RAIN RFID Digital Product Passport Evolution Model

Version 2
September 2026

Executive Summary

The textile and apparel industry is leading the way in adopting Textile Digital Product Passports (DPP), driven by the Ecodesign for Sustainable Product Regulation (ESPR) alongside increasing needs for supply chain transparency and circularity. Far from being a regulatory requirement, the DPP serves as a foundation for establishing long-term value that goes well beyond standard compliance.

This whitepaper introduces a five-stage Digital Product Passport (DPP) Evolution Model, built upon RAIN RFID as the foundational physical data carrier. The model is designed to guide companies beyond basic DPP compliance, enabling them to leverage RAIN RFID as a strategic financial instrument. As organizations advance through the DPP maturity stages, they initially prevent financial leakages and progressively unlock new revenue opportunities.

The foundational implementation of Digital Product Passports begins with currently achievable identification solutions, allowing brands to meet regulatory mandates without introducing excessive operational complexity. This initial phase involves piloting a combination of data carriers — such as QR, NFC, and RAIN RFID at a batch-level granularity that is specific to distinct products and use cases. At this stage, the financial focus centers entirely on minimizing compliance costs and mitigating audit risks.

As organizations advance, they introduce unique item-level identification to drastically improve forward supply chain operations, ultimately delivering finished products to the end-consumer. By tagging RAIN RFID at the source, traceability is achieved that elevates inventory accuracy from roughly 65% to an optimal 99%[1], curbing erosion and driving operational efficiency. The most significant value is realized when embedding a persistent Digital RAIN tag to stay with the product during its entire life, granting entry into the re-commerce sector, which is expanding three times faster than the firsthand market. The global resale market is estimated to be $360 billion by 2030[1].

Although initial DPP maturity accommodates various data carriers, the greatest financial gains are expected by utilizing RAIN technology to deliver services and insights that extend beyond regulatory compliance. In contrast to optical QR or printed codes, RAIN technology facilitates high-volume, without light or line-of-sight scanning, which is essential for scaling automated industrial sorting, product resale, and recycling. Pairing RAIN tags with QR codes enables consumer access and complies with DPP EU requirements, with GS1 Digital Link being a primary commercial standard. This empowers

[1] Avery Dennison 'Missing Billions', GS1.

brands to capitalize on circular economy incentives and explore highly profitable business models like rentals and repairs.

The potential economic benefits of the RAIN-supported DPP strategy are conservatively projected to generate between $15-22 billion in annual value across the worldwide textile value chain.

RAIN RFID DPP Self-Assessment

The self-assessment tool is developed to discover your DPP Evolution Level and understand the next stage of your organization's digital product passport journey. The assessment is anonymous.

Message from the authors

This whitepaper and the Self-Assessment have been produced by the RAIN Alliance Sustainability Community.

Introduction

Developed by the RAIN Alliance Sustainability Community, the DPP Evolution Model offers textile brands and retailers a strategic framework to move beyond regulatory compliance and unlock substantial economic value through circular business strategies.

Advancing through these stages enables organizations to transition their primary focus from defensive compliance to proactive value creation.

The model is designed to illustrates the unique technical benefits of RAIN RFID compared to alternative data carriers, including:

- **Mass Reading:** RAIN RFID data carriers allow end-of-life services to scan hundreds of items per second, without line-of-sight, which is essential for industrial-scale waste sorting. Evidence is available from a case study run by Avery Dennison in partnership with TEXAID.
- **Durability:** Embedded RAIN RFID can be designed and manufactured to offer superior durability compared to printed QR codes, if they are engineered to withstand the wear and tear throughout a product's entire lifecycle. This resilience supports sustainable circularity; RAIN Alliance articles highlight how these durable data carriers can give garments a second life and provide concrete evidence of how the technology facilitates textile recycling.
- **Unique Identity:** Each chip has a factory-locked unique ID (TID), which provides a higher level of anti-counterfeiting and data integrity for the Digital Product passport. An article released by Trimco demonstrating how RAIN technology is offering game changing technology against counterfeiting.
- **Automation:** It removes the manual labor of scanning individual product items, making the "circular" return of products more economically viable. A series of pilot case studies by Avery Dennison are providing evidence of RAIN technology for circularity.

RAIN RFID DPP Evolution Overview

The DPP evolution level is defined consistently across three dimensions:

- **Strategic Focus & Operational State:** Defines where the RAIN RFID tag is introduced in the process, how far the identity extends across the product lifecycle and, how product data is handled,
- **Financial Drivers:** Captures the primary business motivation behind DPP adoption and RAIN deployment—shifting from cost containment to ecosystem monetization.
- **Economic Uplift & Circular Value**: Measures the realized financial return and material efficiency unlocked at each stage.

RAIN RFID serves as the essential data carrier across all levels.

Financial drivers and economic values are based on global apparel market analyses from sources such as Boston Consulting Group, Grandview Research, academic studies, and real-world case studies. A more detailed description and calculation of these financial drivers and their economic uplift, as well as an extensive list of all references, can be found in the CFO appendix.

