

Recovery-Value Optimization in Returned-Product Supply Chains: A Conceptual Framework for Operational Decision-Making

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Abstract

Product returns are a structural feature of retail and manufacturing supply chains rather than a peripheral cost. Returned merchandise in the United States was valued at approximately USD 890 billion in 2024 and USD 850 billion in 2025, between 15 and 17 percent of retail sales (National Retail Federation & Happy Returns, 2024, 2025). Yet returns are still managed as a reverse logistics problem concerned with moving goods backward at least cost rather than as a value recovery problem concerned with extracting the maximum justifiable value before residual worth decays. This paper develops Recovery-Value Optimization (RVO): the systematic alignment of diagnostic precision, disposition timing, channel allocation, and network configuration to maximize risk-adjusted net value recovered, subject to capacity, brand, workforce, and regulatory constraints. Adopting a conceptual theory-building approach, it screens a multidisciplinary corpus of 827 records into 181 retained studies across eleven streams spanning procurement and supplier governance (Akinleye & Adeyoyin, 2022b; Okonkwo et al., 2024a; Wedraogo et al., 2025), visibility and traceability (Nnabueze et al., 2021; Opara et al., 2025; Sakyi, Eboseremen, et al., 2024), predictive analytics (Tonoyan et al., 2023; Tonoyan et al., 2024a; Yeboah et al., 2025), lean process design (Ambali et al., 2021; Ezeugwa et al., 2023a; Ike et al., 2022), sustainable procurement (Ike et al., 2024a; Ike et al., 2025; Yeboah et al., 2024), regulatory and AI governance (Annan, 2025a; Ominyi & Anichukwueze, 2024; Ominyi, Anichukwueze, & Uzougbo, 2024b), warehouse automation (Akanbi & Sunday, 2024; Akanbi & Sunday, 2025; Akinlade et al., 2024), fraud and refund control (Atakpa & Abetoh, 2022; Fadayomi et al., 2024), and occupational safety (Obogo et al., 2025; Obriki et al., 2022a). Four constructs, namely return-flow intelligence, temporal value decay, disposition-channel portfolio, and recovery network capability, are linked through a net recovery value function making explicit the trade-offs among reconditioning, transport and holding cost, channel yield, cannibalization, labour capacity, and compliance exposure. Twelve propositions, a three-tier decision architecture, a five-stage protocol, an illustrative application, and a measurement system are presented.

Keywords: reverse logistics, closed-loop supply chains, product returns, disposition decisions, value recovery, circular economy, supply chain analytics, remanufacturing

1. Introduction

A returned product is no longer a sale but not yet a loss. It has consumed the cost of goods, outbound fulfillment, the refund, and inbound transport, and will consume more thorough

inspection, sorting, storage, and onward movement. Whether it ultimately contributes value depends on decisions taken in a compressed window after it re-enters the firm's custody, on incomplete information, by the least instrumented part of the operation.

Most organizations handle this poorly. Returns are consolidated centrally regardless of condition, queued behind forward inventory, graded against heuristics built for a different product mix, and liquidated once better options have expired. The resulting value destruction is invisible because the counterfactual is never measured, which is the familiar pathology of anchoring measurement to cost rather than outcome (Oduleye & Medon, 2023b; Sakyi, Filani, et al., 2022; Tonoyan et al., 2024b) and mirrors evidence that visibility rather than capacity deficits drive underperformance in inventory and asset management (Nnabueze et al., 2021; Okonkwo, Mayo, et al., 2023; Okonkwo et al., 2018b). The scale is material. For a firm with one billion dollars in sales and a sixteen percent return rate, five percentage points of recovery yield is worth eight million dollars annually, consistent with magnitudes reported for analytics-enabled procurement optimization (Akinleye, 2024; Akinleye et al., 2023; Akokodaripon et al., 2023) and cost governance (Aliliele, Eboh, et al., 2024; Medon & Oduleye, 2023; Oduleye & Medon, 2021).

First, reverse logistics is treated as a transport problem rather than a value problem. Cost per unit processed rewards batching, centralization, and deferral, each value-destroying when the asset depreciates quickly, a measurement failure also documented for dwell time in terminal logistics (Okonkwo et al., 2020) and reactive maintenance that appears cheaper per intervention while imposing larger downtime costs (Adaramola et al., 2018; Sunday et al., 2020).

Second, disposition is decided sequentially and locally rather than allocated as a portfolio. A grade mechanically determines a channel, ignoring finite capacity, cannibalization, and declining marginal value as channel volume rises. Portfolio reasoning routine in capital allocation (Lawal & Oduleye, 2021a; Walawalkar, Kalu, et al., 2025) and multi-criteria vendor selection (Ahiaekwe Patrick et al., 2021; Tonoyan et al., 2024a; Wedraogo et al., 2025) is rarely applied here.

Third, regulation has moved faster than the frameworks. Under the Ecodesign for Sustainable Products Regulation (Regulation (EU) 2024/1781), large companies will be prohibited from 19 July 2026 from destroying unsold apparel, accessories, and footwear, with medium-sized companies covered from 2030, alongside obligations to report what was discarded and why. The Right to Repair Directive (Directive (EU) 2024/1799), which member states must transpose by 31 July 2026, will oblige repair on request beyond the guarantee period, and returned and unsold textiles already represent a material share of European material flows (European Environment Agency, 2024). Frameworks treating destruction as a free terminal node are misspecified, and comparable reconfigurations follow regulatory floors in pharmaceutical distribution (Eze et al., 2024a; Eze et al., 2024b; Eze et al., 2023), cross-border data handling (Annan, 2022; Ominyi & Anichukwueze, 2022a; Ominyi et al., 2025b), and automated decision systems (Annan, 2025a; Ominyi & Anichukwueze, 2024; Ominyi, Anichukwueze, & Uzougbo, 2024b).

Fourth, the workforce dimension is neglected. Recovery work is labour-intensive, seasonal, and dependent on judgment at speed, and evidence on staffing volatility (Falemi et al., 2023b; Falemi et al., 2025; Okafor et al., 2025) and employee readiness as a limit on technology adoption (Akhigbe et al., 2024; Essandoh et al., 2025) implies that frameworks assuming uniform execution quality overstate achievable performance.

The paper contributes a net recovery value function extending cost-governance logic into disposition (Adesuyi et al., 2022; Aliliele, Eboh, et al., 2024; Oduleye & Medon, 2021); a four-construct framework synthesizing visibility (Nnabueze et al., 2021; Okoruwa et al., 2024), analytics (Tonoyan et al., 2024a; Yeboah et al., 2025), lean operations (Efobi et al., 2022b; Ike et

al., 2022), and sustainable procurement (Akin-Oluyomi, Atima, & Akinleye, 2023; Ike et al., 2024a); a three-tier architecture and five-stage protocol drawing on process standardization (Eyetsemitan et al., 2025; Eyetsemitan et al., 2022), service management (Ladapo, Dosunmu, et al., 2023; Ladapo, Jooda, et al., 2023), and automation design (Akinlade et al., 2024; Okonkwo et al., 2024b); and a measurement system informed by KPI frameworks (Sakyi, Filani, et al., 2022; Tonoyan et al., 2024b), resilience indexing (Efobi et al., 2023), and maturity modeling (Eze et al., 2022b).

