational condition to be continuously managed rather than as a problem to be eliminated. Second, apparel supply chains are marked by asymmetrical power relations and contradictory expectations. Lead buyers frequently impose cost, speed, and flexibility pressures while simultaneously demanding credible evidence of ethical and sustainable production, thereby requiring upstream manufacturers to sustain opposing imperatives concurrently. This is precisely the conceptual terrain to which trialectic thinking speaks: progress is not achieved by selecting one side of the opposition, but by introducing a mediating third element that enables the opposing poles to be held in productive tension. Third, the sector’s persistent opacity and information asymmetry across tiers mean that this ‘third way’ cannot remain merely discursive, cultural, or attitudinal. It must be materially instantiated through a structural and technological mechanism capable of rendering the chain legible, auditable, and governable. Traceability is therefore not an incidental application of the theory; rather, it represents the concrete organizational form through which the ‘third way out’ becomes operational in this empirical context. For this reason, strategic duality and trialectic thinking provide the organizing theoretical framework for the study.

This theoretical stance offers a compelling lens for examining the role of traceability systems in managing profitability and sustainability duality. Technologies such as barcodes, RFID, and ERP systems have long been used. However, the integrated use of existing and emerging technologies has opened a new chapter as a bridging mechanism, enabling visibility across supply chain processes while simultaneously improving operational performance. On one hand, these tools enhance efficiency, reduce waste, and support cost control, aligning with the goal of profitability. On the other hand, they foster transparency, ethical sourcing, and environmental monitoring, core components of sustainable practice.

Rather than resolving the tension between profit and sustainability through compromise, traceability systems allow organizations to reframe the relationship between these goals. They become sites where both values can be pursued concurrently. In this way, traceability may be conceptualized as a trialectic tool, not merely a technological solution but a structuring mechanism that helps organizations navigate complex and often

conflicting expectations. Adopting this dualities-informed approach situates this study within a broader conversation on organizational paradoxes and sustainable innovation. By applying this theoretical lens to the domain of supply chain traceability, this research aims to explore how companies actively manage strategic tensions not by choosing one side over the other, but by developing integrative strategies that accommodate both profitability and sustainability through the management of dualities.

Figure 1 summarizes the conceptual model that guides this study. The upper layer represents the structural duality between profitability and sustainability as a persistent tension rather than a problem to be solved by subordinating one pole to the other. Consistent with the trialectic logic of Janssens and Steyaert [28], combined physical and digital traceability is positioned as the mediating ‘third way’—a structuring mechanism through which the two poles are held in dynamic balance. This bridging mechanism is enacted through the four duality-management mechanisms identified empirically in this study (economies of scale via platformization, authentication and verification, new benchmarking matrices, and data-driven decision making), each of which maps onto intended organizational outcomes that, taken together, allow profitability and sustainability to be pursued concurrently. Crucially, the model is not deterministic: the lower band specifies boundary conditions—implementation cost, interoperability with legacy systems, data quality at the point of capture, cost-sharing disputes, organizational and supplier resistance, and the need for industry-wide collaboration—that moderate whether the mechanisms in fact deliver the intended outcomes. The model is therefore advanced as an analytical lens rather than a validated causal claim, and the limitations of the single-case evidence on which it draws are discussed in the concluding section.

The theory identifies six strategies for managing dualities. However, it suggests that when viewed through a processual lens, three of these, sequencing, layering, and the helix type [66], tend to be more static and less adaptable. In contrast, strategies such as interpenetration, reframing, and the involvement of a third party introduce a dynamic dimension. By incorporating a third element, these approaches preserve the ongoing tension between opposing forces, enabling organizations to develop more flexible and evolving solutions [28].

Key Concepts

Several terms recur in the analysis and are defined here, before they appear as findings, to keep the argument clear. Technology affordance refers to the action possibilities a technology offers an organization in a given context—what the technology makes it possible to do—rather than to its features in the abstract; this study is concerned with the affordances of traceability for managing the duality. The four mechanisms identified in the findings are labelled as follows. Platformization denotes extending an organization’s existing digital platforms with new traceability and sustainability functions, so that the cost of capability is spread across shared infrastructure rather than incurred afresh. New benchmarking matrices denotes the previously unavailable performance measures—spanning financial, materials, logistics, and sustainability domains—that traceability data make computable; a specific instance is green margin mapping, the practice of identifying points in the chain where environmentally preferable choices also generate additional revenue or cost advantage. Incentive loop engineering denotes the deliberate alignment of sustainability actions with rewards; such as linking verified sustainability performance to financing, premium customers, or internal targets, so that sustainable behaviour becomes self-reinforcing. These terms are introduced as analytical labels here and substantiated with evidence in the findings.

