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Evaluating the Impact of Deposit Return Schemes on Producer Risk in the UK Soft Drinks Industry

School of Management
Logistics and Supply Chain Management

MSc
Academic Year: 2025 - 2026

Supervisor: Dr Ajay Deshmukh
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This thesis is submitted in partial fulfilment of the requirements for the degree of Master of Science
(NB. Remove if the degree award is based solely on examination of the thesis)

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I declare that:

- the thesis submitted has been written by me alone.
- the thesis submitted has not been previously submitted to this university or any other.
- that all content, including primary and/or secondary data, is true to the best of my knowledge.
- that all quotations and references have been duly acknowledged according to the requirements of academic research.

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Abstract

This thesis examines how Deposit Return Scheme (DRS) architecture shapes the financial exposure of soft drinks producers. A UK-wide DRS is planned to launch in 2027 to improve recycling rates for beverage containers. However, uncertainty remains regarding scheme operation, financial settlement and interaction between devolved administrations. Divergence across the UK home nations, alongside concurrent packaging waste regulation, creates structural complexity for producers operating across jurisdictions. Although the literature typically frames DRS as a cost transfer mechanism, this study argues that exposure is structurally generated through governance design, allocation rules and settlement sequencing rather than arising as a fixed compliance cost.

The research adopts a systematic informed literature review. Core themes were reconstructed as exposure transmission mechanisms and analysed across governance structure, allocation geometry and liquidity timing to explain how obligations are embedded and amplified across settlement cycles.

Findings demonstrate that UK-style DRS design creates endogenous exposure pathways through advance deposit financing, reconciliation uncertainty and inter-jurisdictional divergence. Exposure accumulates across cycles rather than dissipating as the system matures. The analysis identifies an efficiency-exposure paradox in which higher recycling performance increases financial impact. Policy layering and incomplete harmonisation further shape exposure scale and persistence.

The thesis contributes a governance-centred analytical framework that shifts debate from distributive cost transfer to architectural exposure generation. It provides managerial and policy recommendations to reduce amplification while preserving environmental objectives.

Keywords:

Regulatory Governance; Policy Divergence; Extended Producer Responsibility (EPR); Liquidity Risk; Financial Exposure; Regulatory Architecture

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List of Abbreviations

CE	Circular Economy
DEFRA	Department for Environment, Food & Rural Affairs
DMO	Deposit Management Organisation
DRS	Deposit Return Scheme or Schemes
EPR	Extended Producer Responsibility
IMA	Internal Market Act
NGO	Non-Governmental Organisation
pEPR	Packaging Extended Producer Responsibility
PET	Polyethylene Terephthalate
rPET	Recycled Polyethylene Terephthalate
PRN	Packaging Recovery Note

1 Introduction

1.1 Background

Deposit return schemes (DRS) are established regulatory instruments designed to increase the collection of used beverage containers for recycling into high-quality, food-grade materials for reuse in new beverage packaging. This supports circular economy objectives centred on retaining material value within closed loops (Geissdoerfer et al., 2017).

DRS operate across more than 50 jurisdictions globally, as of January 2025 and more than 70 schemes are expected by 2027 (Reloop Platform, 2024).

UK and international policy documents position DRS as mechanisms to improve return rates, enhance material purity and strengthen recycling performance (Department for Environment, Food & Rural Affairs, 2021, [DEFRA]; Scottish Government, 2019). The UK government and devolved administrations have committed to implementing DRS from October 2027 (Deposit Scheme for Drinks Containers (England and Northern Ireland) Regulations, 2025), alongside reforms to extended producer responsibility and recycled content obligations (DEFRA, 2024a).

The implementation of DRS forms part of a broader restructuring of the UK packaging regime, including reformed Packaging Extended Producer Responsibility (pEPR) (DEFRA, 2024a). Collectively, these reforms reshape how the beverage sector finances and manages end-of-life packaging. The restructuring and DRS implementation occurs within a devolved and partially differentiated regulatory landscape, where interoperability, sequencing and policy alignment vary across administrations.