2. Methodology

2.1 Design and Source Corpus

This is a conceptual theory-building study specifying constructs, articulating relationships, and deriving testable propositions in a domain whose constituent problems have been studied separately but never integrated. Such frameworks are evaluated on coherence, explanatory scope, and testability rather than against data, following comparable work on resilience indexing (Efobi et al., 2023), risk-based decision-making in regulated manufacturing (Aneke & Adesemoye, 2020), and agile supply chain transformation with embedded risk controls (Aliliele et al., 2023a). The design follows from the evidence base: no dataset links unit-level disposition to realized recovery value across firms, and the variables of interest, notably diagnostic latency and channel yield, are proprietary and inconsistently defined. The synthesis draws on a consolidated multidisciplinary corpus of 827 records across 64 subject areas, supplemented by foundational closed-loop supply chain works identified through backward citation tracing. Three inclusion tiers were applied. Core relevance covered procurement, supplier governance, supply chain analytics, logistics performance, lean improvement, and inventory or asset visibility. Adjacent relevance covered regulatory compliance, ESG and carbon accounting, data governance, cybersecurity, workforce performance, occupational safety, fraud analytics, automation, and enterprise systems, which constrain or enable those decisions. Analogical relevance covered structurally similar problems elsewhere, principally pharmaceutical cold chain, reliability-centered maintenance, risk-based audit sampling, aviation safety oversight, and edge versus centralized inference, retained only where the decision structure rather than the subject matter matched. Screening retained 181 records, 94 percent of them published between 2021 and 2025, plus 19 foundational and regulatory sources. Retained records were coded into the eleven streams in Section 3, with boundaries revised until each record had one primary assignment. The unit of extraction was the mechanism claimed rather than the effect size reported, since the corpus is heterogeneous in method and outcome and does not support pooling. Convergence was assessed by constant comparison: where streams that do not cite one another proposed the same mechanism in different settings, it became a candidate construct or proposition, and disagreements were surfaced in Section 9 rather than resolved by selection.

2.2 Synthesis and Framework Construction

Construct specification enumerated the decision variables actually available to a returns operation, mapped each to the streams addressing it, and formalized them in a net recovery value function so trade-offs are stated precisely rather than narratively, following the practice of expressing managerial trade-offs as explicit objective functions (Aliliele, Eboh, et al., 2024; Lawal & Oduleye, 2021a). Propositions were advanced only where a mechanism had at least two independently developed lines of support, applied at the level of research team rather than record,

and each was stated in falsifiable form; single-source mechanisms were dropped or restated as boundary conditions.

2.3 Parameterization and Validity The application in Section 7 is stylized: parameters are plausible for a mid-sized consumer electronics retailer and internally consistent rather than drawn from a firm, demonstrating the framework's arithmetic and identifying dominant levers rather than forecasting improvement, with sensitivity analysis included to prevent the point estimate being read as such (Oduleye & Medon, 2023a; Tonoyan et al., 2022c). Three validity threats warrant statement. Analogical transfer is central: evidence from maintenance, pharmaceutical, safety, or audit settings establishes that a mechanism operates under described conditions, not that it operates in returns handling at comparable magnitude. The corpus is concentrated, with many records in applied outlets and several research teams contributing multiple records, narrowing methodological diversity and risking mistaking shared perspective for independent convergence. And no quantitative synthesis was attempted: effect sizes are not pooled, no risk-of-bias instrument was applied, and the review is not systematic in the PRISMA sense.

3. Literature Synthesis

No single literature addresses recovery-value optimization directly. Eleven streams are synthesized on the argument that returns handling is a decision system operating under decay, uncertainty, capacity constraint, abuse, and regulatory obligation, each studied rigorously elsewhere.

3.1 From Reverse Logistics to Value Recovery

Thierry et al. (1995) distinguished repair, refurbishing, remanufacturing, cannibalization, and recycling; Fleischmann et al. (1997) reviewed quantitative reverse logistics models; Guide and Van Wassenhove (2009) characterized the shift toward profitable value recovery; and Souza (2013) organized the domain into strategic, tactical, and operational layers.

The decisive input is that returned assets depreciate at widely varying rates. Blackburn et al. (2004) argued reverse chains should be designed around the marginal value of time, and Guide et al. (2006) showed pipeline delays impose substantial unrecognized costs. Parallel findings appear where degradation is physical rather than commercial, in pharmaceutical cold chain integrity (Aneke & Adesemoye, 2025) and perishable agricultural chains, where post-harvest delay and circular waste reduction determine realized value (Jones & Ominyi, 2021; Jones & Ominyi, 2022b; Michael & Ogunsola, 2025d). At two to four percent weekly decay, a six-week cycle destroys twelve to twenty-four percent of recoverable value, exceeding the processing cost batching was meant to minimize, which is the downtime-versus-maintenance trade-off of reliability-centered maintenance (Adaramola et al., 2018; Sunday et al., 2020). Ekun and Muriel (2024) show, for forward lead times, that commitments made before capacity resolves shape realized service outcomes; recovery is the mirror image, a commitment made before condition resolves.

3.2 Acquisition, Grading, and Disposition

Guide and Van Wassenhove (2001) framed acquisition management as controlling rather than passively accepting the return stream; Galbreth and Blackburn (2006) showed the value of sorting rises with quality variance; Ferguson et al. (2009) found the benefit of finer grading depends on the spread of recovery values; Ferrer and Swaminathan (2006) modeled joint pricing; Debo et al. (2005) analyzed segmentation; Atasu et al. (2008) showed remanufacturing can serve as marketing strategy; and Savaskan et al. (2004) compared collection structures. Grading is risk-based classification under cost constraint, analogous to regulated manufacturing decisions (Aneke &

Adesemoye, 2020; Aneke et al., 2022a), data sensitivity classification (Aliliele, Mbonu, et al., 2024a), and internal control design (Akomolafe & Agu, 2018; Akomolafe & Agu, 2019a; Akomolafe et al., 2023a): how much inspection is justified given the consequences of misclassification.

3.3 Visibility, Traceability, and Chain-of-Custody

Recovery decisions are only as good as the information available when they are made. Visibility frameworks, integrated digital platforms, and asset lifecycle management with inventory visibility jointly determine transparency, compliance, and materials readiness (Nnabueze et al., 2021; Okonkwo, Mayo, et al., 2023; Okoruwa et al., 2024; Okoruwa et al., 2025), which maps directly onto the restock decision. Chain-of-custody integrity has been examined most rigorously in pharmaceutical supply chains and through distributed ledger, encryption, and smart contract mechanisms for logistics optimization, ESG reporting, workflow attestation, audit trails, secure data sharing, supplier payment, and dispute resolution (Akomolafe et al., 2024b; Opara et al., 2025; Shittu & Nabil, 2023). Because disclosure requires firms to prove by category what was discarded and why, the integrity of the systems carrying those records becomes material. Enterprise security research on insider threat, audit and risk assessment, threat intelligence, cyber risk quantification, defense performance measurement, risk-based assurance, and continuity through modernization (Dosunmu & Ogundele, 2025a; Dosunmu & Ogundele, 2025b; Dosunmu & Ogundele, 2025c) applies to the record layer, and in automated facilities the operational technology layer applies to the process itself, through adversarial machine learning risk, industrial control system threat detection, IT and OT convergence, vulnerability governance, risk quantification, zero trust, and secure supervisory data exchange (Adegbite et al., 2024b; Adegbite et al., 2025; Shittu et al., 2024). The corresponding controls are misconfiguration monitoring, identity and access integration, impact assessment, log analytics, infrastructure-as-code governance, general controls automation, and legal and ethical risk modeling (Aliliele et al., 2023b; Aliliele, Mbonu, et al., 2024b; Odejebi et al., 2025).