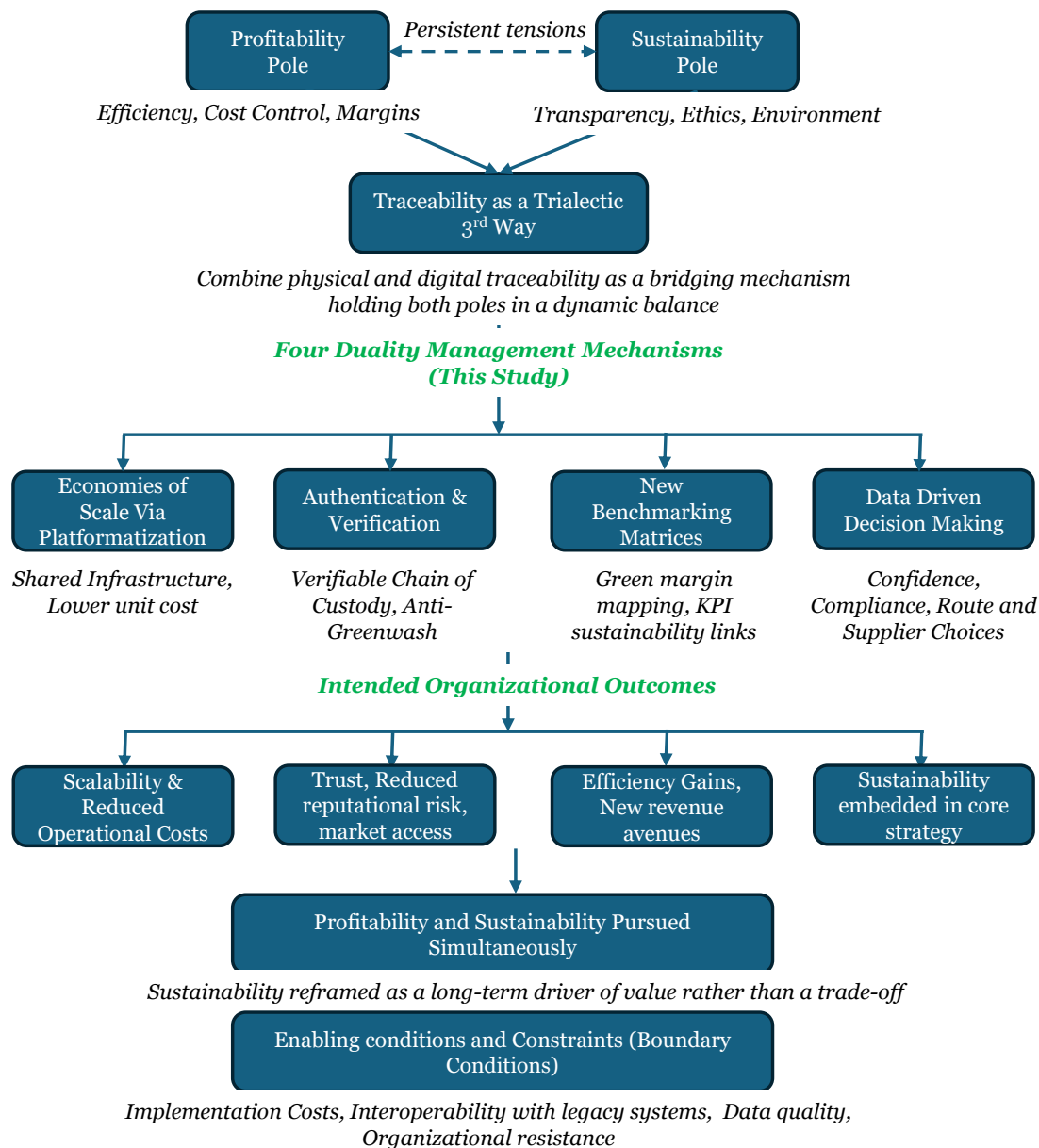


Figure 1. Conceptual model—traceability as a trialectic ‘third way’ linking the profitability–sustainability duality to organizational outcomes.

4. The Case Organization

Our study draws insights from a traceability pilot project undertaken jointly with a prominent South Asia-based global apparel producer, which operates production facilities across South Asia and Africa, alongside a technology partner based in Oceania with specialized expertise in cotton farming.

The organization employs over 14,000 individuals and operates across nine countries, with ten manufacturing sites in South Asia and Africa. Its customer base is predominantly in Europe and America. The company has positioned itself as a forward-thinking industry leader, committed to innovation and sustainability, and holds several global certifications. It has achieved an annual revenue of approximately USD 250 million and has aligned its strategic direction with the United Nations Sustainable Development Goals (UN SDGs). In anticipation of the EU DPP regulations, the organization sought a solution that could offer full traceability across its upstream supply chain, from Tier 5 to its own facilities.

To contextualize the pilot, it is useful to outline how the organization's supply chain operated beforehand. Prior to the initiative, the company functioned as a Tier-1 apparel manufacturer within a conventional, document-based multi-tier model. Direct operational visibility effectively stopped at its immediate suppliers; the deeper tiers—knitting, spinning, ginning, and cotton farming—were legally independent firms that exchanged limited information, so provenance beyond the first tier rested largely on supplier self-declaration and paper or PDF documentation reconciled manually. Assurance of origin and sustainability attributes was therefore inferential rather than verifiable end-to-end, which is the specific weakness the pilot set out to address.

The organization was also not new to sustainability when it undertook the pilot. It held several recognized certifications and had aligned its corporate strategy with the UN Sustainable Development Goals, competing in part on its ethical-sourcing credentials with European and North American buyers. The company already had acquired international certification schemes held (e.g., Global Organic Textile Standard—GOTS) and have been adhering to various supplier code-of-conduct and audit programs to provide traceability and transparency to its clients. These prior commitments matter analytically: they indicate that the firm already accepted the sustainability pole of the duality, so the pilot is best understood as an effort to make existing commitments verifiable and economically defensible rather than as a first adoption of sustainability. This starting position should be borne in mind when interpreting the outcomes reported below.

In response, the organization piloted a comprehensive traceability solution capable of integrating both digital and physical verification methods. This pilot did not disrupt ongoing operations, yet it enabled traceability and transparency in the chain of custody, with the intention of adding long-term value and reinforcing margins over time. As the pilot ran for a limited period (approximately 200 days) on a single product line, the indicators reported in this study are preliminary; they capture early operational effects observed during and immediately after the pilot rather than audited long-run financial returns. Preliminary operational indicators are summarized in Table 1. The selected technology was cutting edge and well-aligned with the project's objectives. The pilot spanned roughly 200 days and focused on their high-volume product, a classic round-neck T-shirt. The goal was to trace the fabric, the core component of the garment, through all five tiers of the supply chain. We collected data for this research once the pilot was completed.

Table 1. Preliminary operational changes observed during the traceability pilot.

Indicator	Preliminary Observation During/After the Pilot
Chain-of-custody coverage	Extended from Tier 1 visibility only to verifiable coverage across all five tiers (Tier 5 farm to Tier 1 manufacturing) for the piloted product line.
Provenance verification time	Physical (pigment) and digital (blockchain/QR) checks available at each tier. Substantial reduction of average time to verify provenance before vs. after.
New data and benchmarks	New benchmarking metrics generated across financial, materials, logistics, sustainability, human-capital, and compliance domains that were previously unavailable.
Certification and reporting effort	Previously fragmented certification schemes consolidated into a single verifiable record.
Operational efficiency	Reductions of measured change in processing time, manual reconciliation effort, waste, or per-unit cost observed during the pilot.
Commercial and financing outcomes	Reported securing of favourable EU financing for African expansion and addition of premium customers. Firm-level growth of ~20% CAGR over three years is reported, but is a company-wide figure and cannot be attributed solely to the pilot.

