DPP FOR SUPPLY CHAINS

An initiative for onchain digital product passports in the apparel industry

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/ INTRODUCTION



In collaboration with Sitra, STRGL is researching the adoption of onchain digital product passports in the apparel industry. The initiative promotes transparency and traceability in line with upcoming regulations from the European Union.

LEGISLATIVE LANDSCAPE

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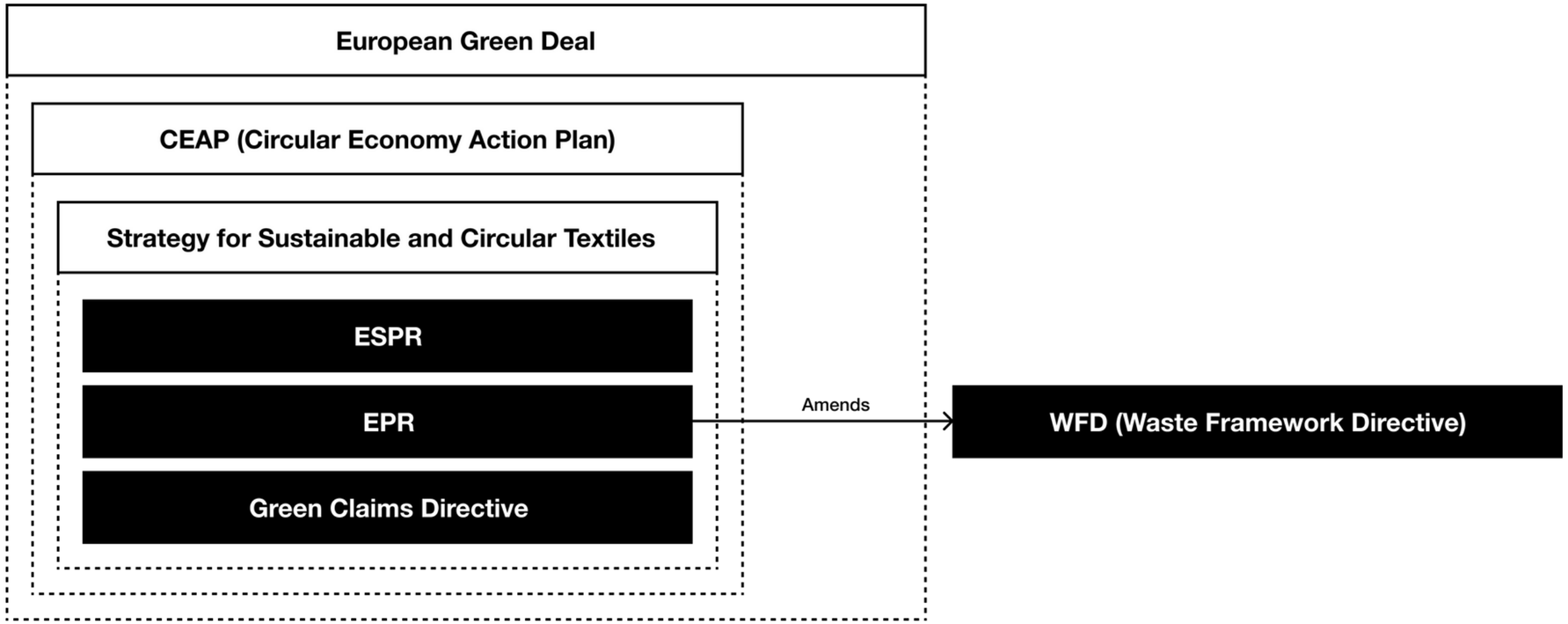
Shifting consumer priorities and legislative landscape

Global warming has changed consumer priorities and has started a legislative push toward better supply chain traceability.

Consumer Demand	Alarmed by global warming, consumers are becoming more and more conscious about the buying decisions they make. To make informed decisions, they need access to more data across the product value chain.
The EU's Strategy for Sustainable and Circular Textiles	The EU's Strategy for Sustainable and Circular Textiles addresses the production, consumption, and disposal of textiles to promote the sustainability of this critical sector for European trade.
The European Data Strategy	The European Data Strategy aims to establish "a single market for data". It strives to make the EU a global leader in a data-driven society by establishing a pan-European data infrastructure that allows data to flow freely.

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The European regulatory framework toward sustainability



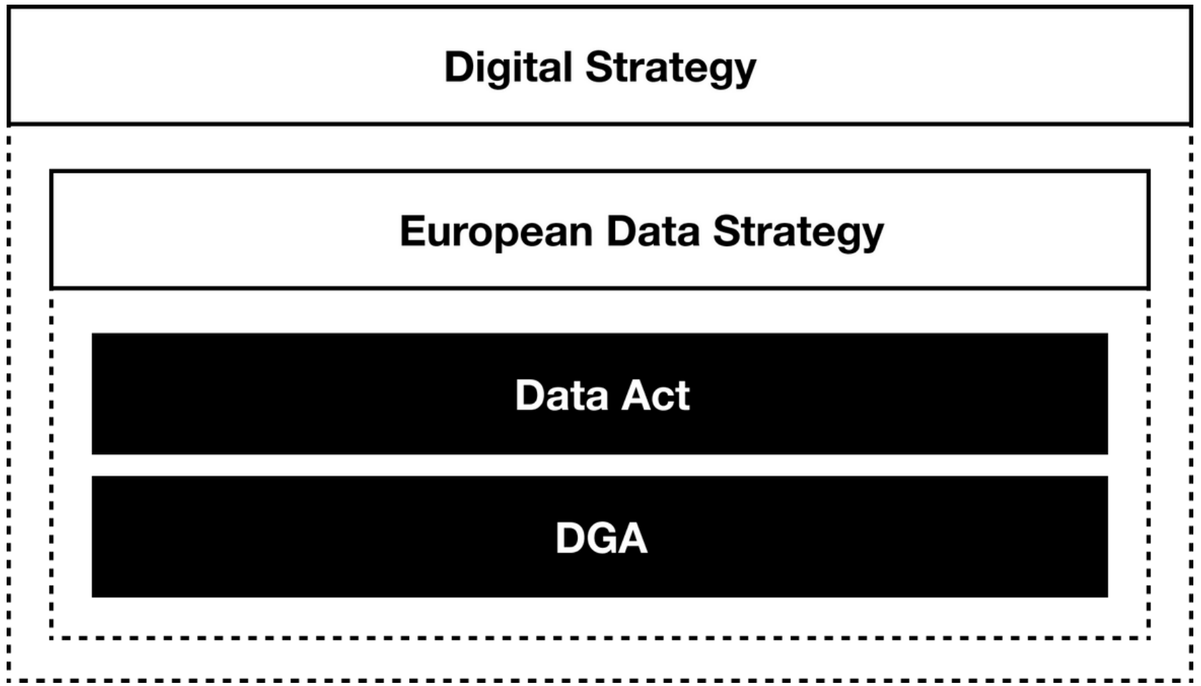
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The EU's Strategy for Sustainable and Circular Textiles