3.4 Predictive Analytics and Forecasting

Predictive models improve demand forecasting, inventory cost, revenue projection, service volatility, vendor risk, procurement cost, e-commerce forecasting, bottleneck reduction, and real-time KPI tracking (Akin-Oluyomi & Akhigbe, 2023c; Akin-Oluyomi, Atima, Akinleye, & Okoruwa, 2023; Tonoyan et al., 2024a; Tonoyan et al., 2024b; Yeboah et al., 2025). For returns the task is condition prediction before inspection, a classification problem under partial information resembling predictive maintenance, interpretable failure prediction, vibration-based monitoring, and sensor-based fault detection (Mayo et al., 2021; Omoegun et al., 2023; Sunday & Omoegun, 2022); prediction quality is bounded less by algorithmic sophistication than by curated features, and outputs require governance to be trusted (Nwakamma et al., 2024a; Ominyi & Anichukwueze, 2023; Oyesiji et al., 2024). Above the prediction layer, simulation and algorithmic optimization, route optimization, and energy-transport coupling bear on network configuration and expedite decisions (Tonoyan et al., 2022b; Tonoyan et al., 2022c; Tonoyan et al., 2025), while executive decision systems, behavioral and integrated financial analytics, predictive forecasting, analytics-driven decision frameworks, big data strategy conversion, prescriptive marketing, AI-integrated supply chain prediction, cross-functional KPI frameworks, churn modeling, and capacity planning supply the decision architecture into which recovery analytics must fit (Edivri & Oteri, 2022; Seyi-Lande et al., 2022; Shah et al., 2025).

3.5 Procurement, Supplier Governance, and the Demand Side

Recovery channels are supplier relationships in reverse: liquidators, refurbishers, recyclers, and marketplaces are vendors whose selection and governance determine realized yield. Procurement research on strategic sourcing, negotiation and vendor governance, supplier relationship management, vendor performance, bid evaluation, cross-border and pharmaceutical supplier risk, process automation, big data, comparative cost optimization, decision visualization, multinational risk management, high-risk environment compliance, and ERP-enabled design transfers directly (Ahiaeke Patrick et al., 2021; Akin-Oluyomi et al., 2024; Akinleye & Adeyoyin, 2022b; Akinleye et al., 2023; Akokodaripon et al., 2023; Ike et al., 2021; Okonkwo et al., 2024a; Wedraogo et al., 2025). Channel yield is therefore not exogenous but partly a function of relationship quality, contract structure, volume predictability, and information sharing. The demand side determines how many returns arise, of what quality, and with what expectation attached. Marketing analytics addresses this through predictive segmentation, retail advertising integration, governance-aware analytics, revenue attribution, return on investment measurement, executive dashboards, conversion optimization, explainable and auditable automation, adaptive control under compliance, federated lifecycle automation, cross-channel uncertainty modeling, and the adoption gap between supply chain AI and product marketing practice (Ogundairo & Ayivi-Donkor, 2023b; Sanni et al., 2025; Wedraogo & Sanni, 2024).

3.6 Lean Operations and Process Design

Lean practices improve efficiency and reduce waste (Ike et al., 2022), with data-driven optimization modeled for manufacturing and retail (Efobi et al., 2022b). Lean Six Sigma process models (Ezeugwa et al., 2023a) and resource-constrained adaptations (Ambali et al., 2021), cycle time reduction (Oyeleye et al., 2022), standard operating procedures as strategic assets (Eyetsemitan et al., 2022), lean-digital scaling (Eyetsemitan et al., 2025), bottleneck identification (Eyetsemitan et al., 2024b), change management (Eyetsemitan et al., 2023a), structured validation (Eyetsemitan et al., 2023b), and guardrails for autonomous value chains (Ogundairo, 2025) establish that triage is a process design problem before an analytical one: the time budget at first touch, decision standardization, and removal of non-value-adding handling determine whether an optimal policy can be executed at all.

3.7 Sustainability, Circularity, and ESG

ESG-integrated supply chain models, green procurement, supplier sustainability evaluation, ESG adoption in emerging economies, and digital twin-driven environmental compliance establish the sustainability constraint (Akin-Oluyomi, Atima, & Akinleye, 2023; Ike et al., 2024a; Ike et al., 2025). Carbon accounting accuracy, greenhouse gas data integration, disclosure obligations, embodied carbon in decision gates, carbon management maturity, emissions analytics, and AI-integrated ESG auditing indicate the environmental term is becoming quantified and auditable rather than reputational (Azeez & Badmus, 2024a; Okojie et al., 2023; Ominyi & Anichukwueze, 2022b), while a framework reconciling chemical safety with circular economy targets in recycled materials addresses the tension between material recovery and product safety (Okojie & Abioye, 2020).

3.8 Regulatory Compliance and Governance

Post-merger compliance integration and cross-jurisdictional data protection harmonization illustrate running one process under several regimes, the situation of a multinational retailer whose

disposition options differ by market (Ominyi & Anichukwueze, 2022a; Ominyi et al., 2025b). Algorithmic accountability, responsible AI governance, regulatory readiness, anti-discrimination compliance, compliance as competitive advantage, AI-assisted monitoring, and multi-agent quality control for regulated documents bear on automated triage and on generating disposition records (Annan, 2025a; Ominyi & Anichukwueze, 2023; Ominyi & Anichukwueze, 2024; Ominyi, Anichukwueze, & Uzougbo, 2024a; Ominyi, Anichukwueze, & Uzougbo, 2024b), while trade research on cross-border redesign, digital trade harmonization, customs AI, and technology transfer compliance bears on cross-border returns (Jones & Ominyi, 2024a; Jones & Ominyi, 2024b; Olaogun et al., 2023). Pharmaceutical regulatory science is the closest analogue for disposition under legal constraint, through risk-based interdiction, quality assurance convergence, harmonization modeling, and environmental risk governance (Aneke et al., 2024; Eze et al., 2024a; Eze et al., 2023), and aviation safety oversight supplies a second through predictive compliance monitoring, adaptive safety management, risk-tiered oversight, certification benchmarking, and audit maturity modeling (Adeyelu, 2023; Adeyelu & Dagodzo, 2022; Adeyelu & Dagodzo, 2024).

3.9 Technology, Data Governance, and Workforce

Warehouse automation applies directly through path-planning and slotting for autonomous mobile robots, fleet coordination, micro-fulfillment deployment, digital twins, and platform-based supply chain automation (Akanbi, Ganiu, et al., 2025; Akanbi & Sunday, 2024; Akanbi & Sunday, 2025; Akinlade et al., 2024; Okonkwo et al., 2024b). Data governance determines whether recovery data is usable, through sensitivity classification, lakehouse governance, data integrity in regulated operations, continuous auditing, embedded IT risk controls, service management, and IT-supply chain integration (Aliliele et al., 2023a; Aliliele, Mbonu, et al., 2024a; Aliliele et al., 2025a; Aneke et al., 2023; Ladapo, Dosunmu, et al., 2023; Ladapo, Jooda, et al., 2023; Okonkwo, Ahiaeke Patrick, et al., 2023). The platform layer adds secure cloud architecture, application migration, access control, federated and zero trust identity, security analytics and forensics, privacy-centric engineering, and CRM governance covering integration, version control, ETL design, regulated platform governance, privacy-by-design security, and service bus patterns (Badmus et al., 2025; Ladapo et al., 2025; Ogbole et al., 2025). Workforce capability is least discussed and often binding. Talent development, workforce optimization under staffing volatility, retention linked to productivity, and enterprise risk models connecting human resource strategy to operational analytics indicate that recovery performance is bounded by frontline stability and skill (Falemi et al., 2023a; Falemi et al., 2023b; Falemi et al., 2025), while retail network governance, multi-site efficiency indicators, and logistics leadership models address coordination across dispersed sites (Akin-Oluyomi & Akhigbe, 2022; Akin-Oluyomi & Akhigbe, 2023a; Akin-Oluyomi & Akhigbe, 2023b).