The Role of RAIN RFID - dual data carrier interoperability

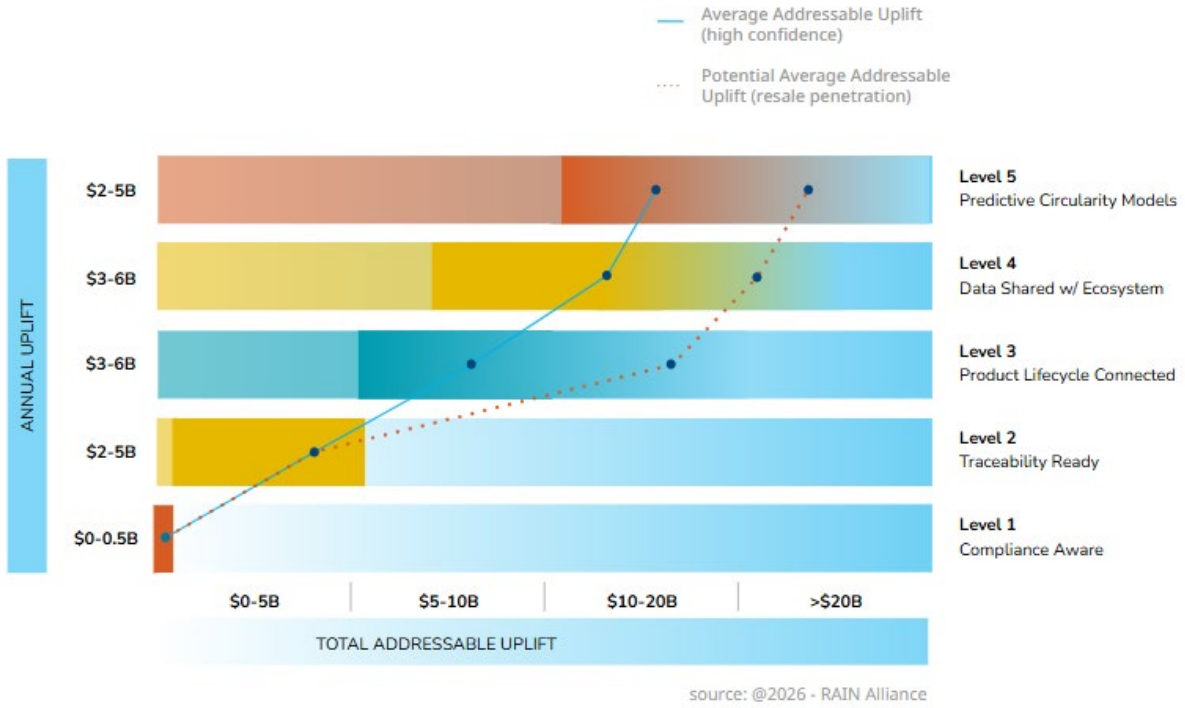
Across all levels, RAIN RFID serves as the essential "physical-to-digital bridge". It is uniquely suited for the textile industry because it is low-cost, requires no line-of-sight for reading thousands of items, and is durable enough to withstand washing and wear throughout the product's life.

GS1 TDS and TDT offer an approach on how to combine RAIN RFID tags with QR codes, to ensure that business operations can use RAIN technology while consumers use QR codes, both digital identifiers using the same SGTIN.

RAIN DPP Evolution levels and annual economic uplift

EVOLUTION LEVEL	STRATEGIC FOCUS & OPERATIONAL STATE	ANNUAL UPLIFT & FINANCIAL DRIVER
Level 1 Pre-operational	**Fragmented & compliance-aware** DPP awareness with a focus on risk mitigation and cost avoidance. DPP-relevant product data is siloed in PLM/ERP systems, and RAIN is limited to isolated pilots.	**$0–0.5B** Risk & cost avoidance
Level 2 Operational	**Structured & traceability-ready** Tagging RAIN at the source establishes forward supply-chain traceability. Data is transitioning from siloed to item-level visibility. Focus on inventory, accuracy, and labour productivity.	**$2–5B** Operational efficiency & inventory accuracy
Level 3 Integrated	**Lifecycle-connected & DPP-capable** RAIN embedded into the product, ensuring it functions across the product life cycle. Verified product identification secures brand integrity, drives recommerce, and reduces fraud. Product data accessible for compliance efficiency (audits, green claims, chain of custody). *If resale penetration of the secondhand market increases, uplift can reach the $5–12B range.*	**$3–6B** Re-commerce & compliance
Level 4 Optimized	**Ecosystem-integrated & value-generating** RAIN RFID enables data sharing with external partners — such as recyclers and resale platforms — to monetize the ecosystem.	**$3–6B** Ecosystem monetization
Level 5 Circular-native	**Adaptive & circular-native** RAIN RFID enables integration of DPP product data into the core operating model to leverage the full circularity value. Revenue shifts to service-based models (rental, repair subscriptions).	**$2–5B** New business models
Total addressable economic uplift (Levels 1–5)		**$10–22B**

Ranges are annual addressable economic uplift. Level 3 upside is contingent on secondhand market resale penetration.



High Confidence levels estimating the annual uplift for evolution level 1 and 2. The higher the maturity level, increasing variables and yet unproven theories.

Detailed Summary of Each Evolution Level

Level 1: Fragmented & Compliance-Aware

At this foundational stage, organizations are aware of the upcoming DPP mandates and are actively testing various digital data carriers to determine the optimal fit for their specific product categories and operational needs, including RAIN technology.

- **State: Product** data remains siloed across various systems like Product Line Management and Enterprise Resource Planning. Printed QR codes meet immediate consumer DPP mandates, whereas RAIN RFID use is limited to isolated pilots, often relying on post-manufacture tagging.
- **Economic Impact:** Value is primarily found in avoiding rising compliance costs and audit risks, which can run between $5M–$20M annually for global apparel brands.