To allow the claims of operational and commercial value to be assessed rather than asserted, Table 1 reports preliminary indicators observed during and immediately after the pilot. Where verifiable figures were available, they are stated; remaining cells are flagged for the figures held by the case organization. These indicators are illustrative and pilot-bounded, and several (notably firm-level growth) cannot be attributed solely to the traceability initiative.

The trialled pilot explored an innovative traceability system that integrated both digital and physical tracking mechanisms. This system was particularly valuable in addressing concerns such as greenwashing and recent sustainability controversies by offering verifiable chain-of-custody assurance. A key feature of the technology was a patented pigment applied at the cotton harvesting stage. This pigment, embedded directly into the cotton, could be digitally read at each stage of the value chain using a scanner that emitted a signal to validate its presence. The pigment application began at the farm level (Tier 5), after which the cotton was cleaned at the ginning stage (Tier 4), with both stages carried out in Oceania. Subsequently, the cotton was transported to Southeast Asia for spinning (Tier 3) and knitting (Tier 2), before reaching the apparel production facility (Tier 1) located in South Asia (refer to Figure 2). While the finished garments were typically shipped to markets in Europe and the United States, the final retail stage was excluded from the pilot.

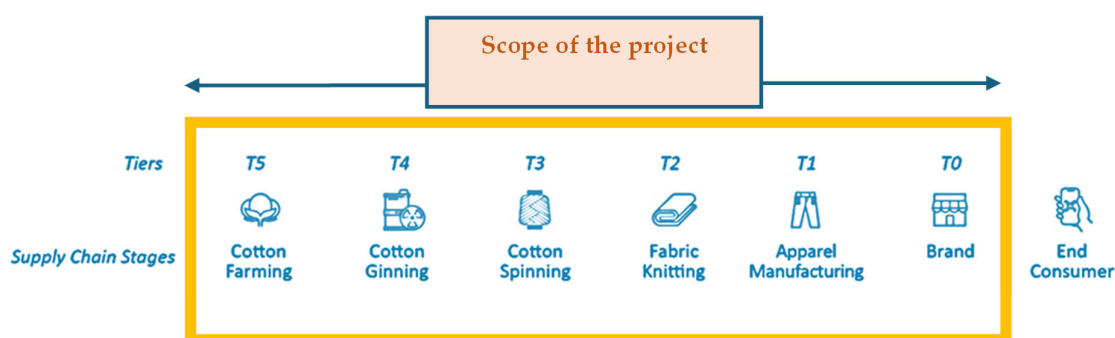


Figure 2. Scope of the implemented traceability pilot.

The selection of a combined traceability scheme was deliberate, reflecting the limitations of prevailing industry approaches in a multi-tier cotton supply chain. Conventional labelling and document-based systems, including certificates, transaction records, and packaging-level barcodes or QR codes, are inexpensive and widely adopted, but remain detached from the material itself. Consequently, they may be copied, removed, exchanged, or lost during transformation processes such as ginning and spinning. RFID and IoT-enabled systems enhance automation and logistics visibility, yet they typically identify cartons or finished garments rather than fibre and impose additional unit-level costs that are difficult to justify for high-volume commodity products. Blockchain platforms provide tamper-evident records across independent actors, but immutability secures only the record, not the accuracy of the data entered. Without a physical link between data and material, ledger-based systems remain vulnerable to substitution and inaccurate source-level inputs.

The pilot's scheme was designed to address this gap by pairing a physical marker with a digital record. The patented pigment is embedded into the cotton itself at harvest, so the identifier travels with the material through ginning, spinning, and knitting—stages at which packaging-based tags are typically lost—and can be verified by scanner at each tier. This physical anchor is then linked to a digital record that aggregates the tier-by-tier readings. The combination is what gives the scheme its advantage: the physical marker mitigates the 'garbage-in' weakness of ledger-only systems by binding the data to the material, while the digital layer provides the shareable, auditable record that a physical

marker alone cannot offer. For a deep, commodity-based apparel chain in which the central evidentiary problem is proving fibre origin across many independent upstream firms, this physical-plus-digital pairing was judged to fit the use case more closely than any single mainstream solution.

All traceability data were securely captured and stored using blockchain technology. Access was granted to authorized internal users and key supply chain actors, promoting transparency and collaboration. Consumers could also scan a QR code attached to each garment, which revealed detailed product information such as the manufacturing location, timeline, and producer. Importantly, the immutable nature of these blockchain records ensured the integrity and auditability of the product's journey, both physically and digitally.

The apparel manufacturing company had already implemented several internal traceability mechanisms. Their ERP system was SAP, complemented by barcode and RFID technologies used to monitor raw materials and finished goods. Additionally, they had introduced facial recognition tools for staff access and attendance, geofencing to monitor the movement of containers, and data analytics tools to support informed operational decisions. However, a key challenge remained in connecting these internal systems with the diverse and often disconnected platforms used by supply chain vendors. Many suppliers operated independently using spreadsheets or various ERP and barcode systems, resulting in limited visibility across multi-tiered networks.

The company's sustainability journey has continued to expand its footprint and capacity, achieving a 20% compound annual growth rate (CAGR) over the last three years. It has also added premium customers to its portfolio, further strengthening its efforts. As a result, it has attracted more investors from the EU who are eager to be part of a sustainable journey.

5. Methodology and Analysis

This study explores complex organizational phenomena within real-world settings. As a result, a qualitative interpretive case study design is deemed more appropriate to address the central question under investigation [67,68]. The interpretive epistemological stance supports understanding the subjective social constructions of actors who manage dual priorities and how organizations implement strategies to balance sustainability with financial imperatives [69]. A single case study was selected, identified as a revelatory case that had implemented a traceability initiative aimed at driving sustainability transformation while integrating it into existing operations and value chains. This made it well-suited for exploring the dual pressures involved [70].