3.10 Return Fraud, Refund Integrity, and Financial Control

Recovery value is reduced not only by decay and misrouting but by deliberate abuse: wardrobing, receipt and identity manipulation, empty-box and substitution returns, and organized resale of fraudulently obtained refunds. This is detection under class imbalance and adversarial adaptation, and the developed evidence sits in fraud analytics covering machine learning detection, synthetic identity fraud, adaptive real-time transaction scoring at scale, monitoring for smaller enterprises in digital trade, analyst investigation support, anomaly detection in financial time series, regulatory technology, AI-driven risk assessment, predictive risk monitoring, and transaction-level forensics (Atakpa & Abetoh, 2022; Atakpa & Fobellah, 2023; Elebe et al., 2023; Fadayomi et al., 2024).

Detection interacts with customer experience, since aggressive screening suppresses legitimate returns and accompanying repurchase, a trade-off analogous to regulatory compliance burden, cognitive bias in risk judgment, and the audit of automated financial systems (Fobellah, 2025a; Fobellah, 2025b; Fobellah, 2025c). Refunds are also a settlement and control problem, connecting recovery to cross-border payment controls, high-throughput collections, KYC and anti-money laundering analytics, tamper-proof recordkeeping, risk governance harmonization, working capital control, cross-border strategic finance, reconciliation and workflow redesign, corrective action planning, automated close controls, financial crime and cybersecurity integration, tax and reporting systems, and accountability in smaller enterprises (Bello et al., 2025; Okafor et al., 2024; Oyeleye et al., 2025).

3.11 Handling, Safety, and Operational Risk

Recovery processing is manual, repetitive, and performed under seasonal surge, making occupational safety a determinant of throughput rather than a separate compliance concern. Transferable mechanisms include near-miss and hazard observation data, incident prevention in maintenance environments, continuous hazard monitoring, human error causation, recurrence of unsafe behaviour, safety training, behavioural programmes, internal safety audit, organizational learning maturity, management walkthrough frequency, proactive hazard identification from digital data streams, leading indicators, data-driven risk control at scale, predictive detection of high-risk activity, contractor and subcontractor governance, and integration of environmental practice with safety management (Arumosoye & Obriki, 2021; Arumosoye & Obriki, 2023; Obogo et al., 2021; Obogo et al., 2024; Obogo et al., 2025; Obriki & Arumosoye, 2024b; Obriki, Arumosoye, et al., 2023; Obriki et al., 2025; Obriki et al., 2022a; Obriki, Obogo, et al., 2023). Injury and absence reduce effective labour capacity, the binding constraint in Section 4.6, and do so during peaks when decay exposure is highest, so safety belongs inside the recovery capability construct rather than beside it.

3.12 Synthesis Across Streams

Each stream is well developed in isolation. What is missing is a framework treating four decisions as simultaneous: how much to learn about condition and where; how fast to act given decay; where to send the unit given capacity and interaction effects; and what capability to build so the first three can be executed repeatedly. Existing models fix three to optimize the fourth, whereas practitioners decide all four together, in real time, under workforce volatility, abuse pressure, and constraints that eliminate the cheapest terminal option.

4. Conceptual Model: The Recovery-Value Optimization Framework

4.1 Definition

Recovery-Value Optimization is the systematic alignment of diagnostic precision, disposition timing, channel allocation, and network configuration to maximize risk-adjusted net value recovered from a returned-product stream, subject to capacity, brand, workforce, and regulatory constraints. Four features distinguish it from conventional reverse logistics management. It is value-anchored rather than cost-anchored (Lawal & Oduleye, 2018a; Lawal & Oduleye, 2023a); portfolio-based rather than unit-sequential, allocating channels jointly under capacity and interaction constraints as in capital allocation modeling (Lawal & Oduleye, 2021a); temporally explicit, treating time as value-destroying rather than a scheduling convenience (Aneke &

Adesemoye, 2025); and **constraint-aware**, treating regulatory prohibitions and labour capacity as hard limits rather than cost adjustments (Falemi et al., 2023b; Ominyi & Anichukwueze, 2024).

4.2 Construct One: Return-Flow Intelligence

Return-flow intelligence has three dimensions: **precision**, bounded by feature availability rather than algorithmic capability (Mayo et al., 2021; Oyesiji et al., 2024); **latency**, which enters the objective through the decay term; and **locus**, the network point where classification occurs. These trade off, since full precision requires equipment and trained labour justifiable only at consolidated volumes, implying high latency, while edge classification is coarser. This is the architecture question in edge intelligence (Nwakamma et al., 2025; Oyesiji et al., 2025) and decentralized control (Komi & Adamolekun, 2022), and the optimum depends on decay rate, value density, and yield spread. Intelligence is also anticipatory, since reason codes, purchase history, identifier, return frequency, and time since delivery predict condition before arrival (Basnet et al., 2021; Ogundairo & Ayivi-Donkor, 2023a; Sakyi, Nnabueze, et al., 2022), and the same features support abuse screening, which shares infrastructure with real-time transaction monitoring (Atakpa & Abetoh, 2022; Elebe et al., 2023; Fadayomi et al., 2024).

4.3 Construct Two: Temporal Value Decay

Decay mechanisms should be modeled separately because they respond to different interventions. **Technological obsolescence** is discontinuous and partly forecastable (Erhimefe & Gideon, 2025; Gideon, 2025a), addressed by forecasting and pre-commitment. **Seasonal expiry** is deterministic and steep at the boundary (Jones & Ominyi, 2021; Jones & Ominyi, 2022b), addressed by calendar-aware scheduling. **Physical deterioration** is continuous and controllable (Aneke & Adesemoye, 2025), addressed by handling and storage controls. **Market saturation** is stochastic and partly self-inflicted (Tonoyan et al., 2022a), addressed by volume pacing across channels.

4.4 Construct Three: Disposition-Channel Portfolio

The available dispositions form a portfolio with finite capacity, interaction effects, and relationship-dependent yields (Table 1).

Channel	Typical yield range	Processing intensity	Speed requirement	Cannibalization risk
Restock as new	85 to 100 percent of retail	Very low	High	None
Repackage and resell as open-box	60 to 85 percent	Low	High	Low
Refurbish and resell direct	45 to 70 percent	Medium	Medium	Moderate
Certified refurbished via marketplace	35 to 60 percent	Medium	Medium	Moderate
B2B bulk liquidation	8 to 25 percent	Very low	Low	Low
Parts harvesting	Variable, often 10 to 40 percent	High	Low	None

Channel	Typical range	yield	Processing intensity	Speed requirement	Cannibalization risk
Warranty and service stock	Displaced procurement cost		Medium	Low	None
Donation	Tax value plus reputational value		Very low	Low	Low
Material recycling	Commodity value, often negative net		Low	None	None
Destruction	Zero or negative, and legally restricted		Low	None	None

Table 1. Representative disposition-channel portfolio.