This PWC Global Sustainability Reporting Survey, shows that sustainability reporting is no longer a marketing or voluntary exercise—it is a data-heavy compliance mandate. For global apparel brands, surviving this shift requires fundamentally digitizing and auditing a supply chain that was historically designed to be invisible, siloed and often asynchronous.

Research of nearly 300 corporate leaders confirm that Governance related issues have replaced environmental concerns as the top ESG reputational risk.

See the CFO appendix for detailed calculation of the value potential.

Level 2: Structured & Traceability-Ready

This level establishes visibility over item-level data to satisfy multiple business and compliance needs, encouraging the use of traceability and identification technology.

Operating uplift

Public references from the RAIN Alliance Case Study Library, GS1 and Avery Dennison 'Missing Billions' are providing insights to improved inventory accuracy, moving from roughly 65% to an optimal 99% accuracy with RAIN RFID retail case studies.

Labor saving

According to an inspiring Auburn RFID lab/Dillards study, RAIN RFID significantly boosts labor productivity. By enabling staff to perform rapid and precise cycle counts, this technology eliminates the need for tedious, large-scale manual inventories. This automated visibility ultimately streamlines shipment tracking, simplifies locating missing items, and maintains high inventory accuracy. For further insights into how RAIN RFID is transforming the retail sector, the RAIN Alliance Case Study Library and GS1 offer several valuable retail case studies.

- **State:** During manufacturing, RAIN RFID tagging is established at the source by assigning a unique Product Serial Number (e.g. a GS1 SGTIN, a RAIN Alliance ISO Numbering System [https://therainalliance.org/cin/] or some other ISO/IEC 15459-compliance encoding [https://www.aimglobal.org/registration-authority-iso-iec-15961/]) to each item. In one step, this data is encoded onto the RAIN tag and printed as a QR code on the care label, giving brands forward supply chain visibility from factory floor to point of sale.
- **Economic Impact:** Significant gains in labor productivity, enabling operational cost saving and improved inventory accuracy. This leads to increased turnover and customer satisfaction. Brands see increased margins, reduced operating, and labor costs. Research Contributing sales uplift of 1.5%–5.5% increase due to better stock availability.

See the CFO appendix for detailed calculation of the value potential.

Level 3: Product Lifecycle-Connected & DPP-Capable

A critical shift happens here: the RAIN tag is designed and manufactured to remain with the product throughout its entire lifespan; the digital RAIN RFID identity is designed to function post-sale. This allows data to be tracked across the product's entire lifecycle, including secondary markets. By tracking products at this stage, companies can manage returns, combat return fraud, and enable brand protection and authentication—essential capabilities for a fast-growing recommerce market projected by research from Thredup and CNBC to reach $360 billion by 2030.

Recommerce uplift

While the resale market's financial value is booming, the actual percentage of global apparel units that are successfully resold is shockingly low. Because global clothing production is so massive and difficult to track unit-by-unit, researchers typically measure this in terms of material flow and waste. Meanwhile, in the United States, an estimated 11.3 million tons of textile waste, equivalent to 85% of all textiles, end up in landfills annually[2]. According to Ellen Mc Arthur (Fashion and the circular economy) the textile recycling rate is less than 1%. If 87% of garments are landfilled or incinerated, the units entering resale, reuse, or downcycling (like cleaning rags) is around 13%. We assume verified identification will help garments enter resale channels.

Counterfeit & authenticity

Counterfeit products in apparel and luxury segments are a large global issue. OECD estimates global trade in grey markets and counterfeits at hundreds of billions across categories. Identity based verification contributes to actually reducing or stopping this fraud when verifications systems are implemented, and checks are applied appropriately.

Return Fraud reduction

According to the NRF Happy Returns report, 93% of retailers identify retail fraud and other exploitative behaviors as a "significant issue," accounting for 5-10% of total return value. Implementing item-level verified commerce offers a powerful solution by reducing return fraud, boosting compliance efficiency, combating counterfeits, strengthening brand protection, and driving re-commerce.

[2] source: https://earth.org/statistics-about-fast-fashion-waste/

This 7-minute video on Reducing Return Fraud with RFID breaks down exactly how scanning serialized tags at the point of sale catches fraudulent returns and immediately updates retail inventory systems.

These RAIN RFID case studies "How RAIN is giving every garment a digital identity and a second life" examine how two fashion and apparel brands, On Running and Hessnatur, are putting this into practice today, with technology partners Nedap (iD Cloud platform) and Trimco Group together with circularity.ID® from circular.fashion respectively. Together, they demonstrate how connected product identity drives measurable outcomes in sustainability, operational efficiency, consumer engagement, and regulatory readiness

Compliance efficiency

To substantiate green claims and prepare audits, apparel brands and retailers must ensure their assertions are verifiable. During an audit, if a company's claims are found to be vague or unprovable, regulatory bodies can compel them to alter packaging, issue public corrections, or pay severe fines, as demonstrated in this example from H&M. Implementing a digital trace through RAIN RFID, a verifiable chain of custody is established, giving auditors direct access to the factual data backing these claims. This product data information creates an auditable digital product passport, proving the precise percentage of organic cotton or recycled material in a specific garment or product.

- **State:** Data is accessible to multiple players (repairers, resellers), allowing for better management of product identification and return fraud reduction. Improves Compliance efficiency due to verifiable product data.
- **Economic Impact:** With nearly 17% of all annual retail sales being returned, businesses face a substantial challenge. Verified product identification secures brand integrity, reduces return fraud. While conservative estimates value the recommerce opportunity at $3B–$6B. When resale penetration gets higher, this has potential to elevate its valuation to $12B.