The case merits the 'revelatory' designation for three reasons that also guided its selection. First, multi-tier traceability reaching the deepest tiers of a cotton chain remains rare in practice; most apparel firms achieve visibility only to their immediate suppliers, so an organization that had operationalized verifiable provenance from Tier 5 to Tier 1 offered an unusual opportunity to observe the phenomenon of interest directly rather than retrospectively or hypothetically. Second, the firm sits squarely on the profitability–sustainability tension this study examines: it competes on cost with European and North American buyers while differentiating on sustainability credentials, which makes the duality consequential rather than abstract. Third, the organization was willing to grant access not only to senior decision-makers but also to live system data, which is uncommon and allowed managerial accounts to be triangulated against the traceability records themselves. The case was identified through the technology partner and selected purposively against these criteria; we therefore make no claim that it is statistically representative, only that it is information-rich for an exploratory study of how the duality is managed.

The role of the technology partner also warrants clarification, as it bears on how the findings should be read. The pilot was delivered jointly with an Oceania-based partner specializing in cotton provenance, which supplied and operated the core verification technology—the embedded cotton pigment and the associated scanning and digital-record layer—and provided the upstream agronomic access (at the farming and ginning tiers) that made fibre-level tracing feasible. The focal manufacturer led integration into its own operations and supplier relationships. This division of roles is analytically relevant because the capabilities observed in the case were co-produced with a specialist partner rather than developed in-house, a point we return to when discussing the transferability and limitations of the findings.

Data collection involved a combination of purposive and snowball sampling approaches. While the latter may not fully capture the diversity of stakeholders, it enabled connections with individuals possessing a high level of domain-specific expertise [71]. This approach uncovered valuable insights that might have been overlooked through purposive sampling alone, thereby enhancing the richness and depth of our findings [72].

Data were collected through virtual interviews using a semi-structured interview guide that was developed and shared in advance with participants. Five employees at the managerial level and above, who were directly involved in the traceability implementation project, participated in the study (Table 2). These participants came from departments such as supply chain and logistics, and information technology. Although the sample included only five participants, their experience, averaging 16.8 years, and interview durations ranging between 45 and 90 min were deemed adequate for our initial findings. With informed consent, all interviews were recorded in accordance with ethical research practices. After each session, the recordings were transcribed, and detailed notes were compiled. In addition to interviews, real-time data from system and consumer interfaces confirmed product movement, provenance, journey, endpoint, and custody trail. This served as a primary data source and illustrated the effectiveness of the traceability system. This combined approach enriched the data, with secondary sources such as company websites, presentations, and internal documents used to triangulate and validate findings. Member checking was employed to enhance the credibility of the study [73]. The qualitative data were then analyzed and coded using NVivo 15 software to identify recurring themes and patterns [74].

Table 2. Participants details.

Participants and Their Positions	No. of Interviews and Minutes per Interview	Years of Industry Experience
Supply Chain Category Manager	3 × 90 min	12
General Manager Commercial and Logistics	4 × 60 min	19
Supply Chain Director	2 × 90 min	17
Chief Information Officer	6 × 65 min	24
Raw Material Innovation Manager	5 × 50 min	12

A deductive thematic analysis was used as the method of analysis, guided by the strategic duality theory of Janssens and Steyaert [28]. Therein, each citation obtained from the interviews was mapped to identify how the organization balanced profitability and sustainability: structural duality of profitability vs. sustainability. These theoretical duality management strategies served as initial sensitizing concepts during the coding process.

The analytical procedure proceeded in five steps, described here in full because the credibility of the four mechanisms rests on it. First, all interview transcripts, interviewer notes, system-data extracts, and secondary documents were imported into NVivo and read repeatedly for familiarization. Second, a deductive coding frame was established a priori from strategic duality theory: the duality-management strategies identified by Janssens and Steyaert [28]—including reframing, interpenetration, and the involvement of a third party—together with the overarching profitability and sustainability poles were entered as parent nodes, so that the theory structured the first coding pass rather than serving only as background. Third, interview excerpts were coded to these nodes at a first-order level, with new child codes created inductively where the data did not fit an existing category, preserving openness to disconfirming evidence. Fourth, first-order codes were clustered into second-order themes, and a theme was retained as one of the four mechanisms only where it (i) recurred across multiple informants, (ii) could be expressed as a duality-management move in the theory’s terms, and (iii) was corroborated by at least one non-interview source (system data or internal documents). Fifth, the consolidated mechanisms and supporting interpretations were returned to informants through member checking [73] and adjusted where they did not recognize our reading.

This procedure makes explicit how the four mechanisms—economies of scale through platformization, authentication and verification, new benchmarking matrices, and data-driven decision making—were derived: each is a second-order theme that satisfied the three retention criteria above and that maps onto the trialectic logic of holding the two poles together through a mediating third element. The theory thus did more than frame the study at the outset; it supplied the coding categories against which excerpts were judged and the criterion—a recognizable duality-management move—by which candidate themes were accepted or rejected. Table 3 illustrates this excerpt-to-construct mapping, and Appendix A presents the sample coding framework. Reading the findings against the theory in this way also clarifies the study’s theoretical contribution: where the existing duality literature largely asserts that opposing poles can be held together, this case specifies a concrete material mechanism—multi-tier traceability—through which the ‘third way’ is operationalized, and identifies the four organizational moves that enact it.

Table 3. Worked examples of deductive coding (excerpt > code > strategy).

Illustrative Interview Excerpt	First-Order Code	Strategy (Construct)
“Platformization is basically about using the platforms you already have and adding new features to support sustainability efforts...”	Reusing shared infrastructure to spread cost	Economies of scale via platformization
“The pilot included authentication and verification in one place... [it] clearly provided us with a very transparent process...”	Single-point verifiable chain-of-custody	Authentication and verification
“Using the data that we got... we developed new benchmarks. Some are directly aligned with UN’s SDG goals... some are related to financials.”	Creating joint sustainability—financial benchmarks	New benchmarking matrices
“What [new data] we could see opened the eyes of our managers... they could potentially get the transparency end-to-end...”	Data-enabling managerial decisions	Data-driven decision making

Finally, because several findings concern performance, it is important to be explicit about how profitability and related outcomes were assessed. The evidence for these outcomes is primarily perceptual: it rests on the accounts of senior managers describing the effects they attributed to the pilot, rather than on an audited financial analysis isolating the pilot’s contribution. These accounts were triangulated where possible against operational

system data (for example, confirmation of provenance and chain-of-custody coverage) and against secondary materials such as company reports and presentations, but the study did not have access to a controlled financial dataset that would permit causal attribution of margin or cost effects to the traceability initiative. Claims about improved margins, funding access, efficiency, and value creation should therefore be read as managerially perceived and qualitatively supported, not as quantified financial results; the preliminary indicators in Table 1 mark, with placeholders, the specific figures that would be required to substantiate them.