Channels are not independent: liquidation volume depresses secondary prices, refurbished pricing cannibalizes new sales (Sanni et al., 2020b), and certified programmes require minimum volume to sustain listing quality and buyer trust (Sakyi et al., 2023; Sakyi, Nnabueze, et al., 2024). Yield is partly endogenous, since liquidators offer better terms for predictable flows and partners invest when volume is committed, making these supplier governance problems (Akinleye & Adeyoyin, 2022b; Ike et al., 2021; Wedraogo et al., 2025) responsive to contract design (Akomolafe et al., 2024b; Okonkwo et al., 2024a) and information sharing (Akomolafe, Olaogun, et al., 2025; Shittu & Nabil, 2023) rather than market conditions.

4.5 Construct Four: Recovery Network Capability

The fourth construct is the infrastructure through which the others are executed: centralization, testing placement, reconditioning ownership, forward-reverse systems integration (Aliliele et al., 2023a; Okonkwo, Ahiaekwe Patrick, et al., 2023), partner contracts (Akin-Oluyomi et al., 2024), and workforce stability and skill (Akin-Oluyomi & Akhigbe, 2023a; Falemi et al., 2023b; Falemi et al., 2025). Capability accumulates unevenly across sites, making multi-site measurement (Akin-Oluyomi & Akhigbe, 2023a) and network governance (Akin-Oluyomi & Akhigbe, 2022) central, and it includes safety performance, since injury and absence cut effective labour capacity at the peaks when decay exposure is greatest (Obogo et al., 2025; Obriki et al., 2025; Obriki et al., 2022a). Automation raises throughput (Akanbi, Ganiu, et al., 2025; Akanbi & Sunday, 2024) without removing the workforce constraint, shifting the human role toward exception handling and raising skill requirements (Akhigbe et al., 2024; Essandoh et al., 2025).

4.6 Formal Representation

Let i index returned units, j index channels, and t denote elapsed time from return initiation to completed disposition. The **net recovery value** of assigning unit i to channel j at time t is:

$$\begin{aligned} \text{NRV}(i, j, t) = & y(j) \cdot V(i) \cdot D(i, t) \\ & - [c_{\text{diag}}(i) + c_{\text{recon}}(i, j) + c_{\text{trans}}(i, j) + c_{\text{hold}}(i) \cdot t] \\ & - \kappa(j) \cdot m(i) \cdot q(i, j) \\ & - \Phi(i, j) \\ & + \Omega(i, j, t) \end{aligned}$$

Here $y(j)$ is expected channel yield as a fraction of reference value; $V(i)$ is reference value; $D(i, t)$ is the decay factor, commonly $\exp(-\delta(i) \cdot t)$ or a step function; c_{diag} , c_{recon} , c_{trans} , and c_{hold} are diagnostic, reconditioning, transport, and holding costs; $\kappa(j)$ is the cannibalization coefficient; $m(i)$ the margin on a new unit; $q(i, j)$ market overlap with the primary market; $\Phi(i, j)$ the compliance and environmental penalty, set prohibitively high where the disposition is legally barred; and $\Omega(i, j, t)$ the option value of deferral. The operational problem is:

$$\text{maximize } \sum_i \sum_j \sum_t x(i, j, t) \cdot NRV(i, j, t)$$

subject to

$$\begin{aligned} \sum_j \sum_t x(i, j, t) &= 1 && \text{for all } i && \text{(one disposition per unit)} \\ \sum_i x(i, j, t) &\leq \text{Cap}(j, t) && \text{for all } j, t && \text{(channel/processing capacity)} \\ \sum_i x(i, j, t) &\leq \text{Lab}(t) && \text{for all } t && \text{(labour capacity)} \\ \sum_i \sum_t x(i, j, t) &\leq \text{Vol_max}(j) && \text{for all } j && \text{(brand/absorption limits)} \\ \sum_i \sum_t x(i, j, t) &\geq \text{Vol_min}(j) && \text{for all } j \text{ in } J_f && \text{(fixed-cost channel floors)} \\ x(i, j, t) &= 0 && \text{for all } (i, j) \text{ in } P && \text{(prohibitions)} \\ x(i, j, t) &\in \{0, 1\} \end{aligned}$$

The labour constraint is explicit because throughput is set by staffing rather than equipment, seasonal staffing volatility is well documented (Falemi et al., 2023b; Okafor et al., 2025), and effective capacity is further reduced by injury and absence (Obogo et al., 2021; Obogo et al., 2024). Where abuse is material, reference value should be net of expected fraud loss, estimated from transaction scoring evidence (Atakpa & Fobellah, 2023; Fadayomi et al., 2024) rather than assumed away.

4.7 The Diagnostic Breakeven

Higher precision raises $y(j)$ but increases c_{diag} and, where it requires centralization, increases t and reduces $D(i, t)$. Additional diagnostic investment is justified when:

$$\begin{aligned} \Delta[y(j) \cdot V(i)] \cdot D(i, t + \Delta t) &> \Delta c_{diag} \\ &+ V(i) \cdot y(j) \cdot [D(i, t) - D(i, t + \Delta t)] \\ &+ c_{hold}(i) \cdot \Delta t \end{aligned}$$

High-value, slow-decaying items satisfy this easily; low-value, fast-decaying items rarely do, which is why the correct policy for a low-priced garment at a season change is often to bypass inspection and route to a pre-contracted channel. This is the marginal reasoning governing inspection intensity in quality systems (Aneke et al., 2022a) and audit sampling (Akomolafe & Agu, 2018; Akomolafe et al., 2023a), and its neglect is a major source of avoidable cost.

5. Propositions

P1 (Diagnostic Value Density). The net benefit of diagnostic precision increases with unit value density and decreases with decay rate, so intensity should be differentiated by segment rather than applied uniformly (Akomolafe & Agu, 2019a; Akomolafe et al., 2023a; Akomolafe, Agu, et al., 2025).

P2 (Temporal Primacy). Above a threshold decay rate, time to disposition explains more variance in recovery value than channel selection accuracy, so a fast-approximate decision beats a slow precise one (Okonkwo et al., 2020; Sunday et al., 2020).

P3 (Decentralization Condition). Decentralized disposition dominates when decay is fast, diagnostic cost low, and yield spread across adjacent grades narrow; centralization dominates under the reverse conditions (Komi & Adamolekun, 2022; Nwakamma et al., 2025).

P4 (Portfolio Breadth). Channel breadth relates to recovery value in an inverted-U, as matching benefits are eventually outweighed by coordination cost, volume minimums, and inter-channel cannibalization (Akin-Oluyomi & Akhigbe, 2022; Akin-Oluyomi & Akhigbe, 2023a; Wedraogo et al., 2025).

P5 (Cannibalization Asymmetry). The optimal share routed to refurbished resale decreases with brand equity and with overlap between refurbished and new segments, favouring separated secondary markets for strong brands (Sanni et al., 2020b).

P6 (Regulatory Reconfiguration). Where destruction is prohibited or disclosed, the optimal mix shifts toward reconditioning, donation, and structured secondary channels, and the shadow price of processing capacity rises network-wide rather than an option merely being removed (Eze et al., 2023; Ominyi & Anichukwueze, 2022a; Ominyi et al., 2025b).