See the CFO appendix for detailed calculation of the value potential.

Level 4: Ecosystem-Integrated & Value-Generating

Integrating circular data flows transforms the Digital Product Passport system into a collaborative, multi-stakeholder platform. Within this ecosystem, persistent RAIN tags open new avenues for value creation, shifting the commercial focus from cost reduction to generating revenue across a product's entire lifecycle.

Early adopter fashion brand Nobody's Child is going beyond SKU-level data.

For each style, a high volume of product and supply chain attributes is captured, validated and linked to a unique digital identity that sits behind the QR code in the care label.

With traceability and data structures in place, the focus shifted toward operational readiness and long-term value creation. Product-level impact data now supports more informed internal decision-making, while the DPP infrastructure forms a strong foundation for ESPR and CSRD compliance. At the same time, the DPP creates a direct engagement point with consumers, allowing customers to access verified product information and circularity options through a simple scan.

In the publication "Fashion and the circular economy deepdive", Ellen MacArthur presents a structural and economic framework for a circular fashion industry, identifying a $560 billion opportunity. This blueprint relies on key pillars: extending garment lifespans, scaling rental and resale business models, and improving care and repair services. DPP and RAIN technologies act as the critical digital infrastructure needed to track, verify, and route garments through these circular systems. DPP and RAIN RFID Identification have the ability to create trust — the apparel sector's primary point of friction — enabling measurable growth in the secondhand market.

Direct resale margin capture

Whereas in evolution level 3 it is assumed that verified resale improves the recovery value, now it is assumed that brands actively capture margin from the resale ecosystem. Managed Marketplaces (like ThredUp) take physical possession of the items and handle photography, listing, and shipping. The operational costs are heavy, and a net margin would hover around 50%-70%.

Reverse logistics optimization

Processing a return often consumes a substantial portion of an item's original value. Identity-enabled processes improve a retailer's reverse logistics efficiency, as evidenced by the ACS and Avery Dennison case study. By improving operating efficiency, considerable saving are achieved that reducing the high cost of return handling and return fraud reduction.

Waste and Mark down reductions

RAIN technology also resolves the "blind spot" in retail inventory. According to a SAGE report, without RAIN RFID, most retailers over-order by 10%–20% to avoid stockouts, resulting in average markdowns of around 25%. With RAIN RFID, precise inventory tracking eliminates buffer stock and excess manufacturing, directly lowering scope 3

emissions. Additionally, RAIN RFID enables omnichannel routing. If a jacket isn't sold in Madrid but is in high demand in Amsterdam, the retailer knows exactly where the Madrid jacket is and can ship it directly to an Amsterdam customer. This ensures items sell at full price rather than ending up in a clearance bin or a landfill.

Beyond the grey markets

The grey market involves the sale of authentic, brand-name goods through unauthorized distribution channels. By cleaning up the grey market, brands immediately see margin improvements because their premium and luxury retail channels no longer have to price-match unauthorized discounters. Because RAIN tags don't require line-of-sight, they can be hidden inside the garment. This makes it incredibly difficult for counterfeiters to replicate the exact digital signature or for diverters to easily locate and remove the tags without damaging the clothing.

- **Status:** Brands share product data with recyclers and resale platforms to monetize the entire ecosystem, as exemplified by innovative models like "Save Your Wardrobe".
- **Financial Value:** Direct capture of resale margins (10%–20%), reduced waste via intelligent routing and identity-based triage in reverse logistics (BCG) and minimized impact from grey-market diversion in luxury segments.

See the CFO appendix for detailed calculation of the value potential.

Level 5: Adaptive & Circular-Native

Leveraging the full value potential is highly contingent on external variables, including evolving consumer behavior, scaled reverse logistics infrastructure, regulatory policy enforcement, and global recycling ecosystem maturity.

At this level, the use of DPP data is more strategic as it comes from new circular business models like rentals, resale, and repair. The DPP sustainability and product data becomes the core of companies operating model, enabling continuous optimization.

Service based revenue margin

According to the EMF, circular business models have the potential to claim 23% of the global fashion market by 2030. If this market share is reached, it could lead to an overall CO_2 equivalent emission reduction for the fashion industry of up to 16% — providing up to a third of the emissions cuts needed for the industry to align with a 1.5-degree climate pathway.

The core financial drivers of apparel companies undergo a significant transformation when they transition toward business models centered on retaining product ownership, such as through renting, leasing, sharing, or structured take-back schemes.

Over production reduction

At present, global apparel manufacturing volume is massive, resulting in substantial overproduction. Ellen MacArthur (A new textile economy - redesigning fashion's future) estimates that this overproduction and the accompanying waste lead to an annual loss of $500 billion in value. Additionally, an investigation by the European Environment Agency of the European Union into the volume of unsold and returned textiles concluded that the average share of unsold textile products in research literature is **21%**, estimating that this unsold stock ultimately ends up being destroyed. (JRC: study on destruction of unsold products).

Pricing premium

PWC – voice of the consumer survey (2024) , academic studies, and global market surveys confirm a definitive "willingness to pay" for sustainable apparel, evidencing that consumers will spend circa 10% more on verified lower carbon footprints. In high-value segments, sustainability is an expected baseline standard, rather than an add-on. Successfully capturing a 20% premium in high-end apparel requires pairing this verified footprint with tangible benefits: superior fabric quality, extreme durability, exclusive design, or a compelling brand narrative.