6. Case Study Observations

Through iterative engagement with the data, four mechanisms were identified that show how the case organization balances the tension between profitability and sustainability. These constructs framed the coding process, as depicted in Appendix A, and provided the structure through which empirical themes were interpreted.

To make the coding process transparent and to allow readers to judge the link between evidence and interpretation, Table 3 provides worked examples of the deductive coding. For each of the four duality-management strategies, it pairs an illustrative interview excerpt with the first-order code assigned to it and the theory-informed construct under which it was grouped. The deductive sample coding is provided in Appendix A and the interview guide in Appendix B.

6.1. Attaining Economies of Scale Through Digital Platformization

Our findings revealed that companies often operate in isolation when implementing traceability initiatives aimed at sustainability. Apparel supply chains are inherently complex, involving cross-border suppliers, intricate bills of materials, and highly competitive, price-sensitive markets. Consequently, no single entity within the supply chain can (i) independently achieve the level of transparency necessary for holistic sustainability, and (ii) attain economies of scale.

“It is simply not possible to do these [traceability] on our own. Too costly.”—Chief Information Officer

The case revealed that, although regulations and policies like the UN SDGs are encouraging industry-wide action, since companies are not yet legally mandated to comply, there has not been collective action towards sustainable efforts. Moreover, the case demonstrated that without a platform, supply chain partners do not have a consolidated view of traceability and transparency, mostly shaped by their individual capacities, business models, and information systems. As a result, data are often processed, stored, and made visible in inconsistent formats.

“Sustainability is a global initiative. . .it’s not local. . .so, we have to stick to the global definitions. This platform allows us to just that”—Supply chain category manager

Case participants lamented on the fact that no company in the supply chain could develop a technology that can deliver full supply chain transparency. Rather, an effective solution will require the integration of multiple technologies to enable interoperability and seamless data flow between legacy systems and new infrastructure. For instance, the pilot project referenced in this study utilized a combination of pigment markers, scanners, blockchain, APIs, and QR codes to establish end-to-end traceability across the chain of custody.

“You can’t get full supply chain transparency with just one technology. It takes bringing together different tech solutions and platforms from everyone involved, both supply chain players and brand partners. Usually, it’s a step-by-step process that involves aligning

strategies, rolling things out in phases, and often tweaking the systems you already have.”—Chief Information Officer

However, implementing such a system demands substantial investment in digital infrastructure, alignment on data standards, and a cultural shift toward openness in data sharing. Interview respondents underscored the necessity of industry-wide collaboration, noting that while the pilot was technically successful, scaling it proved challenging due to unresolved debates over cost sharing. As one participant noted, the end buyer often holds disproportionate influence in commercial decisions.

“Setting up a system for full supply chain transparency means investing in digital tools and getting everyone to work together. It’s a key enabler that supports other strategies and helps partners collaborate in real time, influencing and growing with each other. . . but by using what’s already in place and making good use of existing data, you don’t have to spend a lot on new investment.”—Supply chain category manager

Such statements underscore the need for collective action through industry consortia, where competitors and stakeholders collaborate to define sustainability benchmarks and coordinate traceability verification efforts. Such coalitions not only facilitate standardization but also create opportunities to influence policy and embed sustainability into industry-wide norms.

This dynamic can foster organizational inertia, where even minor changes are seen as disruptive due to their potential ripple effects. To address this, time-bound, controlled pilot programs conducted under real supply chain conditions, can serve as an effective strategy for de-risking innovation. This helps address common challenges such as perceived technological misfit, resistance to adoption, and implementation failures stemming from inadequate testing or contextualization. By trialling traceability technologies within live operational settings and involving shared suppliers, firms can assess feasibility, refine processes, and secure stakeholder alignment prior to full-scale rollout. This staged approach to innovation suits cost-sensitive supply chains by enabling a balance between experimentation and operational efficiency. Furthermore, the iterative learning fostered through these controlled labs enhances scalability and drives continuous improvement in sustainable traceability solutions.

“Platformization is basically about using the platforms you already have and adding new features to support sustainability efforts. Since you’re building on existing infrastructure and using data that’s already there, it doesn’t take a huge investment. . . it’s not starting from scratch. The idea is to connect traditional platforms with sustainable ones to create a smooth, integrated system.”—Raw material innovation manager

6.2. Authentication and Verification Increase Perpetuation

The case study revealed that the certification process, which included authentication and verification, is increasingly becoming a gatekeeper for access to regulated and sustainability-focused markets. Authentication and verification are major aspects of the apparel industry, to which the case organization belongs. The case organization highlighted that by increasing authentication and verification through the technology pilot, not only did they manage to identify the bottlenecks in the supply chain, but they also increased the transparency in sourcing and sustainability. Their credibility has often come into question due to the risk of greenwashing and the prevalence of counterfeit practices. Furthermore, many of these certification bodies only validate the sustainability of inputs at a particular stage and do not ensure the integrity of the chain of custody beyond the initial certification.

“The pilot included authentication and verification in one place. It [the technology app] was clearly provided us with a very transparent process of the entire supply chain.”—Chief information officer

The technology app united the previously fragmented certification landscape.

“...suppliers frequently struggle with multiple certification schemes that are time-consuming, costly, and often lead to confusion, complexity, and inefficiency.”—Supply chain director

Moreover, the company identified that the app allowed them to meet the regulatory requirements through product-level traceability, which was increasingly mandated; the need for both physical and digital traceability is critical.

“By focusing on transparency and using tech to track the chain-of-custody, we’ve been able to simplify operations, make our supply chain more efficient, and add value to our products. When you combine that with other strategies, it also cuts down waste and backs up our sustainability goals... building strong relationships with suppliers has pushed innovation, opened doors to new products, and really helped us stand out from the typical manufacturers.”—Chief information officer

This reality validates the case organization’s decision to trial a dual-traceability approach: using a pigment applied at the cotton stage as a physical tracer, and a blockchain-based platform as a digital tracer. Together, these technologies ensure that the chain-of-custody remains intact throughout the supply chain.