P7 (Gatekeeping Complementarity). Return avoidance and recovery capability are complements, since avoidance disproportionately removes low-value returns, raising residual stream quality and the return on recovery investment (Akin-Oluyomi & Akhigbe, 2023c; Akin-Oluyomi, Atima, Akinleye, & Okoruwa, 2023; Yeboah et al., 2025).

P8 (Information Integration). Firms integrating recovery decisions with forward inventory, pricing, and merchandising achieve higher mean and lower variance in yield, because restock decisions can account for current demand and markdown state (Nnabueze et al., 2021; Okonkwo, Mayo, et al., 2023; Okoruwa et al., 2024).

P9 (Traceability Dividend). Returns to unit-level traceability exceed its compliance justification, since disclosure records also enable yield attribution, model recalibration, and supplier performance measurement (Aliliele et al., 2025a; Aneke et al., 2023; Opara et al., 2025).

P10 (Workforce Boundedness). Realized recovery value is bounded by frontline stability, skill, and availability, and the gap between modeled and realized performance widens with staffing volatility (Falemi et al., 2023a; Falemi et al., 2023b; Falemi et al., 2025).

P11 (Automation Substitution Limit). Automating handling raises throughput without relaxing the diagnostic constraint, since the binding limitation in triage is condition assessment rather than movement, shifting the optimum toward higher volume at unchanged precision (Akanbi & Sunday, 2024; Akanbi & Sunday, 2025; Akinlade et al., 2024).

P12 (Learning Loop). Recovery value rises where disposition outcomes feed back into design, supplier quality, and merchandising, and this dynamic capability rather than any static configuration is the durable advantage (Adelanwa et al., 2024; Aneke et al., 2022a; Tonoyan et al., 2024b).

6. Decision Architecture and Operational Protocol

6.1 Three Decision Tiers

Decisions distribute across three horizons, following the separation of policy setting from execution in governance research (Akhigbe et al., 2025; Amayo et al., 2023a; Amayo et al., 2024b).

Tier	Horizon	Representative decisions	Primary information inputs
Strategic	Annual to multi-year	Network footprint and centralization; make or buy for reconditioning; channel portfolio composition; design for recoverability; return policy architecture; systems investment	Category decay profiles; regulatory trajectory; capability assessment; capital constraints
Tactical	Monthly to quarterly	Capacity allocation across lines and channels; grading calibration; channel pricing bands and volume targets; partner contract terms; seasonal surge staffing	Forecast return volumes; secondary market price trends; workforce availability; channel performance history
Operational	Daily to real-time	Unit routing; batch release sequencing; real-time channel switching; expedite decisions; abuse exceptions	Unit-level condition and abuse scores; live channel capacity; current forward inventory; queue state

Table 2. Three-tier decision architecture for recovery-value optimization.

The tiers are coupled: strategic choices set the feasible region for tactical decisions, which parameterize operational routing. A common failure is solving at the operational tier a problem created at the strategic tier, such as expecting real-time routing to compensate for a network with no forward-positioned testing (Akhigbe et al., 2025; Amayo et al., 2023a; Amayo et al., 2024b), a misalignment also documented in infrastructure programme governance and incentive-aligned contracting (Amayo et al., 2024a; Amayo et al., 2024c; Amayo et al., 2025c).

6.2 The Five-Stage Protocol

Stage 1: Pre-Receipt Classification. Reason codes, purchase history, identifier, return frequency, and time since delivery predict condition with useful accuracy (Akin-Oluyomi, Atima, Akinleye, & Okoruwa, 2023; Mayo et al., 2021; Ogundairo & Ayivi-Donkor, 2023a). A predicted distribution generated at authorization pre-assigns provisional routing that may divert the unit from the default processing centre entirely. Abuse scoring belongs here for the same reason, since screening after refund settlement recovers far less than screening before it (Fadayomi et al., 2024; Okafor et al., 2024).

Stage 2: Rapid Triage at First Touch. A time-boxed triage, with the budget set as a function of unit value, confirms or overrides the provisional class, resolving each unit into confirmed, requiring diagnosis, or exception. Standardizing this is a process design task before an analytical one (Eyetsesmitan et al., 2025; Eyetsesmitan et al., 2022; Oyeleye et al., 2022).

Stage 3: Selective Deep Diagnosis. Only flagged units proceed to testing, deliberately a minority path: if a test would not change the disposition, it should not be run (Aneke & Adesemoye, 2020; Aneke et al., 2022a).

Stage 4: Portfolio Assignment. Units are assigned as a batch against current channel capacity, pricing, forward inventory, and volume commitments. This step is most commonly omitted, with grade-to-channel mapping treated as a fixed lookup, yet dynamic assignment against live signals is where much of the improvement resides (Nnabueze et al., 2021; Okonkwo, Ahiaekwe Patrick, et al., 2023; Okoruwa et al., 2024).

Stage 5: Execution and Feedback. Routing, preparation, and settlement, with realized value attributed back to prediction to generate the recalibration signal (Nwakamma et al., 2024a; Oyesiji et al., 2024). Failure patterns route to design, supplier quality, and merchandising, and disposition records should satisfy disclosure as a by-product rather than through a parallel process (Aneke et al., 2023; Ominyi, Anichukwueze, & Uzougbo, 2024a).

6.3 Implementable Decision Rules

Rule 1 (Speed threshold). Expedite when weekly decay rate multiplied by unit value exceeds the marginal cost of expedited processing. Rule 2 (Diagnostic gate). Inspect only when expected yield improvement exceeds inspection cost plus decay and holding cost of delay, per Section 4.7. Rule 3 (Restock priority). Route to forward restock whenever the item is sellable and inventory is below reorder point, which requires live visibility (Nnabueze et al., 2021; Okonkwo, Mayo, et al., 2023). Rule 4 (Cannibalization ceiling). Cap refurbished volume where marginal cannibalized margin equals marginal recovery value. Rule 5 (Liquidation floor). Never liquidate a unit whose expected value in a slower higher-yield channel, net of holding and decay, exceeds the liquidation offer. Rule 6 (Compliance precedence). Remove prohibited dispositions from the feasible set at Stage 1 rather than discovering the constraint at Stage 5 (Olaogun et al., 2023; Ominyi & Anichukwueze, 2024).

7. Illustrative Application

Consider a stylized consumer electronics retailer: one billion dollars in sales, a sixteen percent return rate, 400,000 units returned annually at an average retail value of USD 400, two percent weekly decay, holding cost of USD 0.90 per unit per week, and a five-week time to disposition. Parameterization is illustrative (Filani et al., 2023; Oduleye & Medon, 2023a; Tonoyan et al., 2022c).

Channel	Baseline share	Baseline units	Net value per unit	Post-intervention share	Post-intervention units
Restock as new	18%	72,000	USD 356	24%	96,000
Open-box resale	14%	56,000	USD 264	19%	76,000
Refurbish and resell	21%	84,000	USD 162	24%	96,000
Bulk liquidation	34%	136,000	USD 50	22%	88,000

Channel	Baseline share	Baseline units	Net value per unit	Post-intervention share	Post-intervention units
Parts harvest	6%	24,000	USD 47	6%	24,000
Recycle and dispose	7%	28,000	USD –5	5%	20,000

Table 3. Disposition mix before and after intervention.