Within this converging regime, exposure is not evenly distributed across beverage sectors. Deposit return obligations are based on the number of containers placed on the market. Government estimates indicate that approximately 31 billion single-use drinks containers are sold annually in the UK, comprising 12 billion plastic bottles and 14 billion cans (DEFRA, 2024b). The exclusion of glass from the England, Scotland and Northern Ireland

schemes concentrates deposit liability within PET and metal streams, thereby generating higher relative operational exposure for producers whose portfolios are structurally dominated by these formats. This configuration is characteristic of the soft drinks sector (Wilcox & Mackenzie, 2021).

For soft drinks producers, whose packaging mix is structurally weighted toward PET bottles and cans, multiple regulatory instruments now operate concurrently on this material base. The Plastic Packaging Tax requires a minimum 30% recycled content in plastic packaging (Finance Act 2021, Part 2). Reformed EPR, will link cost allocation to packaging recyclability in 2026 (Department for Environment, Food & Rural Affairs et al., 2023). DRS will then introduce per-unit deposit pre-financing, reporting and reconciliation obligations from October 2027. As these instruments converge on the same materials streams, compliance requirements are concentrated in a single operational domain. This concentration differentiates the regulatory environment faced by soft drinks producers from sectors with greater reliance on glass packaging.

1.2 Problem Statement

UK packaging policy is undergoing rapid and concurrent restructuring through the introduction of reformed EPR, the planned implementation of a UK-wide DRS, and wider circular economy objectives, creating material uncertainty for affected producers.

Producers are required to make decisions in the absence of regulatory clarity regarding packaging formats, material choices, logistics systems, and investment commitments under conditions of evolving scheme design, devolved governance variation, and incomplete information regarding future cost exposure and operational requirements.

There is limited integrated analysis of how these intersecting regulatory instruments collectively shape producer cost exposure, operational configuration, and supply-chain decision-making. As a result, producers lack a clear evidence-based understanding of the trade-offs, constraints, and risks associated with compliance under a converging policy regime.

This study adopts a systematic analytical synthesis design, operationalised through a structured systematic literature review, to consolidate and analyse existing evidence on deposit-return systems and extended producer responsibility. The approach is used to examine how policy design, system architecture, and governance arrangements shape producer-level cost exposure and operational decision-making.

Together, these considerations establish the rationale for the study and necessitate the objectives that follow.

1.3 Research Aims and Objectives

This study aims to synthesise existing academic literature to examine how Deposit Return Schemes (DRS) reshape the operational configuration and cost exposure for UK soft drinks producers. It further assesses the implications for supply chain performance, regulatory compliance, and organisational resilience.

The following objectives have been established:

Objective 1 - Identify and categorise the key supply-chain and compliance cost components arising from DRS implementation.

Objective 2 - Analyse how DRS affects core internal supply-chain functions and the operational adaptations required to sustain efficiency and regulatory compliance.

Objective 3 - Analyse UK and international DRS implementations, including documented lessons from the collapsed Scottish scheme, to identify externally generated operational, compliance and financial risks relevant to soft drinks producers.

In this study, supply-chain resilience refers to the ability of the system to absorb, adapt to, and recover from operational and compliance-related disruption introduced by DRS implementation.

1.4 Research Question

The study is guided by the following research question:

Overarching Research Question

How do Deposit Return Schemes reshape the operational configuration and cost exposure of UK soft-drinks producers, and what roles does UK policy divergence play in shaping these impacts?

Three research questions are identified:

Research Question 1: What new supply-chain and compliance cost categories arise from DRS implementation, and how do they alter producers' financial exposure?

Research Question 2: How does DRS implementation affect internal core supply-chain functions and what operational adaptations are required to sustain efficiency and regulatory compliance?

Research Question 3: How do externally generated variations in DRS design and implementation across the UK create operational, compliance and financial risks, and what are the implications for supply-chain resilience?

Together, these questions decompose the overarching research problem into separable analytical dimensions, enabling structured examination of financial, operational and governance-related impacts.

1.5 Scope of the Research

Although DRS covers the full beverage category, this study focuses on the operational and cost implications for soft drinks producers, who rely heavily on food-grade PET for bottle-to-bottle recycling and face stringent recycled-content and EPR obligations. Alcohol is included within DRS, but relies more heavily on glass and aluminium, and is therefore referenced only where relevant to interpreting wider sector impacts.

Geographically, the research examines the United Kingdom, drawing selectively on EU, Nordic and global schemes to situate the UK's evolving approach within established DRS practice.