Abbreviation	Name	Summary	Applicable
ESPR	Ecodesign for Sustainable Products Regulation	Seeks to improve the environmental performance of products by setting various standards manufacturers must meet before selling their products in the EU market. Requires products to have a Digital Product Passport containing mandatory information on circularity and other environmental aspects.	2026/27
EPR	Extended Producer Responsibility	Extends the producer's responsibility to the post-consumer stage of a product. This includes the collection, recycling, and final disposal of the product. National EPR-based legislations are already active in some EU countries (e.g., the French AGEC law).	2024
-	Green Claims Directive	A proposed directive against greenwashing. It establishes clear criteria on how companies should prove their environmental claims and labels. Additionally, the directive sets requirements for these claims and labels to be checked by an independent and accredited verifier.	2024

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The European regulatory framework toward a unified data economy



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The European Data Strategy

Abbreviation	Name	Summary	Applicable
-	Data Act	A key regulation reinforcing the user's position in accessing and utilizing data they generate by using products and services. It aims to boost the European data economy by unlocking industrial data, optimizing its accessibility and use through standardization, and fostering a competitive and reliable European cloud market.	2025
DGA	Data Governance Act	Seeks to increase trust in data sharing, strengthen mechanisms to increase data availability, and overcome technical obstacles to data reuse. The DGA will also support the development of common European data spaces in strategic domains, involving private and public players in various sectors.	2023 (active)

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There is no circular economy without the data economy.

Marja-Liisa Niinikoski
CEO, Finnish Textile and Fashion

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DIGITAL PRODUCT PASSPORT

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Introducing the Digital Product Passport

The Digital Product Passport (DPP) will require companies to share production, material, and supply chain information with consumers, regulators, and the rest of the value chain.

1	Helps consumers and businesses make informed choices when purchasing products
2	Facilitates repairs and recycling based on the accurate and system interoperable product composition data
3	Improves transparency about products' life cycle impacts on the environment
4	Helps authorities to better perform checks and controls on, e.g., sustainability (ESG) and transportation (eFTI)

Even with the new possibilities of decentralization, the market still doesn't have a one-stop solution

For DPP technology to be a truly wholistic solution, it needs to cover five key use cases

Consumer	Sharing vital product information directly with consumers
Retail	Sharing product information with distribution channels, e.g., online retail platforms and brick-and-mortar stores
Resell	Sharing product information on second-hand marketplaces
Recycling	System interoperability with post-consumer recyclers
Customs	System interoperability with customs

MARKET RESEARCH

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Pain points of textile industry supply chains

Textile industry supply chains are notoriously complex, opaque, and fragmented. Consumers and regulators call for increased traceability and transparency.

Complexity

The journey from fiber to finished product is complex: production and documentation practices vary from supplier to supplier. Commonly, each tier communicates directly only with its most proximal supply chain partners.

Opaqueness

There is an unwillingness and unpreparedness to share information. Suppliers are incentivized against transparency in fear of a diminished competitive edge or an adverse reaction from the public. Documentation is mostly inward-facing.

Fragmentation

There is a lack of compatible systems architecture across departments and organizations. Data exchange requires manual labor and often relies on archaic methods. The accuracy of shared information cannot be unanimously verified.

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Powered by blockchain technology, the DPP addresses industry pain points

Four factors innate to onchain systems combat issues related to traceability and transparency.

Immutability 1	Data entries on the blockchain are immutable; edits are documented as entries of their own.
Traceability 2	Data entries on the blockchain are traceable to whoever made them and when.
Transparency 3	Due to immutability and traceability, making false claims, even in the short term, runs the risk of remediation costs and reputational damage.
Resistancy 4	In the absence of a central server, the blockchain is more resistant to faults than traditional systems.

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Requirements for adopting the digital product passort

A cross-compatible and transparent traceability solution comes with technical and infrastructural requirements for compliant parties and regulators.

From analog systems to software	To avoid the labor-intensive task of manually migrating databases to the blockchain, analog or flat databases should be transferred to, e.g., ERP or SCM systems. Technical solutions with varying levels of automation are available for data migration across software.
Access management	While onchain data entries are immutable and transparent by definition, full-scale transparency is not necessary. Access rights may be applied to restrict or grant entry depending on the viewing party.

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Requirements for adopting the digital product passort

Shared data management practices	To enable cross-compatibility, metrics and data formats should be standardized, and data sets should meet a particular standard. Consistent headings should be used to ensure seamless systems automation.
Organizational investments	Compliant organizations should conduct strategic planning to implement new systems incrementally. Dedicated teams should be appointed to meet the heightened requirements for documentation.
Incentivizing compliance	Legislative requirements for systematic documentation should be in place to encourage compliance. Fiscal (tax and funding-related) and non-fiscal (market access, public procurement) benefits should be offered to compliant parties.