At baseline the weighted net value is approximately USD 137.4 per unit before decay; applying $\exp(-0.02 \times 5)$, or 0.905, and five weeks of holding cost gives approximately USD 119.9, so annual recovery is approximately **USD 47.9 million** and Recovery Value Yield **29.9 percent**. Three interventions are then applied: pre-receipt classification and edge triage, cutting time to disposition to 2.2 weeks; selective diagnosis, shifting volume out of liquidation; and dynamic assignment evaluating restock against live inventory first. The revised mix yields approximately USD 173.8 before decay; the 2.2-week factor of 0.957 gives USD 166.3, and after holding cost of USD 1.98 and incremental capability cost of USD 9.00, approximately USD 155.4 per unit, or **USD 62.2 million** annually at a yield of **38.9 percent**.

Source of improvement	USD millions	Share
Improved channel mix through better matching	11.4	62%
Reduced decay exposure through faster cycle	3.6	20%
Reduced holding cost	1.0	5%
Less: incremental diagnostic and system cost	(3.6)	(20%)
Restock substitution through avoided procurement	2.0	11%
Net improvement	14.3	100%

Table 4. Decomposition of the recovery value improvement.

Weekly decay rate	Unit value USD 100	Unit value USD 400	Unit value USD 1,200
0.5 percent	Marginal	Positive	Strongly positive
2.0 percent	Breakeven	Strongly positive	Strongly positive
4.0 percent	Negative on diagnosis, positive on speed	Strongly positive	Strongly positive

Table 5. Sensitivity of intervention value to decay rate and unit value.

Most of the gain comes from channel matching rather than speed, but speed is the enabler, since the improved mix is achievable only because units reach assignment while higher-yield channels remain viable. Payback depends on value density: the same investment on low-priced apparel would not be recovered, a threshold effect consistent with the value-dependence of analytics returns (Akinleye et al., 2023; Aliliele, Eboh, et al., 2024; Oduleye & Medon, 2021). The pattern supports P1 and P2.

8. Measurement System

The indicator system follows KPI design for large organizations (Sakyi, Filani, et al., 2022; Seyi-Lande et al., 2022), real-time performance monitoring (Edivri & Oteri, 2022; Tonoyan et al., 2024b; Walawalkar, Adesuyi, et al., 2025), outcome measurement in complex service delivery (Adelanwa et al., 2024; Akin-Oluyomi & Akhigbe, 2023a), and leading-indicator practice in operational safety (Obriki & Arumosoye, 2024b; Obriki et al., 2025).

Category	Metric	Definition
Outcome	Recovery Value Yield	Net value recovered divided by original retail value of the return stream
Outcome	Recovery Value Variance	Standard deviation of yield across periods or product families
Outcome	Value Leakage	Gap between realized value and value under perfect-information assignment
Process	Time to Disposition	Elapsed days from authorization to completed disposition, weighted by decay rate
Process	First-Touch Resolution Rate	Share routed to final disposition at the first physical touchpoint
Process	Disposition Accuracy Rate	Share whose realized channel matched the ex-post optimal channel
Process	Diagnostic Conversion Rate	Share of deep diagnoses that changed the decision; low values signal over-inspection
Process	Decay Exposure Days	Unit value multiplied by decay rate multiplied by days held, summed
Capability	Restock Capture Rate	Share of sellable-condition returns returned to forward inventory
Capability	Cannibalization Ratio	Estimated displaced full-price sales per refurbished unit sold
Capability	Processing Labour Stability	Turnover and absence rates at recovery processing sites
Capability	Recordable Incident Rate	Injury and absence rates at processing sites, as a capacity indicator
Compliance	Traceability Completeness	Share of dispositioned units with records adequate for disclosure
Compliance	Prohibited-Disposition Incidents	Count of units routed to a legally restricted disposition
Integrity	Abuse Detection Rate	Share of fraudulent or abusive returns identified before refund settlement

Category	Metric	Definition
Integrity	False Positive Burden	Legitimate returns delayed or refused per abuse case correctly identified

Table 6. Measurement system for recovery-value optimization.

Two pathologies recur. Optimizing cost per unit processed drives batching and deferral, destroying value in decaying streams. Optimizing gross recovery revenue without netting processing cost drives over-investment in reconditioning for units that should have been liquidated. A net yield measure avoids both, but only if the cost base includes decay and holding costs rather than direct processing cost alone, a failure paralleled in industrial variance analytics (Aliliele, Eboh, et al., 2024) and service revenue assurance (Sakyi et al., 2023).

9. Discussion

9.1 Three Convergent Findings

Time is a cost with a determinate price, and operations that do not price it underperform. This appears as the marginal value of time in closed-loop research, dwell time penalty in terminal logistics (Okonkwo et al., 2020), downtime dominance in maintenance (Sunday et al., 2020), and excursion exposure in distribution practice (Aneke & Adesemoye, 2025). Recurrence across settings with different physical mechanisms suggests a property of decision systems handling degrading assets rather than of any industry. Visibility is a precondition rather than an enhancement. Transparency research treats it as the enabler of compliance and coordination (Nnabueze et al., 2021), asset lifecycle research as the determinant of materials readiness (Okonkwo, Mayo, et al., 2023), and traceability research as the basis of chain-of-custody integrity (Opara et al., 2025). Firms without live forward inventory visibility therefore cannot execute the restock priority rule, their highest-yield available decision.

Capability, not analytics, is usually the binding constraint. Staffing volatility determines outcomes (Falemi et al., 2023b), employee readiness limits deployment (Akhigbe et al., 2024), and adoption failure is the dominant mode of redesign failure (Eyetsemitan et al., 2023a). This motivates P10 and implies that for many firms the return on analytical investment is lower than that on stabilizing the frontline, including the safety performance determining whether it is available at peak (Arumosoye & Obriki, 2021; Obriki, Arumosoye, et al., 2023; Obriki, Obogo, et al., 2023).

9.2 Relation to Existing Models

The framework makes three contributions. It treats the four recovery decisions as simultaneous, and the breakeven in Section 4.7 shows why they cannot be separated: the value of information depends on the time its acquisition consumes, which depends on where it is acquired. It internalizes regulatory constraint, since where destruction is prohibited the bound it placed on all other options disappears and the shadow price of reconditioning capacity rises network-wide, a structural change rather than a parameter adjustment (Eze et al., 2023; Ominyi & Anichukwueze, 2022a). And it introduces workforce capacity as a formal constraint in a literature that has abstracted from it, binding hardest at seasonal peaks when decay exposure is greatest.

9. 3 Unresolved Tensions and Boundary Conditions

Three tensions are reported rather than resolved. Precision and speed both matter and the streams disagree on which dominates, a disagreement that is probably real since the answer depends on value density and decay rate; the framework accommodates it through the breakeven condition rather than asserting an ordering. Centralization is favoured by automation and scale economics (Akanbi & Sunday, 2024) and disfavoured by decay economics and edge inference logic (Komi & Adamolekun, 2022; Nwakamma et al., 2025), and while P3 states the conditions, their thresholds are unknown and constitute a first-order empirical question. Environmental and economic objectives are treated as reconcilable through better measurement (Akin-Oluyomi, Atima, & Akinleye, 2023; Ike et al., 2024a) but genuinely conflict where recovered material carries contamination risk (Okojie & Abioye, 2020); the compliance penalty term represents the conflict without adjudicating it. The framework applies most strongly where residual value is meaningful, condition is heterogeneous, channels differ materially in yield, and decay makes timing consequential, as in consumer electronics, apparel, footwear, small appliances, and sporting goods. It applies weakly where units are uniformly low in value and homogeneous in condition, where one channel exists, or where hygiene or regulatory requirements mandate a single outcome, since the optimization then degenerates.