Recycling yield improvements

With material costs accounting for 40–50% of a garment total cost, optimizing material recovery and recycling yield represents a substantial opportunity.

By maintaining comprehensive data on the precise components, dyes, and hardware used, apparel brands can drastically improve the sorting and recycling efficiencies that commonly burden closed-loop recycling infrastructure, ultimately securing high-value material assets (Schumacher & Forster, 2022).

- **State:** Brands use predictive analytics for product lifecycles and closed-loop designs informed by real-world data.
- **Economic Impact:** Revenue is generated through Service-based models (rental, repair subscriptions, Product-as-a-Service - EMF, Fashion and circular economy deep dive). Verified low-impact products may also command a price premium, and material recycling improvement will recover material cost.

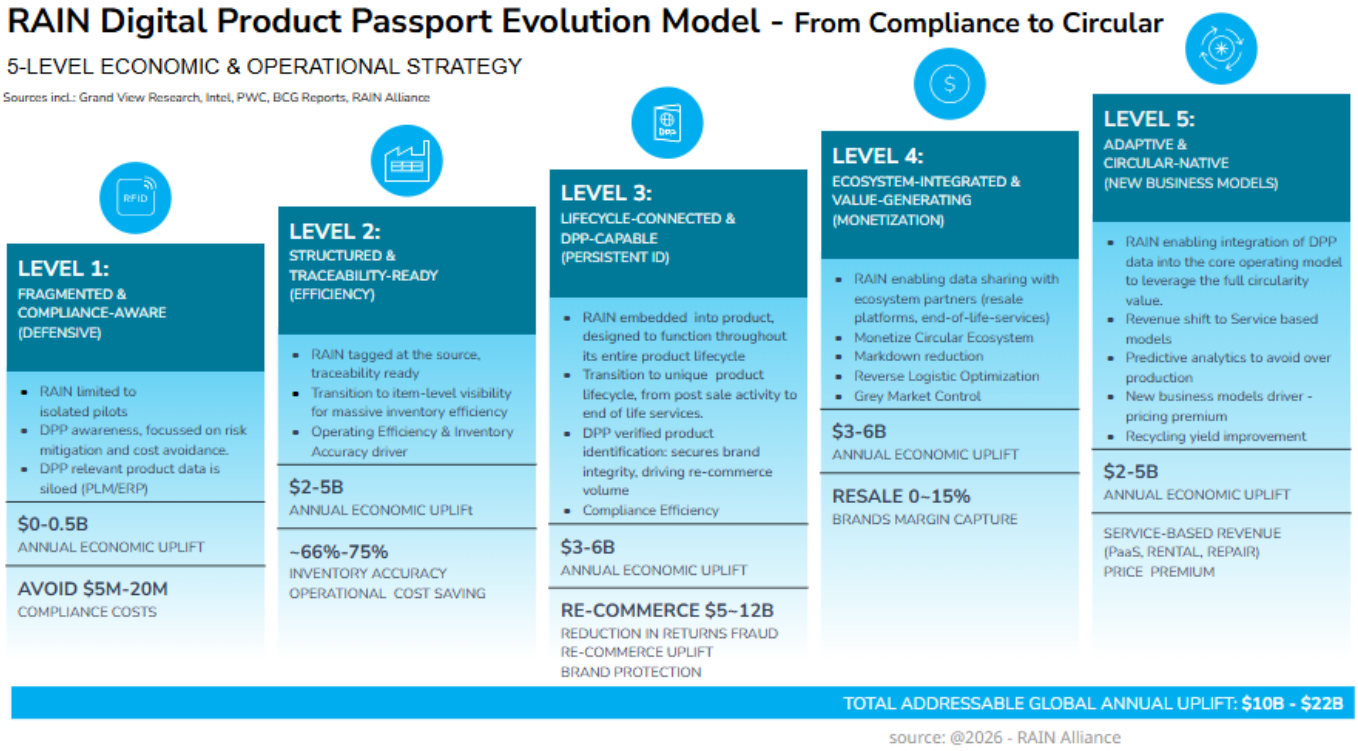
See the CFO appendix for detailed calculation of the value potential

Highlights of the Model and the Economic Value Summary

- **Source Data:** The economic values are derived from global apparel market analyses, citing sources like Grandview Research - Definition Premium Market Apparel market outlook to 2033, and Boston Consulting Group - Resale's Next Chapter: How Fashion and Luxury Brands Can Win in the Secondhand Market for operational efficiency gains.
- **RAIN RFID Circularity:** Level 2 and 3 emphasize that source tagging is the "unlock" for all subsequent levels. Without a persistent digital ID at Level 3, the circular ecosystem (Level 4/5) cannot verify product authenticity or impact. Evidence is provided from RAIN articles, "How RAIN RFID Is Giving Every Garment a Digital Identity —and a Second Life".
- **Financial Sources:** Labor and Inventory efficiencies are derived from public sources from GS1, Auburn RFID lab/ Dillard study
  - Re-commerce: Values derived from the Ellen MacArthur Foundation (EMF) 2021 reports on circular fashion economics.
  - Fraud Reduction: OECD report categories for counterfeit and return fraud estimates.

The RAIN RFID Evolution Infographic

The infographic illustrates how RAIN technology enables the progression from cost avoidance to high value circularity. It maps the logical maturity path from left to right, rising diagonally. The complexity and value scale together, but the peak uplift happens at level 3, where the digital ID becomes persistent after the initial sale.