6.3. New Benchmarking Matrices

The platform developed and tested in the pilot managed to develop a wealth of new data that were previously not available to the company. Such data ranged from financial, materials management, logistics, sustainability, human capital management to policy/legislative requirements. Such data then were converted into new benchmarking matrices that went beyond the sustainability initiatives.

“We were surprised by the amount of new data that the platform created. So much of new benchmarks. . .”—Chief information officer

Quantifiable data on sustainability initiatives, especially on the apparel sector, are gaining popularity amongst the general consumers as well. With the public focus on fast fashion and ethically sourced materials, general consumers are keen to know how their clothing is sourced, produced, and distributed. Prior to the development of the pilot platform, it is rare that a case organization received data regarding such aspects.

“Using the data that we got. . .we developed new benchmarks. Some are directly aligned with UN’s SDG goals. . .some are related to financials.”—Chief information officer

The new benchmarks obtained through the digital platform allowed the case organization to identify new sustainable opportunities, partnerships and adhere to compliances with a high level of confidence. It also allowed the case organization to benchmark their performance against some of the industry benchmarks. Therein, the technology platform generates consistent and continuous benchmarks for the whole supply chain. The case organization employed the platform for green margin mapping and incentive loop engineering to empower organizations to define, monitor, and reward sustainability metrics in real time. This fosters alignment across suppliers and partners, transforming sustainability from an aspirational goal into a data-driven operational practice.

“It was like an awakening. . .all of a sudden we knew where we stand. . .not just from the perspective of sustainability. . .but in other aspects too”—Chief information officer

By explicitly linking sustainability initiatives to key performance indicators, the case organization uncovered micro-opportunities where environmental and social actions generate cost savings, operational efficiencies, or revenue enhancement. Traceability technologies play a critical role in this approach by enabling data-driven decision making and offering clear, mapped insights. This ensures that sustainability decisions are grounded in quantifiable evidence rather than based on assumptions or reactive responses to external pressures.

“This strategy worked well with duty-free trade agreements and sustainability goals. It brought a more connected and flexible approach. Getting external stakeholders like customers involved really helped boost its impact by encouraging everyone to work together and stay aligned.”—Supply chain director

6.4. Data-Driven Decision Making

The case organization stated that the pilot platform revealed a great deal of new insights to the middle and senior management in the organization. It also provided them with the decision-making confidence that was lacking, especially in relation to sustainability and compliance aspects.

For example, many apparel manufacturers in developing countries benefit from special incentive schemes such as the GSP+ under the European Union’s Generalized Scheme of Preferences (GSP), which offers reduced or zero tariffs when exporting to EU markets. However, such benefits are heavily tied to the adherence to ethical and sustainable production conditions, which in turn place substantial pressure on the management. Considering the transparency of data throughout the supply chain, managers at the case organization gained confidence in reporting on such initiatives like the GSP, saving substantial resources.

“...we were able to secure favourable funding from EU financiers to help expand our supply chain in Africa, as a direct result of the information that we now have...”—General manager commercial and logistics

Moreover, the case study revealed that the managers associated with the pilot made better decisions through the availability of new supply chain data, transparency of data, and the authenticity of data. Such decisions assisted in identifying optimized supply routes, potential new suppliers and better compliance to international and local policies.

“What [new data] we could see opened the eyes of our managers. . .they could potentially get the transparency end-to-end [in the supply chain]. This meant that they can make far better decisions [than before]—Chief information officer

Finally, managers at the case organization demonstrated a high level of confidence, and a sense of pride that their firm is engaged in ethical production of clothing. For a company that has been a leader in producing clothing for some of the global top-brands, attaining a degree of confidence in ethical production was conceived as a major achievement.

“We never thought that the pilot would increase the employee moral. . .our staff always knew that we sourced ethically. . .produced ethically. . .But, now seeing that through data created a new vibe!”—Chief information officer

6.5. Implementation Challenges and Critical Reflections

The four mechanisms above describe how the case organization sought to reconcile profitability and sustainability, but a balanced reading must also register the difficulties encountered, since the technology’s impact was not uniformly positive. The most prominent friction was financial and collaborative rather than technical. Participants were explicit that no single firm could fund or deliver end-to-end traceability alone (“It is simply not possible to do these on our own. Too costly.”), and that scaling the pilot “proved challenging due to unresolved debates over cost-sharing,” with the end buyer holding disproportionate

commercial influence. These accounts indicate that the principal barrier to wider adoption is the distribution of cost and value across the chain, not the availability of technology.

Three further challenges were evident. First, interoperability: the manufacturer's internal systems (SAP ERP, barcodes, RFID) had to be connected with the diverse and often disconnected platforms of upstream suppliers, many of whom relied on spreadsheets or incompatible systems, limiting visibility across the multi-tier network. Second, organizational adaptation and resistance: respondents described the integration as a phased, 'step-by-step' process requiring strategic alignment and the reconfiguration of existing systems, and noted organizational inertia in which even minor changes were perceived as disruptive because of their ripple effects—one reason the firm relied on a time-bound, de-risked pilot rather than full-scale rollout. Third, data dependence: because the system's value rests on the accuracy of data captured at each tier, its assurance is only as strong as upstream data discipline, a vulnerability the pilot reduced but did not eliminate.

Two interpretive cautions follow from these findings. First, the evidence remains largely perceptual, as the mechanisms and benefits were described by five senior informants who were directly involved in the pilot and therefore may have had an interest in presenting it positively. Although member checking and triangulation with system data and internal documents strengthen credibility, they cannot fully eliminate the possibility of positivity bias. Second, the magnitude of improvement is yet to be quantified. Claims regarding efficiency, cost reduction, transparency, and commercial value should therefore be read as preliminary and qualitatively supported, rather than as audited evidence of measurable long-term impact.