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Business models facilitated by the digital product passport

Today, few solutions integrate the textile supply chain end-to-end. Adopting the digital product passport unlocks novel revenue streams for forward-looking organizations.

Scaling new initiatives	After maturity in the pre-purchase supply chain, the DPP's data infrastructure could be harnessed to cover the post-purchase phase. The post-purchase scaling opportunities include the consumer interface, resale, renting, recycling, delivery, and customs.
Monetization of supply chain data	As the implementation of blockchain technology entails effective access rights management, compliant parties may monetize their supply chain data for the purposes of promoting sustainable practices.

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Business models facilitated by the digital product passport

Partnerships with innovators

Partnering with start-ups and industry peers comes with a greater expected ROI compared to in-house R&D.

The estimated market value growth for distributed ledgers is the greatest among technologies in the fashion industry (Figure 1). Coupled with other tech enablers, they have great potential to accelerate traceability.

These tech enablers include:

- **Big Data** to process large, complex supply chain-related data sets
- **AI and machine learning models** to automate information processing
- **RFID tags and readers** to store product information and track products in real time

As these additional tech enablers are complex entities of their own, this report will not address them in detail.

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/ FIGURE 1

DLT has the highest estimated market value growth among fashion industry technologies

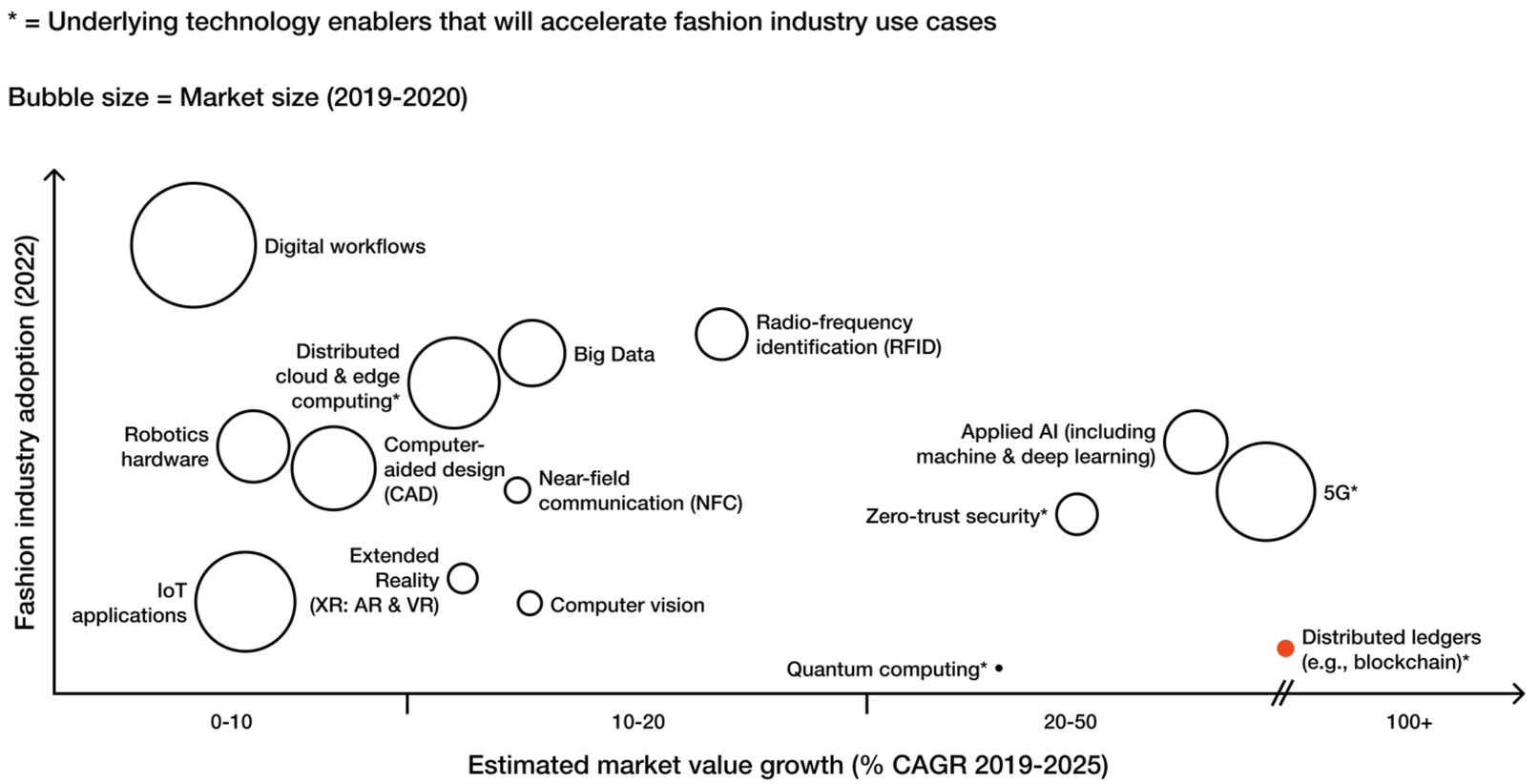


Figure source: McKinsey & Company (2022)