CFO Appendix: Financial Logic & Assumptions

The Strategic Shift: From IT Cost to Compounding Asset

Strategic summary for a CFO

Digital Product Passport (DPP) investment is transitioning from a discretionary IT expense into a multi-year infrastructure asset with compounding financial returns. By building a foundation on persistent item-level identity using RAIN RFID, organizations can scale data platforms across SKUs and seasons to shift rapidly from regulatory compliance to sustained economic advantage.

- Levels 1–2: Pay for the initial hardware and tracking infrastructure.
- Level 3: Protect the brand through compliance automation and fraud prevention.
- Levels 4–5: Monetize the entire lifecycle via new, circular business models.

Metric	Level 1-3 (Current)	Level 4-5 (Future)
Primary Driver	Labor Savings & Inventory Accuracy	Leveraging Circular Business Models

Metric	Level 1-3 (Current)	Level 4-5 (Future)
ROI Source	2-5% Top-line growth	4% Turnover Risk Mitigation
Data Value	Store-level stock counts	Batch-level "Digital Identity" for Customs
Circular Benefit	Reduced overproduction	Lowered EPR Fees & Recycled Feedstock

The Market Foundation & Research Rationale

To ensure the financial models are thoroughly stress-tested, all calculations build upon a highly qualified, multi-tier addressable market baseline:

- Global Apparel Market: Valued at $1.7 Trillion annually.

Source Reference: Grand View Research

- RAIN Target Segment Focused on mid-to-premium retail segments, representing 60%–80% of the total apparel market.

Source Reference: Intel Global Clothing RFID Solution Market Research Report 2025:

- Baseline Addressable Market: Established at a conservative $1.0 Trillion.

Level 1: Fragmented & Compliance Aware

The total estimated value: Between a conservative $0 - $0.5B

At the entry maturity stage, investments focus heavily on establishing basic data frameworks.

- **Data & Software Costs:** Software-as-a-Service (SaaS) for carbon accounting, traceability, PLM integration, and third-party verification ranges from a $5M conservative spend to a $20B medium estimate.

Source Reference: PWC's Global Sustainability Reporting Survey 2025: From insight to value: The sustainability reporting journey continues

- **Cost Avoidance:** Incremental DPP reporting adds a 20% buffer, yielding a potential $0.24B in cost avoidance under medium expenditure scenarios.

Level 2: Structured & Traceability Ready

Total Estimated Economic Effect: Rounded to $2.0B – $5.0B in annual value.

Calculations are based on a conservative 50% penetration of the addressable market ($500B base).

Value Driver	Conservative Estimate	Optimistic Estimate	Rationale & Research Basis
Compliance Efficiency	$0.5B	$1.0B	Large brands average $5M–$20M on ESG reporting, supplier audits, and regulatory data prep. Across 500 mid-to-large global brands, this creates a $4B industry cost base. DPP automation reduces data reconciliation and manual validation costs by 10%–20%. Source Reference: PWC – Global Sustainability Reporting 2025
Operating Uplift	$07.5B	$1.25B	RFID case studies[2] prove inventory accuracy jumps from 65%–75% to 93%–99%. This drives a 1.5%–5.5% sales uplift via improved stock availability. The model conservatively applies a 1.5%–2.5% uplift to the $500B market base. Various Source Reference: GS1, GS1/ECR study, Missing Billions Avery Dennison,
Labor Savings	$1.0B	$2.0B	Auburn University research highlights up to a 96% reduction in cycle count labor, alongside material reductions in receiving and store labor. Retail SG&A[3] is typically 20%–30% of revenue, with labor accounting for half; the model assumes a 0.2%–0.4% savings of revenue. Source Reference: Auburn RFID lab / Dillard Studies
Working Capital Release	$0.5B	$1.0B	Sector inventory averages 15%–20% of revenue ($150B–$200B). A modest 1% reduction in inventory—by minimizing safety

Value Driver	Conservative Estimate	Optimistic Estimate	Rationale & Research Basis
			stock, over-ordering, and markdown exposure—releases meaningful capital. Source Reference:RAMP - SG&A expenses: Definition, formula & examples
Estimated Annual Value	**$2.25B**	**$4.25B**	Combined total of Level 2 operational efficiency drivers.
Rounded Uplift	**$2 B**	**$ 5B**	

Level 3: Lifecycle-Connected & DPP Ready

Total Estimated Annual Value (rounded uplift): $3.0B – $6.0B.

The potential to reach $5.0B–$12.0B if secondhand market penetration accelerates. Calculations utilize an early Level 3 penetration rate of 40%–60%, establishing a midpoint revenue base of $500B.

Opportunity Area	Conservative Estimate	Optimistic Estimate	Rationale & Research Basis
Returns Fraud Reduction	$1.0B	$2.0B	The NRF reported ~$890B in total retail returns in 2024 (16.9% rate); apparel e-commerce returns average 20%–30%. Fraud accounts for 5%–10% of return values ($5B leakage on a $100B return volume). DPP item-level verification reduces this leakage by 20%–40%. Source Reference: NRF Report – Happy Returns 2024
Compliance Efficiency	$0.5B	$1.0B	Large brands average $5M–$20M on ESG reporting, supplier audits, and regulatory data prep. Across 500 mid-to-large global brands, this creates a $4B industry cost base.