The thematic scope emphasises CE policy instruments (EPR and DRS), producer responsibility, and producer-side operational adjustments. Consumer behaviour, downstream reprocessing technologies, and broader CSR themes fall outside scope.

Methodologically, the study draws on secondary academic, policy, Non-Governmental Organisations and industry literature.

These boundaries ensure analytical feasibility and methodological coherence, given the study's secondary evidence design. Defining the scope in this way provides a clear foundation for the analytical lens and methodological choices that follow.

1.6 Structure of the Thesis

To provide a clear overview of how the study progresses from contextual framing to analytical synthesis and contribution, the structure of the thesis is summarised below and visually in Figure 1.1.

Chapter 1 – Introduction:

Sets out the policy and industry context, defines the research problem, and outlines the study's aim, objectives, and scope.

Chapter 2 – Systematic Literature Review:

Systematically synthesises academic, policy, and industry literature on DRS and EPR to examine how producer-level operational and cost implications are treated across the literature, and where evidence remains fragmented or incomplete.

Chapter 3 – Descriptive Analysis:

Maps the DRS literature across jurisdictions and methods, identifies fragmentation in producer-level evidence, and defines the analytical gap addressed in Chapter 4.

Chapter 4 – Thematic Analysis:

Presents and interprets the thematic findings, integrating fragmented evidence into a transmission architecture showing how governance, allocation and settlement design generate producer-level exposure.

Chapter 5 – Discussion:

Interprets the findings against existing scholarship and the UK DRS policy framework, evaluates implications for producer exposure and governance design, and advances policy and managerial recommendations.

Chapter 6 – Conclusion:

Synthesises the study's key contributions, notes its limitations, and identifies avenues for future research.

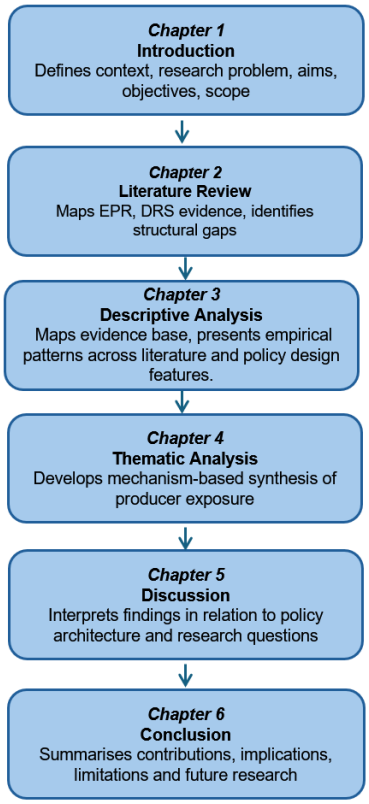

Figure 1.1 Structure of Thesis

Figure 1.1 highlights the staged progression of the thesis, showing how the systematic literature review and descriptive analysis establish the analytical

foundation for the thematic synthesis and discussion of producer exposure that follow.

1.7 Overview of the Thesis

This thesis examines how UK DRS architecture reshapes producer-level operational configuration and financial exposure within a devolved and partially harmonised regulatory environment. It situates DRS within the broader circular economy and Extended Producer Responsibility landscape, identifying an analytical gap in the literature regarding how governance, allocation, and settlement design translate into cumulative and potentially volatile producer liability.

Through a structured synthesis of secondary evidence and conceptual integration, the study reconstructs the transmission mechanisms through which scheme obligations convert into operational adjustment and financial exposure over successive settlement cycles. The impact of the mechanisms on producers is interpreted in terms of governance design, cost allocation impacts, regulatory developments and divergent regulatory approaches across the UK. Both managerial and policy recommendations are outlined to support producer identification and containment of exposure effects.

The final chapter consolidates the theoretical contribution, clarifies managerial and policy implications, and acknowledges the limitations of the analysis.

2 Literature Review

2.1 Introduction

Existing research addresses producer cost exposure under DRS primarily at a system or policy level, leaving firm-level operational and financial implications weakly integrated despite the uncertainty established in Chapter 1. This limits understanding of key dimensions of producer exposure.

This gap motivates a systematic review to clarify what is established, where evidence fragments, and which aspects of producer exposure and decision-making remain insufficiently theorised.