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USER RESEARCH

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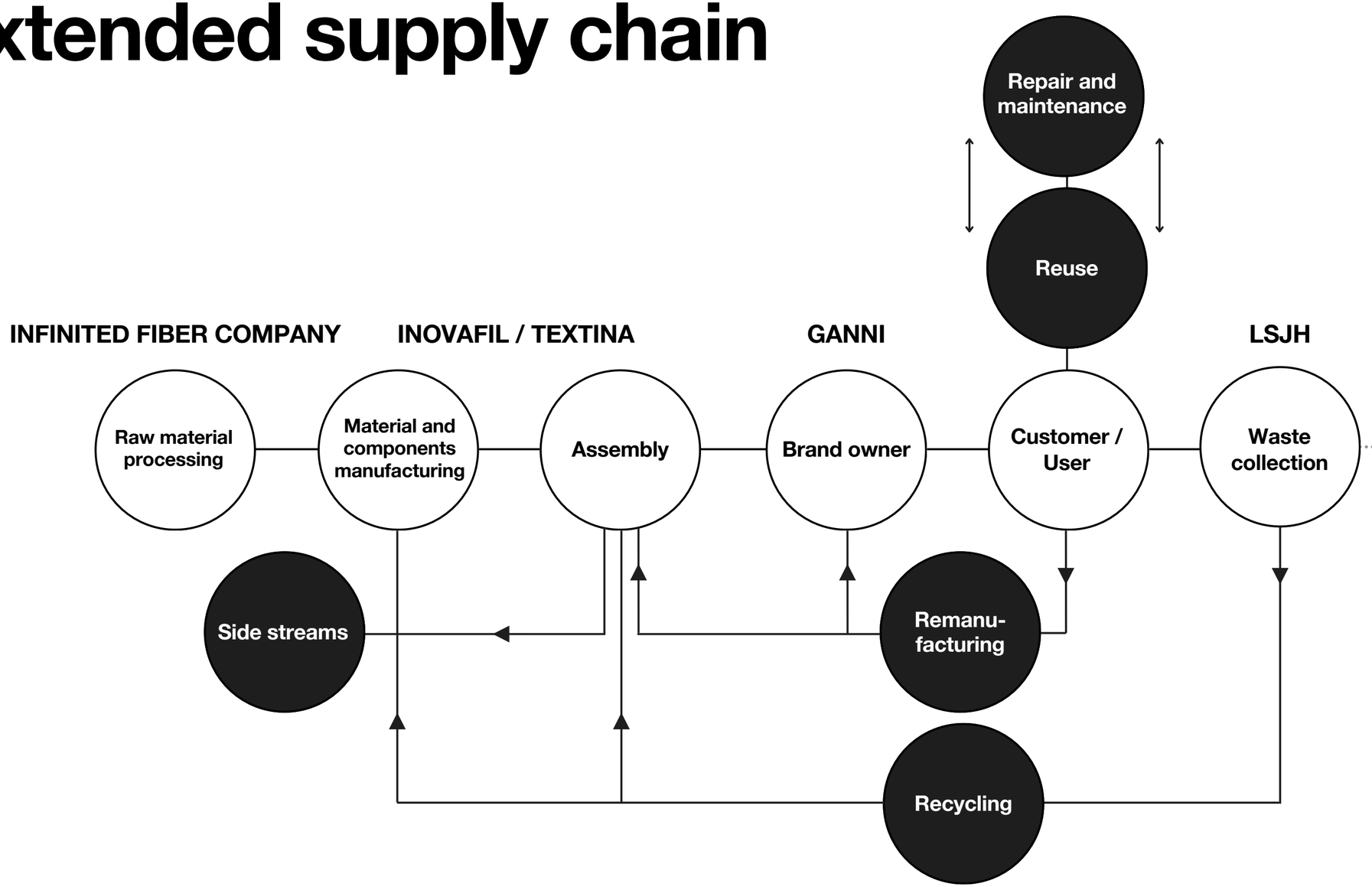
Interviews with trusted industry experts

We conducted five semi-structured interviews to understand current supply chain data management processes and discover hurdles for DPP adoption.

Fiber	Yarn	Fabric	Garment	Recycling
INFINITED FIBER	INOVAFIL	tekstina SINCE 1828	GANNI	LOUNAIS-SUOMEN JÄTEHUOLTO

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The extended supply chain



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Data analysis

A total of 170 individual observations were sorted into seven distinct themes. For each theme, we formed insights highlighting the most central takeaways and explaining the associated phenomena.

Themes (7)

- Lack of uniform processes and software
- Manual data management
- Siloed information
- Importance of certificates
- EU regulation’s (WFD) compatibility with existing systems
- Challenges for early adopters
- User experience issues

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Insights

Lack of uniform processes and software



There is a lack of uniform processes and software for managing (recording, storing, analyzing, and sharing) data. This can be explained partly by the absence of clear and compelling standards.

Manual data management



In the absence of homogenous systems, data is often managed (recorded, stored, analyzed, and shared) manually, making management laborious. Data exchange happens manually via flat files (e.g., through emails and attachments).

Siloed information

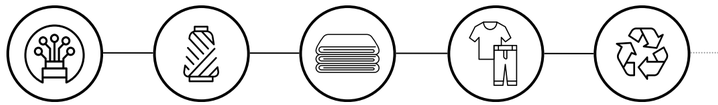


Information is siloed within and across businesses due to security concerns and heterogeneous systems. Data validity is uncertain and susceptible to human error. Businesses have direct access only to their most proximate (upstream and downstream) partners.

Importance of certificates



Certificates are a primary means of information verification. They are the top measures of qualitative information (e.g., social sustainability and impact on ecosystems). Because standards vary globally, certificates lack reliability. There is insufficient hierarchy between certificates and no centralized database.



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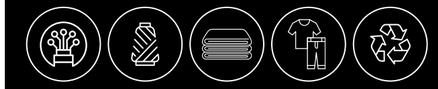
Insights

EU regulation’s (WFD) compatibility with existing systems



While an enabler of standardization, EU regulation risks interfering with well-functioning local systems. End-of-waste criteria differ from country to country. In most countries and EU-level discussions, the repair and repurposing of textiles are often overlooked (textiles = either wearable or waste).