Opportunity Area	Conservative Estimate	Optimistic Estimate	Rationale & Research Basis
			DPP automation reduces data reconciliation and manual validation costs by 10%–20%. Source Reference: PWC – Global Sustainability Reporting 2025
Recommerce Uplift	$1.25B	$2.5B	The secondhand market is projected to exceed $350B by 2030 (Thred up), with used clothing comprising 10% of fashion sales (BCG, EMF). Verified identification acts as a "trust signal," shifting an increased volume to resale, with an increasing recovery value of 5-10% (CNBC). Source References: Thred up, Boston Consultancy Group, CNBC, EMF
Brand Protection (Counterfeits, Authenticity)	$0.2B	$0.6B	Counterfeit goods represent up to 2.3% of global trade ($467B), with apparel as a top target (OECD/EUIPO). The premium apparel segment experiences a 1%–3% revenue loss from diversion (Just Style). Persistent identity verification recovers 20%–30% of this loss across a $100B premium base. Source Reference: OECD – better policies for better lives. Just Style: Footwear and clothing most heavily bootlegged industry.
Total Annual Value	**$2.95B**	**$6.1B**	Combined annual value across all four Level 3 focus areas.
Rounded Uplift	**$3B**	**$6B**	When resale penetration gets higher, these figures can easily reach the $5-12B range.

Level 4: Ecosystem-Integrated & Value-Generating

Total Estimated Annual Value (rounded uplift): $3B – $6B

Global eco system estimates scales between $4.0B and $10.0B. Calculations assume a Level 4 market adoption rate of 30%–50%, resulting in a final addressable revenue base of $400B.

Key Value Pools	Conservative Estimate	Optimistic Estimate	Rationale & Research Basis
Direct Resale Margin Capture	$2.0B	$6.0B	Roughly 10-15% of units from the $400B base enter resale flows ($60B volume). Following approach from level 3 recommerce uplift (EMF). By directly capturing margins from the resale ecosystems, brands transition from 0% to a 10%–20% effective margin capture rate (thred-up) If brands directly operate 30%–50% of that volume, the realizable margin is $2B–$6B. Source Reference: EMF , Thredup
Waste & Markdown Reduction	$0.3B	$0.7B	Apparel retail markdowns average 15%–35%. A 25% markdown on the $400B addressable market creates a $20B markdown pool. Level 4 identity allows for faster rerouting, optimized outlet allocation, and in-season rebalancing to reduce markdowns by 2%–5%. Source Reference: SAGE report.
Reverse Logistics Optimization	$0.2B	$0.5B	Returns handling, sorting, and refurbishment cost roughly 15%–25% (assumed 20%) of item value. Out of an $80B return pool (20% of the $400B base), handling costs constitute a $16B cost pool. Identity-enabled triage reduces handling costs by 2%–4% (up to 5%).

Key Value Pools	Conservative Estimate	Optimistic Estimate	Rationale & Research Basis
			Source Reference: Research Baden, D., & Frei, R. (2021)
Grey-Market & Diversion Control	$0.2B	$0.5B	The premium/luxury segment constitutes 30% of the apparel market, representing a $200B base. Unauthorized channel diversion impacts margins by 1%–8% (averaging 4% or $800M). DPP identification reduces this margin of erosion by 10% - 20%. Source Reference: Grandview Research
Total Annual Value	**$2.7B**	**$5.7B**	Total annual gross margin improvements and savings at Level 5 maturity.
Rounded Uplift	**$3 B**	**$ 6 B**	

Level 5: Circular Ecosystem & Business Transformation

Total Estimated Annual Value (round up): $2B – $5B.

Calculations assume Level 5 market adoption reaches 10%–25%, yielding a refined addressable revenue base of $200B.

Key Value Pools	Conservative Estimate	Optimistic Estimate	Rationale & Research Basis
Service – Based Revenue Margin	$0.5B	$1.5B	Brands capture a 5%–10% revenue shift toward circular services (rental, repair, resale, remaking), which is projected to grow up to 23% of the fashion economy by 2030. Reference Source: EMF

Key Value Pools	Conservative Estimate	Optimistic Estimate	Rationale & Research Basis
Over-production Reduction	$0.75B	$2.0B	Overstock averages 20% of total production ($30B pool). Utilizing improved inventory accuracy and product life data drives a 5%–10% reduction in overproduction. Research literature is estimating 21% that this unsold stock ultimately ends up being destroyed. Reference Source: JRC, EMF, EU-ESPR
Pricing Premium	$0.3B	$0.8B	Based on the assumption that a verified low carbon footprint, customers are willing to pay a 10% premium, Targeting a 20% higher value segment of the market where provenance and digital verification justify higher tiers. Reference Source: PWC – voice of the consumer 2024
Recycling Yield Improvement	$0.2B	$0.4B	Material costs represent 40% of apparel product costs ($80B pool). Better fiber sorting, reduced landfill/incineration, and enhanced sorting yields a 5% increase in material recovery. Reference Source: (Schumacher & Forster, 2022).
Total Annual Value	**$1.75B**	**$4.7B**	Total annual gross margin improvements and savings at Level 4 maturity.
Rounded Uplift	**$2 B**	**$ 5 B**	

Confidence Level

High Confidence levels estimating the annual uplift for evolution level 1 and 2. The higher the maturity level, increasing variables and yet unproven theories.

Evolution Level	Primary Value Type	Rounded Annual Uplift
Level 1	Risk & Cost avoidance	$0–0.5B
Level 2	Operational Efficiency & Inventory Accuracy	$2-5B
Level 3	Recommerce and Compliance *Resale penetration potential*	$3-6B *$5-12B*
Level 4	Ecosystem Monetization	$3-6B
Level 5	New Circular Business Models	$2–5B
Total addressable economic uplift (level 1-5)		$10-22B

Level 3 has the potential to reach $5.0B–$12.0B if secondhand market penetration accelerates

Achieving high adoption at level 5 maturity promises stronger margin performance, particularly in new business models. Leveraging the full value of Level 5 is highly contingent on external execution variables, including evolving consumer behavior, scaled reverse logistics infrastructure, regulatory policy enforcement, and global recycling ecosystem maturity.