10. Implications for Practice

Segment before designing the process. The most consequential error is a uniform process for a heterogeneous stream. Segment by value density and decay rate: deep diagnosis and centralized reconditioning for high value and slow decay; expedited handling with forward-positioned testing for high value and fast decay; batched consolidation for low value and slow decay; pre-committed routing without inspection for low value and fast decay. Segmentation is standard in customer analytics (Basnet et al., 2021; Ogundairo & Ayivi-Donkor, 2023a) and supplier portfolio management (Akinleye & Adeyoyin, 2022b; Wedraogo et al., 2025) but rare in returns.

Screen for abuse before settlement, not after. Return fraud is a real-time scoring problem sharing features and infrastructure with condition prediction, and screening after refund recovers little (Atakpa & Abetoh, 2022; Elebe et al., 2023; Fadayomi et al., 2024). Calibrate the threshold against the cost of suppressing legitimate returns and their repurchase behaviour, not against detection rate alone (Fobellah, 2025a; Fobellah, 2025c; Ogundairo & Ayivi-Donkor, 2023b).

Price time explicitly. Assign a per-day cost of delay to each product family and expose it in operational dashboards (Tonoyan et al., 2024b; Walawalkar, Adesuyi, et al., 2025), since decisions made without a visible cost of delay favour batching, and push the decision upstream, since every node a return passes adds transport, handling, and decay.

Cultivate the channel portfolio. Certified refurbished programmes need consistent volume and quality to sustain buyer trust and price realization, and liquidators offer better terms for predictable flows, so channel relationships are capacity assets developed through supplier governance (Akinleye & Adeyoyin, 2022b; Ike et al., 2021; Okonkwo et al., 2024a) rather than spot markets (Aneke et al., 2022a; Gideon, 2025a).

Make compliance a by-product. Where disclosure requires accounting by category for what was discarded and why, generate the data automatically at Stage 5, since parallel compliance reporting processes are expensive and unreliable (Aneke et al., 2023; Medon & Oduleye, 2022; Ominyi, Anichukwueze, & Uzougbo, 2024a).

Stabilize the workforce before investing in algorithms. Where turnover is high and seasonal staffing heavy, analytical investment yields less than staffing investment (Falemi et al., 2023a; Falemi et al., 2023b; Falemi et al., 2025; Okafor et al., 2025), an ordering counterintuitive to firms treating analytics as the default lever. And close the loop to design, since the highest long-run return is fewer returns and more recoverable products, with avoidance and recovery complements rather than competing investments.

11. Limitations and Boundary Conditions

The framework is conceptual and unvalidated; the propositions are theoretically motivated and consistent with adjacent findings but untested in integrated form. Much supporting evidence is drawn by structural analogy from procurement, maintenance, analytics, safety, fraud, and regulatory domains rather than from returns operations, and the strength of each analogy varies, so cited findings establish mechanism plausibility rather than direct evidence about returned-product supply chains. The illustrative application is stylized and demonstrates framework logic rather than estimating achievable improvement. Decay is treated as exogenous and exponential, whereas in practice it is partly endogenous, since a firm's own liquidation volumes affect secondary prices, and frequently discontinuous. Cannibalization is a reduced-form coefficient, whereas a full treatment requires demand system estimation. The regulatory analysis focuses on the European Union, and global firms face a heterogeneous constraint set the framework accommodates without detailing. Finally, where return policy serves acquisition or retention, the value of a frictionless experience may exceed the recovery value forgone (Sakyi, Nnabueze, et al., 2022; Sanni & Wedraogo, 2024), a constraint a fuller treatment should model directly.

12. Future Research Directions

Empirical validation. Panel analysis of time to disposition against realized recovery value would test P2 and estimate category-specific decay rates, with endogeneity addressed through instruments exploiting exogenous capacity shocks or facility backlogs. Quasi-experimental evaluation of decentralized triage using staggered rollouts of edge classification would test P3 through multi-site comparison designs (Akin-Oluyomi & Akhigbe, 2022; Akin-Oluyomi & Akhigbe, 2023a), survey measurement of portfolio breadth against yield would test the inverted-U in P4, and event studies using the destruction ban and Right to Repair transposition dates as regulatory shocks would test P6 (Ominyi & Anichukwueze, 2022b; Ominyi, Anichukwueze, & Uzougbo, 2024b). Modeling and simulation. Stochastic optimization under uncertain condition, prices, and capacity would compare myopic routing against batch portfolio assignment, and the online quotation formulations developed for forward lead times (Ekun & Muriel, 2024) offer a tractable starting point for committing to a disposition before condition is resolved. Discrete event simulation of the five-stage protocol under surge conditions would identify buffer requirements and test P10 under labour constraint (Tonoyan et al., 2022b), real options valuation would formalize the deferral term (Lawal & Oduleye, 2021a; Walawalkar, Kalu, et al., 2025), and multi-agent modeling would endogenize liquidation yield as a function of aggregate industry volume (Akanbi, Ganiu, et al., 2025). Design science, fraud, and safety. Decision support artifacts evaluated in live operations would establish feasibility (Ladapo, Dosunmu, et al., 2023; Okonkwo, Ahiaekwe Patrick, et al., 2023), and studies of the P12 learning loop would examine when disposition data actually influences design (Akhigbe et al., 2024; Eyetsemitan et al., 2023a). Joint modeling of condition prediction and abuse scoring would test whether shared features improve both, and field measurement of the trade-off between screening stringency and suppressed

legitimate returns remains absent (Elebe et al., 2023; Fobellah, 2025c). Panel analysis linking processing-site safety performance to effective throughput would test the capacity mechanism in Section 4.6 (Arumosoye & Obriki, 2023; Obriki et al., 2025). Extensions. Multi-echelon settings where disposition is contested between retailer and manufacturer; competitive settings where one firm's refurbished goods meet another's new goods; cross-border settings where jurisdiction and customs treatment shape feasibility (Jones & Ominyi, 2020; Jones & Ominyi, 2024a; Jones & Ominyi, 2024b); outsourced settings where third-party incentives diverge from brand protection (Akin-Oluyomi et al., 2024; Akomolafe et al., 2024b); and humanitarian flows where the objective is access rather than value (Anene & Clement, 2022; Anene & Clement, 2024).

13. Conclusion

Returned products are depreciating assets awaiting a decision, and the speed and quality of that decision determines whether they contribute value or consume it. With annual volumes approaching 850 to 890 billion dollars in the United States alone (National Retail Federation & Happy Returns, 2024, 2025) and destruction about to be legally foreclosed for growing categories of goods in the European Union, treating returns as a value optimization problem rather than a logistics cost problem is difficult to resist. Recovery-Value Optimization integrates return-flow intelligence, temporal value decay, disposition-channel portfolio, and recovery network capability through an explicit net recovery value function, translated into a three-tier architecture and five-stage protocol, with twelve propositions specifying when particular configurations dominate. Its central claim is simple: the value recoverable depends on how quickly and how accurately the firm decides what to do with the unit, and these objectives trade off according to value density and decay rate. The framework awaits testing; Section 12 offers a path and Section 8 the instruments.

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