Challenges for early adopters

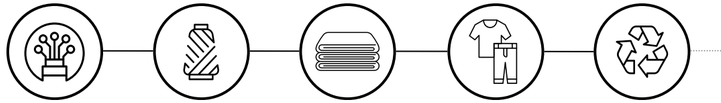


Adopting new solutions is costly, complex, and can interfere with existing processes. Many proactive parties are SMEs, making the relative costs particularly considerable.

User experience issues



Existing software has failed to provide a meaningful view of the supply chain and sufficient onboarding, and the UX has been too complex. There has been insufficient automation in transferring data to new systems, primarily due to data originating from flat files.

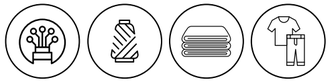


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Recommended actions based on the gained insights

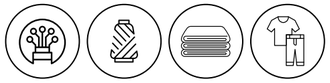
Based on the insights mapped out in the previous slides, we have devised actionable solutions to hurdles for DPP adoption.

Lack of uniform processes and software

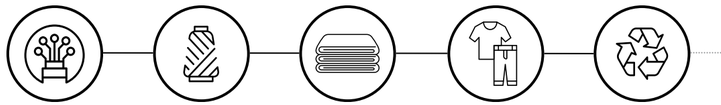


Standardized heading structures and data formats will follow EU regulations on minimum reporting requirements. DPP systems should be cross-compatible with one another (independent of the service provider) to remove future hurdles for systems interoperability.

Manual data management



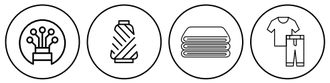
Product-level information (incl. data on health, safety, and environmental impacts covering the entire supply chain) will be stored digitally in distributed ledgers. Instead of sharing stagnant and flat files, the databases will be dynamic and synchronized across computers, ensuring timeliness. Other tech enablers like Big Data, AI and machine learning, and RFID tags and readers should be utilized where possible to automate data management.



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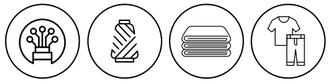
Recommended actions based on the gained insights

Siloed information



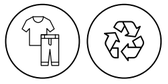
In addition to the minimum sharing requirements established by regulators, businesses may set up access rights to additional entries to share information selectively and securely.

Importance of certificates

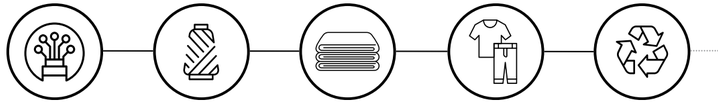


Due to the immutability of blockchain entries, data cannot be altered without leaving a trace, enhancing the likelihood of accuracy (reluctance to make false claims for short-term benefit). Databases of trusted certificates can be established to make it easier to validate green claims. Evaluating certificates' reliability and significance would require participation from neutral third parties. Such evaluation would have to commence globally.

EU regulation's (WFD) compatibility with existing systems



The European Commission aims to establish pan-European end-of-waste criteria, hoping to promote circularity and harmonize standards between countries. Recycling and reuse should be prioritized over discarding post-consumer textiles as waste. Textile waste sorting and recycling are not necessarily governed by law; in Finland, textile repurposing is non-legislative and is executed by independent parties.



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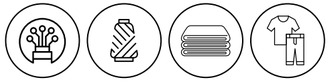
Recommended actions based on the gained insights

Challenges for early adopters

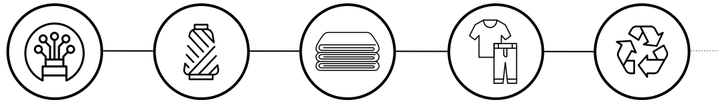


In addition to funding technological innovation, fiscal incentives should be attached to proactive transparency. SMEs should be and are advised on adjusting to new demands regarding technology, processes, and reporting (Sustainability Advisors from the Enterprise Europe Network as per the EU’s SMEs Strategy).

User experience issues



Systems architecture and interface design should be informed by industry needs. Flat databases should be transferred to ERP or SCM solutions as soon as possible to enable automated data transfer once DPPs become mandatory in the coming years. Developing high-quality protocols (or "toolboxes"), including Software Development Kits (SDKs), would nudge product developers toward a pristine UX.



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TECHNO-LOGICAL PERSPECTIVE

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Complementing ESPR & CIRPASS with a technological concept

- Fully interoperable technological, semantic, and organizational aspects of data management and sharing
- All relevant actors shall have free access to DPPs
- DPPs shall remain available after insolvency, liquidation, or other type of cessation of activity
- Rights to modify or update information shall be restricted based on access rights
- Ensuring data authentication, reliability, integrity, and a high level of security and privacy

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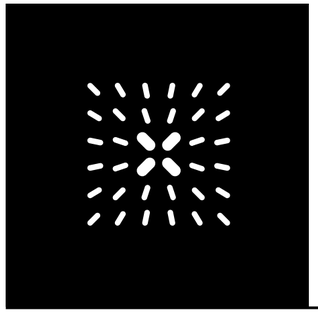
- Data-level interoperability to minimize constraints and facilitate adoption
- Maximum reuse of legacy systems and legacy data
- Built-in flexibility as an essential requirement for DPP systems
- As DPPs are here to stay, we need state-of-the-art technologies
- W3C semantic web standards as an initial framework for access control, access management, authentication, data storage, data processing, data mining, and metadata integration

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- Researching and conceptualizing a DPP knowledge graph that has its technological basis in blockchain
- Researching the necessary smart contracts for completing the decentralized infrastructure
- Calculating the energy efficiency of an optimal decentralized system architecture
- Dividing the knowledge graph into value chain and trust chain-specific data and DID tokens
- Researching the current ERP systems, data formats, and best UX practices for data sharing
- Conceptualising ERP agnostic technologies for optimal protocol integration

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Gaia-X ecosystem



Gaia-X is a pan-European collaboration for developing a secure and sovereign data infrastructure. A complementary project to Gaia-X, Pontus-X pilots compliant decentralized technologies for future data market implementation.