7. Conclusions: Integrating Profitability and Sustainability Through Technology Affordances

Reconciling profitability and sustainability are an increasingly pressing concern for apparel firms. As a single, exploratory case, this study can suggest a possibility rather than demonstrate a general solution; what it reveals is how one manufacturer attempted that reconciliation in practice. Our study adopts an interpretive case study approach to explore strategies for managing this tension through the theoretical lens of strategic duality theory. By taking a trialectic perspective, the study seeks a 'third way,' not a static solution but a processual approach that moves beyond the binary of profit versus sustainability [28]. Our research suggests that organizations facing this duality may have an opportunity to develop strategies that better balance profitability and sustainability [75] using technology affordances, the specific capabilities enabled by technological tools, which provide a pathway to harmonize these objectives by enabling businesses to scale efficiently, operate transparently, and embed sustainability into their core strategies [76,77]. Figure 3 illustrates how distinct technology affordances translate into organizational outcomes that bridge profitability and sustainability. It is noted that the role of the technology was not explicitly explored during the interviews; rather, these affordances appeared when interrogating the mechanisms that the case organization is employing to increase profitability. To align the figure more directly with the empirical material, its links should be read at two levels. The paths running through the four mechanisms identified in the findings—platformization, authentication and verification, new benchmarking matrices, and data-driven decision making—are grounded in the interview and system data. The onward links to higher-order outcomes such as margin improvement and investor access are interpretive and propositional: they reflect managerial expectations rather than measured effects. We therefore treat Figure 3 as a conceptual summary of the case rather than a validated causal model, and the more weakly supported links should be understood in that light, pending the confirmatory data noted earlier.

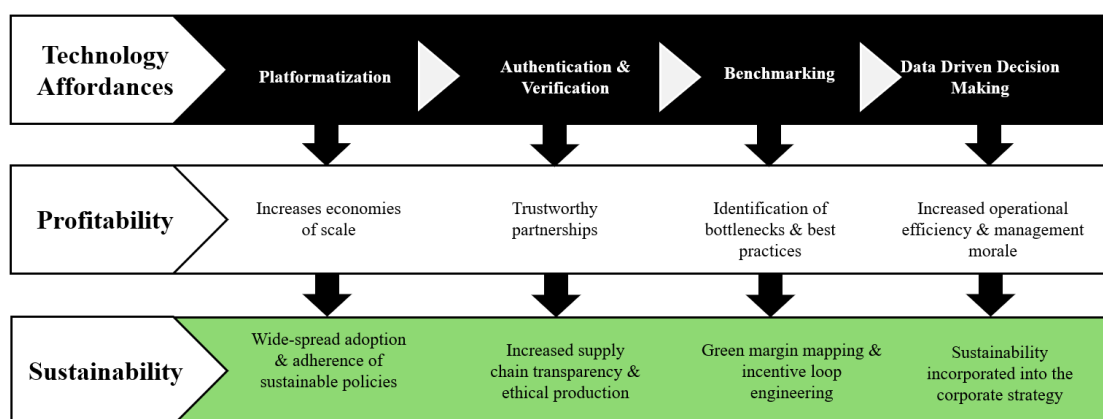


Figure 3. How sustainability is incorporated into the corporate strategy for profitability.

The case study identified platformization as one of the most powerful enablers. This affordance leverages technology to create scalable ecosystems connecting producers, suppliers, customers, and stakeholders. By consolidating transactions, communications, and operations within a unified platform, organizations can achieve economies of scale that drive down operational costs while ensuring consistent sustainability standards across the value chain. This scalability enhances profitability by increasing revenue streams and reducing per-unit costs, while simultaneously facilitating widespread adoption of environmentally responsible practices.

Authentication and verification technologies, such as blockchain, digital IDs, and IoT tracking, further bridge the gap between profitability and sustainability. These technologies create unprecedented levels of supply chain transparency, ensuring ethical production methods and preventing greenwashing [63]. Trustworthy partnerships forged through verified processes reduce reputational risk, attract responsible investors, and strengthen brand loyalty, all of which contribute to long-term profitability.

Benchmarking, supported by data analytics, enables firms to identify bottlenecks, evaluate best practices, and measure progress against industry standards. By mapping performance against sustainability metrics, organizations can uncover inefficiencies that, once addressed, yield cost savings and improved productivity. Furthermore, benchmarking facilitates green margin mapping, a process of identifying areas where environmentally friendly practices can generate additional revenue or cost advantages. When combined with incentive loop engineering, companies can design feedback systems that reward sustainable behaviours internally and externally, creating a self-reinforcing cycle of improvement [78].

Data-driven decision making serves as the connective tissue between technology affordances and strategic outcomes. Advanced analytics, AI, and predictive modelling not only optimize resource allocation but also anticipate market shifts, regulatory changes, and environmental risks. This foresight enables proactive adaptation, reducing the likelihood of costly disruptions. More importantly, it aligns sustainability initiatives with profitability goals by identifying solutions that are both environmentally beneficial and financially viable.

At the organizational level, these technological capabilities lead to increased operational efficiency and higher management morale. Efficient processes reduce waste, energy use, and costs, while motivated leadership ensures that sustainability is embedded into the corporate strategy rather than treated as an optional add-on. Over time, such integration fosters a culture in which sustainability and profitability are mutually reinforcing priorities rather than competing objectives.

In this case, the cumulative effect of these affordances appeared to be a business model in which sustainability was treated not merely as compatible with profitability but

as integral to it. By increasing economies of scale, enhancing transparency, building trust, identifying efficiencies, and engineering incentive systems, traceability technology can, on this evidence, help reframe sustainability from a compliance obligation into a potential driver of value creation. Whether it does so reliably, and for organizations unlike the case studied here, is a question this single exploratory study raises rather than settles.

Ultimately, technology affordances enable businesses to navigate the delicate balance between short-term financial performance and long-term environmental stewardship, suggesting that profitability and sustainability need not be opposite ends of a spectrum. The single-case, pilot-bounded evidence presented here cannot establish this as a general law; rather, it offers a plausible and theoretically grounded account of how, under the right enabling conditions, the two objectives may be pursued as parallel rather than competing paths.

Because these strategies are distilled from a single, well-resourced manufacturer, their applicable scope warrants comment. They are most likely to transfer to firms that resemble the case organization: large lead manufacturers or vertically coordinated chains with the capital, digital infrastructure, and buyer relationships needed to absorb upfront costs and to compel upstream participation. For small and medium-sized apparel enterprises, or for fragmented chains lacking a powerful coordinating actor, the same strategies face clear promotion limitations—platformization presupposes a platform and the volume across which to spread its cost; authentication and benchmarking presuppose suppliers able and willing to capture data; and data-driven decision making presupposes analytical capacity that smaller firms may lack. In such settings, the strategies are likely to require external enablers, such as shared industry platforms, buyer-funded cost-sharing, or regulatory mandates, to become viable. The contribution is therefore best read as a set of mechanisms whose feasibility is contingent on firm size, chain structure, and power distribution, rather than as a universally applicable template.