Glossary:

CSRD	The **Corporate Sustainability Reporting Directive (CSRD)** is an EU regulation that mandates standardized, auditable reporting on Environmental, Social, and Governance (ESG) performance for companies operating within or doing significant business in the European Union. Replaces and expands the previous Non-Financial Reporting Directive (NFRD), establishing non-financial disclosures to the same standard of rigor as traditional financial reporting. source
DPP	The **Digital Product Passport (DPP)** is a standardized digital container and record linked to a physical product via a physical data carrier (such as a QR code, NFC chip, or RAIN RFID tag). Legally established under the EU

	Ecodesign for Sustainable Products Regulation (ESPR, Regulation (EU) 2024/1781), the DPP stores and shares verified product-level information across the entire lifecycle to enable sustainability, circularity, and regulatory compliance. source
EPC	The **Electronic Product Code (EPC)** is a globally standardized identification scheme—managed by GS1 and ISO/IEC—that assigns a unique, serialized digital identity to individual physical objects across the global supply chain. source
EPR	**Extended Producer Responsibility (EPR)** is an environmental policy approach and regulatory framework that extends a producer's financial and operational responsibility for a product to the post-consumer (end-of-life) stage of its lifecycle. Under EPR rules, manufacturers, importers, and brand owners placing products on the market are legally required to organize and fund the collection, sorting, reuse, recycling, or safe disposal of waste generated by those products. source
ESG	**Environmental, Social, and Governance (ESG)**. It is a standardized corporate evaluation framework used by investors, regulators, and consumers to assess an organization's sustainability practices, ethical impact, and long-term risk management alongside traditional financial metrics. source
ESPR	The **Ecodesign for Sustainable Products Regulation (ESPR)**—officially **Regulation (EU) 2024/1781**—is the foundational European Union legislative framework establishing sustainability, circularity, and eco-design requirements for almost all physical products placed on the EU market. It replaces and significantly expands the scope of the former Ecodesign Directive (2009/125/EC), extending beyond energy-related items to cover virtually all commercial product categories, with textiles and apparel prioritized as early focus sectors source
Grey Market	The **grey market** (also referred to as **parallel trade** or **unauthorized distribution**) refers to the sale of genuine, authentic branded products

	through distribution channels that are unauthorized, unintended, or unofficial by the original trademark owner. source
GS1	Global Standards 1 **GS1** is a neutral, non-profit global standards organization that develops and maintains global supply chain standards. Most famous for introducing the barcode, GS1 manages a standardized identification system—including keys like the **Global Trade Item Number (GTIN)**, **GS1 Digital Link**, and the **Electronic Product Code (EPC)** for RFID—to uniquely identify products, physical assets, locations, and entities worldwide. source
JRC	The **Joint Research Centre (JRC)** is the European Commission's internal science and knowledge service. It functions as an independent, evidence-based scientific research body providing technical support, analytical research, and scientific advice to guide EU policy formulation and legislative decision-making. source
RAIN	**RAIN** (an acronym derived from RAdio IdentificatioN), is the term chosen by the industry to describe a standards-based, wireless communication technology operating in the UHF range (between 860 and 930 MHz) with a typical range of many meters. RAIN technology utilizes the ISO/IEC 18000-63 air-interface protocol. In supply chain and Digital Product Passport (DPP) ecosystems, RAIN RFID functions as a physical-to-digital data carrier. It uses passive (battery-free) microchips and antennas to enable automated, high-volume, bulk reading of hundreds of items per second across long distances without requiring direct line-of-sight. source
RAIN Alliance	The RAIN Alliance is a neutral, not-for-profit consortium of companies that together want to create a smarter and more sustainable world by using RAIN technology to connect trillions of everyday items across their entire lifecycle, simply and inexpensively.

RAIN Alliance ISO Numbering Syste	Read more in RAIN source: https://therainalliance.org/wp-content/uploads/2024/05/RAIN_RFID_CIN_Getting_Started_06.2024-2.pdf
RFID	**Radio-Frequency Identification (RFID)** is a wireless, non-contact communication technology that uses electromagnetic fields in radio frequency bands to automatically identify, track, and transfer data to or from tags attached to physical objects.
SGTIN	A **Serialized Global Trade Item Number (SGTIN)** is a GS1 global standard identifier that provides unique, item-level identification for individual physical products across supply chains. Generic terms for a SGTIN include: • Unique Item Identifier (UID) • Serialized Product Identifier • Unique Product Serial Number source
TID : Tag Identifier	TID means “tag ID” and it refers to a unique serial number written to a RIFD microchip when the chip is manufactured. It cannot be altered. The tag ID differs from the serial number written to the tag after it is made. Some serial numbers may be programmed to the tag at the time the tag is manufactured, while others are programmed by the user after the chip’s acquisition. The TID and serial number are sometimes used together to confirm a tag’s authenticity. For example, a counterfeiter might buy microchips and program serial numbers to them to match serial numbers used by popular brands. But the brand owner could confirm a tag is fake by looking up whether it ever received tags with the TIDs in the counterfeit tags, even if the serial numbers looked the same as those it uses. Source: RFID Journal

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