The EU’s single market for data and Gaia-X’s data spaces are parts of an ongoing dialog aiming to set common standards for digital identity, digital currency, and a harmonized data market.

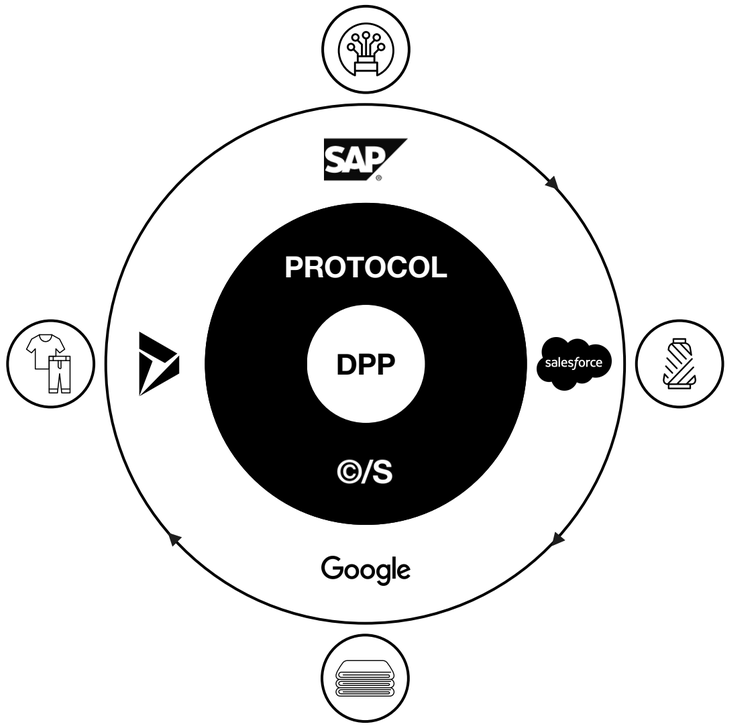
This project has been informed by Gaia-X’s most recent approaches. As part of the Pontus-X network, STRGL is the Finnish lead of the Web3 ecosystem.

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Decentralized tech is best equipped to solve issues related to data-sharing at scale

	Centralized	Decentralized
Data Ownership & Control	One organization has control over all data, which can cause conflicts and lead to data misuse.	Data ownership can be more clearly defined, and data is controlled by the individual or entity that created it.
Data Security & Privacy	Centralized databases present a single point of failure, risking all data if compromised.	Data is distributed across multiple nodes, making it more difficult for attackers to compromise the system, thus enhancing data security.
Data availability	Centralized data is only as available as the organization owning the data wants it to be.	Data is public and available to all paricipants.
Trust	There is no surefire way to guarantee solutions don't allow editing data entries after the fact.	Data entries are immutable, and edits are entries of their own.
Interoperability	Different systems and standards across organizations can cause consistency issues.	Open standards improve interoperability between different systems and organizations.
Regulatory Compliance	Legal and regulatory challenges may arise related to withholding information.	The transparency of blockchain data entries makes it easier to demonstrate compliance unequivocally.

The technological implementation of the DPP



We recommend implementing the DPP as a decentralized knowledge graph. The DPP would employ onchain interaction mechanisms analogous to commonly understood Web2 interactions. Distributed ledger technology (DLT) enables participants to manage, share, and commercialize their parts of the verified DPP data.

Product database

Centralized product data stream application

DPP protocol

Decentralized DPP publication software



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Technology definitions

What	Why
Centralized DPP	Centralized databases don’t allow for wide and open standards for verified credential signatures, broad interoperability, and immutability required by regulation. This means they are non-compliant, or unequivocal compliance is difficult to achieve.
Permissioned blockchain-based DPP	Passport data is stored on a private or consortium blockchain and is only accessible to platform members. Enables limited verified data sharing opportunities. Has immutable benefits and can be compliant with regulation.
Tokenized blockchain-based DPP	Passport data is stored in an NFT imprinted on a public blockchain. Has immutability benefits and is compliant with regulation. Efficient data streaming between B2B solutions and interoperable format across mediums for user. Additional value through innovative use cases.

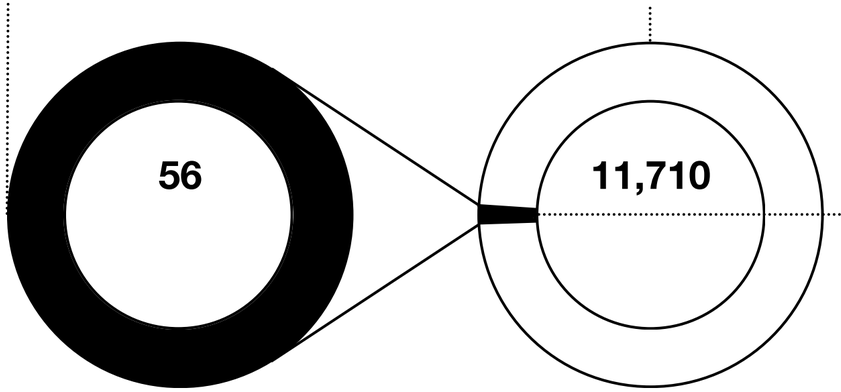
Energy intensity

The DPP protocol should operate on an L2 blockchain scaling solution.

The energy consumption of a single block in a PoS system is not directly dependent on the number of transactions being processed; emissions would remain the same in the event of wider-scale adoption.