7.1. Practical and Policy Implications

These findings are timely given the tightening regulatory environment; most notably the EU Digital Product Passport (DPP), which will require detailed, verifiable product- and supply-chain information for textiles and apparel placed on the EU market. The case illustrates that the data infrastructure firms build to reconcile profitability and sustainability is substantially the same infrastructure that emerging regulation will demand, which reframes compliance from a pure cost into a potential source of operational and commercial value. For apparel enterprises, the practical implication is to treat traceability investment as strategic rather than merely defensive: to begin with a bounded, de-risked pilot on a high-volume line; to prioritize technologies that bind data to the material rather than to packaging; and to convert the resulting data into internal benchmarks and decision support so that the system earns its keep beyond compliance.

For industry associations, the principal implication concerns the cost-sharing and interoperability barriers identified here: because no single firm can deliver end-to-end traceability alone, associations are well placed to convene pre-competitive standards, shared platforms, and common data formats that lower the cost of participation for smaller upstream suppliers. For regulators and policymakers, the evidence suggests that mandates such as the DPP are necessary but not sufficient; their effectiveness will depend on accompanying measures that address the affordability and data-quality constraints discussed above, including support or incentives for SME and upstream-tier adoption, recognition of physical-plus-digital verification where ledger-only records are insufficient, and phased timelines that allow capability to be built across all tiers. Aligning regulatory design with these implementation realities would help ensure that traceability mandates

drive genuine transformation rather than the reputation-management responses this paper cautions against.

7.2. Limitations and Future Research

Several limitations necessarily delimit the contribution of this study and moderate the predominantly affirmative interpretation advanced above. First, the analysis is grounded in a single, information-rich case. Although appropriate for revelatory and theory-building inquiry, this design constrains statistical generalization; consequently, the findings should be understood as analytically transferable rather than empirically representative. Second, the empirical material is derived from five senior managers within the focal manufacturer, thereby privileging one organizational standpoint while excluding upstream suppliers, powerful buyers, brands, and consumers whose incentives and interpretations are central to traceability adoption. This single-vantage design also leaves open the possibility of positivity bias among informants invested in the pilot's success. Third, the pilot was temporally bounded, lasting approximately 200 days and focusing on one product line, which limits claims about the durability of profitability, sustainability, and governance outcomes. Fourth, the reported operational and commercial benefits remain largely qualitative and perceptual; the study does not quantify improvements in cost, transparency, efficiency, or systematically examine instances of technological underperformance. Fifth, the pilot unfolded under favourable conditions, including a capable lead firm, existing digital infrastructure, and supportive partnerships, meaning that transferability to smaller firms or less mature, fragmented supply chains remains uncertain and warrants further empirical scrutiny.

These limitations open clear avenues for future research. Multi-case and cross-sector comparisons would test the transferability of the four mechanisms; longitudinal designs would assess whether reconciliation persists as regulatory and commercial pressures change; and mixed-methods studies incorporating operational and financial metrics would allow the costs of implementation to be weighed explicitly against its benefits. Research that deliberately failed or stalled implementations would further guard against the survivorship and positivity biases inherent in studying a successful pilot. Accordingly, this study should be read as a theory-informed account of how traceability can help organizations manage the profitability–sustainability duality, and as an invitation for confirmatory, comparative, and more critical empirical work—rather than as conclusive evidence that technology resolves the tension in all settings.

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Data Availability Statement: The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Strategy	Profitability Mechanism	Sustainability Mechanism	Theoretical Construct	Deductive Codes
Platformization	Economies of scale Operational efficiency	Broad adoption of sustainable practices	Reframing	Platform integration as enabler of collaboration Digital infrastructure as foundation for sustainability External stakeholder alignment via platforms
Authentication & Verification	Trustworthy partnerships Risk mitigation	Supply chain transparency Ethical sourcing	Trialectic / Strategic Duality	Traceability as structuring mechanism for accountability Sustainability as verifiable and integrated with efficiency
Benchmarking	Identification of bottlenecks Process optimisation	Green margin mapping Incentivising sustainability	Interpenetration	Green growth as competitive advantage Linking incentives to sustainability performance Profit and sustainability decisions as mutually influential
Data-Driven Decision Making	Improved managerial decision-making Operational efficiency	Embedding sustainability metrics into strategy	Trialectic / Strategic Duality	Third-party validation enabling funding and credibility Data as enabler of navigating economic vs. environmental tensions Sustainability embedded in strategic planning

Figure A1. Deductive sample codes.

Appendix B. Semi-Structured Interview Guide

The following guide informed the semi-structured interviews. Consistent with a semi-structured approach, the questions served as flexible prompts and follow-up probes were asked as appropriate.

A. Background and role

1. Could you describe your role and your involvement in the traceability pilot?
2. How would you describe the organization's supply chain and sourcing model before the pilot?
3. What sustainability commitments or practices were already in place prior to the pilot?

B. Motivation and the profitability–sustainability tension

4. What prompted the organization to undertake the traceability pilot at this time?
5. In your experience, where do profitability goals and sustainability goals come into tension in this business?
6. How were those tensions managed before the pilot?

C. Technology selection and implementation

7. How was the traceability technology selected, and what alternatives were considered?
8. How did the combined physical and digital approach work in practice across the tiers?
9. What difficulties, disruptions, or resistance did you encounter during implementation?
10. How were the costs and responsibilities of the system shared across the supply chain?

D. Outcomes and value

11. What operational, financial, or reputational changes have you observed as a result of the pilot?
12. Has the pilot affected how decisions are made, and if so, how?
13. What new data, benchmarks, or metrics did the pilot generate, and how are they used?
14. How, if at all, has the pilot changed the relationship between profitability and sustainability for the firm?

E. Reflection and outlook

15. What would be required to scale the pilot across products or the wider supply chain?
16. How do regulations such as the EU Digital Product Passport factor into your plans?

17. Is there anything important about the pilot that we have not discussed?

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