Polygon emissions
Layer 2 network (Optimistic Solution)
56.22 t/CO2e (annualized)

Ethereum emissions
Layer 1 network (Proof-of-Stake)
11,710 t/CO2e (annualized)



Polygon share of Ethereum emissions
(0.48% of total Ethereum emissions)

Source: Polygon (2022)

Decentralized development

Software built on blockchain, an application of distributed ledger technology forming a so-called “shared computer”, is called a smart contract. When looking at a decentralized DPP solution from a blockchain perspective, we discuss its technical implementation using the emerging development standards of which smart contracts are a part.

SMART CONTRACT



A smart contract is a digital contract that automatically executes, controls, and documents transactions and actions according to predefined terms. It provides security, transparency, and efficiency in various processes while reducing the need for intermediaries and manual control. Software libraries consisting of several smart contracts are called protocols.

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Verifiable credentials: Profiles

PROFILE



Any verified company will have an onchain profile through receiving a KYC-compliant Profile verifiable credential to the SSI environment. Profiles are represented as non-fungible tokens.

The DPP protocol transfers the management rights of the data to the participants. This is achieved by creating direct links between profiles and DPPs they create.

There are two types of DPPs that profile owners can create: Zeros and Plusses. Both of them are onchain data entries that are represented as non-fungible tokens.

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Verifiable credentials: Zeros and Plusses

ZERO

0

- Zeros are the first credential type in the product's value chain.
- In the textile value chain this represents the raw material such as cotton or recycled fiber textile waste.
- Zeros contains:
  - Verifiable credential of its creator
  - Data of the credential such as text or any files
  - Zeros are not linked to anything else than its creator as they are the first entry in the value chain

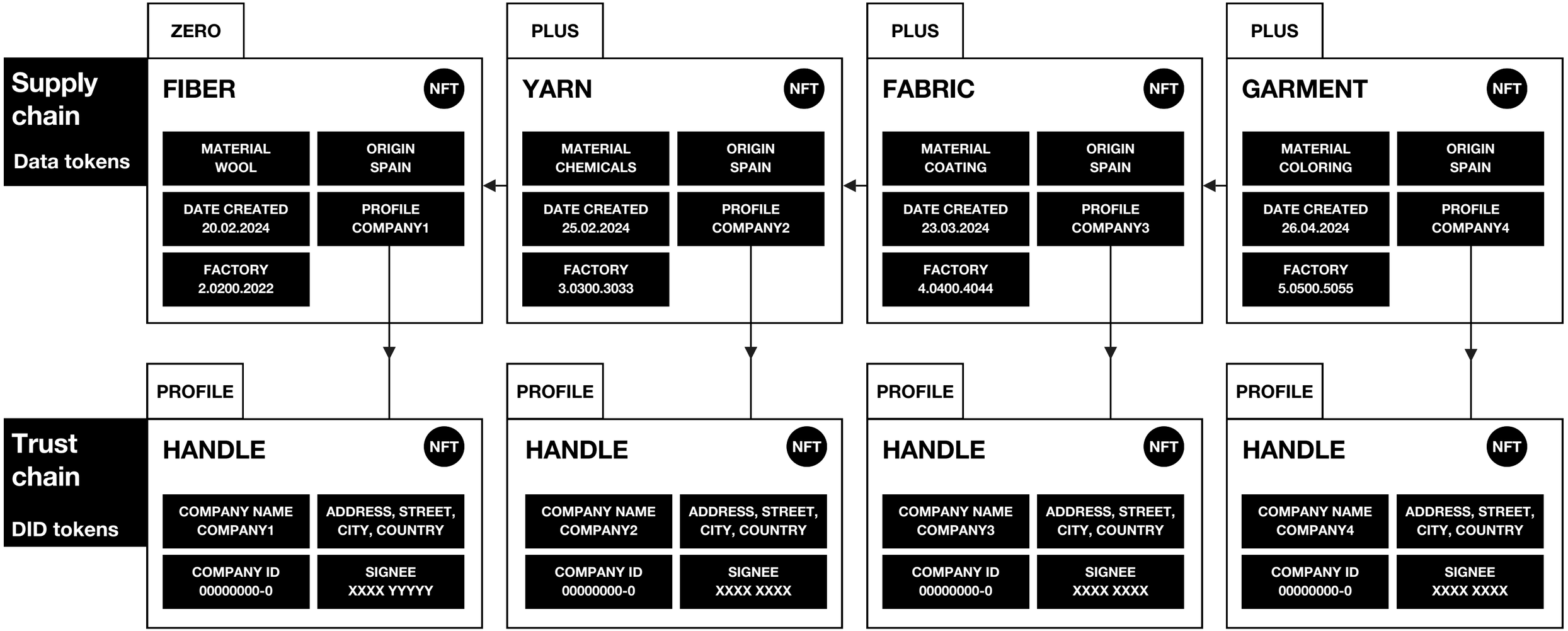
PLUS

+

- Plusses are any credentials after the Zero credentials.
- In the textile value chain this is a product that is derived from another product such as yarn made out of cotton.
- The knowledge graph is essentially one Zero and an unlimited number of Plusses.
- Plusses contains:
  - Verifiable credential of its creator
  - Data of the credential such as text or any files
  - Link to another Plus or Zero credentials type

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Tokenized supply chain modeling



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DPP protocol integrations

For smart contracts to work effectively with centralized product data systems, the integrations for reading and writing data between onchain and offchain environments must be efficient.

GraphQL and SDK (Software Development Kit) APIs serve different purposes and have distinct characteristics. Here are the core differences between them.

SDK

Importing DPP data to the blockchain
Comprehensive React Hooks in the SDK
Simplifying protocol complexity with SDKs

GraphQL

Precision in data retrieval
DPP protocol and GraphQL integration
Efficient indexing for blockchain data

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SDK

Importing DPP data to the blockchain	**For the protocol, an SDK should be used to build applications to import DPP data directly to the blockchain database.**
Comprehensive React Hooks in the SDK	**The SDK should include a collection of React Hooks containing everything needed to interact with the DPP Protocol.**
Simplifying protocol complexity with SDKs	**SDKs provide a foundation that abstracts away the complexity of some concepts of the protocol and API.**

GraphQL API

Precision in data retrieval	**GraphQL allows applications to request exactly the data they need. Applications should specify the shape and structure of the response by defining the fields they want. This will eliminate over-fetching and under-fetching of data.**
DPP protocol and GraphQL Integration	**For the DPP protocol, GraphQL integration is an optimal solution for exporting DPP-related information and data for consumers and different use cases – directly from the blockchain.**
Efficient indexing of blockchain data	**As protocol data on the blockchain is relational, the indexer can work effectively. Mapping the data in a database decoded and in a relational manner would optimize the interface for fast fetching. This would allow equal speed to querying a centralized database, for example.**

STRATEGIC TAKEAWAYS

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The competitive toolbox

Level of decentralization, compliance readiness, and user experience can be key differentiators.

Level of decentralization

Format, source type, and transferability make a solution more or less centralized.

Tokenization refers to the DPPs being stored as NFTs, supporting verifiable ownership and value transference and making the DPPs hard to counterfeit. Source type determines whether data is open or closed source. This indicates how accessible it is to others. Transferability means the degree to which DPPs can be transferred into other software. It is determined by data formats and semantics.

Compliance readiness

As ESPR is the main legislation demanding DPPs, compliance with its requirements is essential.

We believe any solution should be assessed on its capabilities for large-scale data sharing with consumers, retailers, resellers, recyclers, and customs. There are additional relevant stakeholders, such as regulators and law enforcement. Still, these five categories are essential in order to ensure apparel moves seamlessly across countries' borders from one owner to another to eventually recycling.

User experience

User experience is crucial when aiming for wide-scale retention.

Based on our research, current solutions in the market suffer from suboptimal UX, and some brands have opted out of pilots and trials because of adoption difficulties. UX is particularly important when suppliers are filling in the information themselves, as they often have to use different traceability systems with different buyers, and friction with these tools can cause major frustration for the brand's traceability managers.

Total cost overview of DPP solution alternatives over a 10-year period

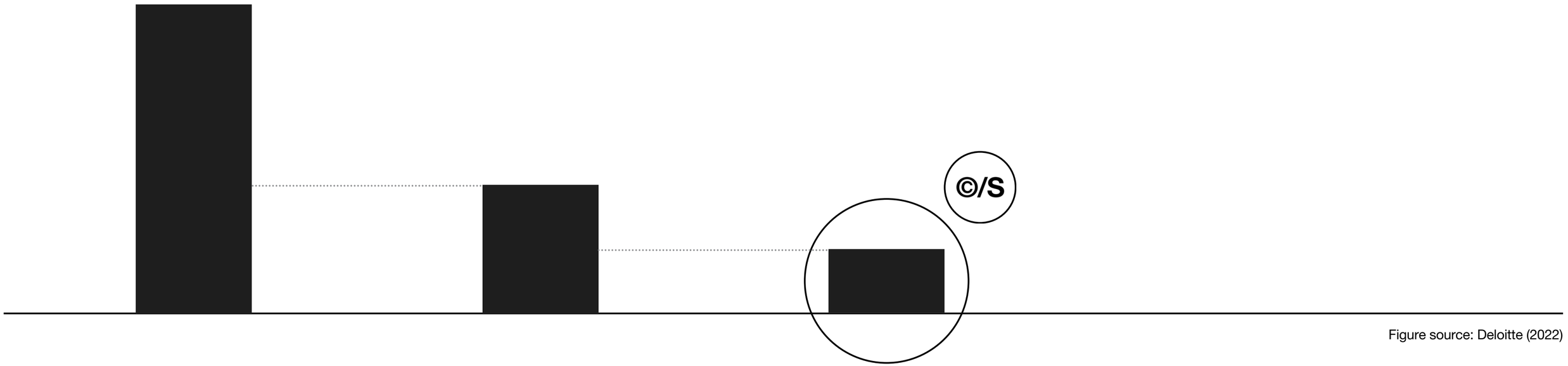


Figure source: Deloitte (2022)

€63-152 Billion

Competing proprietary standards and systems

€9-18 Billion

Institutional centrally-managed standards/specifications model

€3-7 Billion

Global, open, decentralized standards-based model

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The prediction game: navigating the inevitable

Legislation-driven transformation



It is essential for textile and technology operators to assess how the final sustainability legislation will affect value chain requirements and practices regarding data validation, storage, and sharing, as well as the potential business implications of the results. It is also important to examine how commonly used databases, software, and system components interface support the strategy for the future data market and its open standards.

Anticipating the DLT surge



Decentralized technologies, fundamentally different from their centralized precedents, are still mostly unknown territory for enterprises. The current known regulatory frameworks govern the sharing of value chain and product data through decentralized protocols. It is critical for private and public operators to understand the operating models and cost structures of DLT-based solutions to identify the new business models they enable.

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Industry problem points, adopting the DPP, and technological implementation

Problem **Preparedness for the DPP**	Presently, there are practices in the textile industry that make adopting the DPP more challenging. These practices include the prevalence of manual data management and sharing, a lack of standardized data management practices and software within and across companies, and the cost and complexity of adopting new solutions (especially for SMEs).
Solution **Adopting the DPP**	To adopt the DPP as easily as possible, organizations' tasks include adopting software for data management to facilitate an automated transfer to the DPP, following standardized headings and data management standards as required by regulators, and performing strategic planning to implement the DPP incrementally.
Technological implementation	With technological capabilities such as decentralized databases, developer tools, and data query integration, blockchain is an optimal technology for the DPP. The export and import of data between smart contracts and centralized product databases can be designed and built in ways that are complicit with regulation as well as energy- and cost-effective.

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It’s time to adopt.



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