Given the cross-disciplinary and predominantly system-level orientation of the field, this chapter undertakes a structured synthesis to consolidate heterogeneous evidence and enable analytical integration rather than reliance on isolated or descriptive findings (Petticrew & Roberts, 2006; Tranfield et al., 2003).

2.2 Systematic Review Design and Protocol

2.2.1 Review Design and Approach

The study adopts a systematic, informed literature review method as its primary research design, aligned with its explanatory aims and the need for a transparent and auditable approach to literature selection and synthesis (Saunders et al., 2023)

The review followed a pre-planned search and screening process to identify relevant literature. Retained studies were assessed against predefined review questions to establish relevance, analytical positioning, and producer-level focus. Studies identified as analytically central were subjected to more detailed full-text interrogation to support in-depth synthesis.

To ensure transparency in identification and screening, this review adopts PRISMA-aligned reporting principles (Moher et al., 2009). Compliance is evidenced through a documented search strategy and a four-phase flow

diagram (Figure 2.1), tracking identification and screening (Saunders et al., 2023, p. 112). PRISMA checklist compliance was not adopted, as the review synthesises conceptual, operational, and policy-oriented evidence across disciplines.

A systematic approach is appropriate for three related reasons. First, it enables consideration of research questions beyond effectiveness testing, including implementations, economic impact, and meaning in policy-domains undergoing uncertainty (Petticrew & Roberts, 2006, p. 11). Second, DRS scholarship is dispersed across disciplines and requires structured integration (Tranfield et al., 2003). Third, systematic review principles enhance transparency and reduce bias through explicit documentation of search, screening and synthesis procedures (Thomé et al., 2016; Tranfield et al., 2003).

2.2.2 Search Strategy

This section outlines how the search was conducted, including the timeframe, the search strings and key terms, databases used, and a summary of those aspects that were included or excluded.

2.2.2.1 Timeframe

The literature search was directed to the period 2010–2026. This timeframe ensures comprehensive coverage of contemporary DRS design, recent international implementations, and packaging reform relevant to the research objectives.

2.2.2.2 Search Strings and Key Terms

Four analytically distinct searches captured financial exposure, operational effects, governance variation, and policy interaction, aligned to the Research Questions.

Each search combined a core DRS identification block with domain-specific analytical terms. Searches were executed in Scopus, Web of Science and ProQuest. Field operators were adapted per database (Scopus: TITLE-ABS-KEY; Web of Science: TS; ProQuest: NOFT) to ensure consistent retrieval

across title, abstract and indexed keyword fields. Database-specific syntax was adapted to each platform. The illustrative syntax reflects the logical structure applied consistently across databases. Where platform-specific syntax constraints prevented direct replication of the full Scopus search string, simplified but logically equivalent expressions were implemented to preserve conceptual coverage across databases.

The core DRS identification block applied across all searches was:

> ("deposit return scheme*" OR "deposit return system*" OR "deposit refund system*" OR "container deposit" OR "bottle bill*" OR (DRS AND (deposit OR refund OR bottle OR container)))

Search 1 added financial exposure terms, including:

> ((producer* OR manufacturer* OR "brand owner*" OR "beverage industr*" OR "scheme operator*" OR "producer responsibility organisation*" OR retailer*)) AND TITLE-ABS-KEY ((cost* OR fee* OR econom* OR financ* OR fund* OR "cash flow" OR "working capital" OR "operat* cost*" OR "handling fee*" OR "transaction cost*" OR "administrative cost*"))

Search 2 added operational and material recovery terms to the core DRS block:

> ((operational* OR "system mechanic*" OR "physical operation*" OR logistic* OR collection OR sorting OR "reverse vending machine*" OR RVM OR "handling infrastructure*" OR "return infrastructure*" OR "operational process*" OR "PET bottle*" OR "PET can*" OR aluminium OR can OR bottle OR plastic OR PET)) AND TITLE-ABS-KEY ((availab* OR limited OR shortage OR scarce OR supply OR "recycled content" OR "virgin material" OR demand)))

Search 3 added governance variation and implementation to the same core DRS block:

> ((UK OR "United Kingdom" OR Britain OR England OR Scotland OR Wales OR "Northern Ireland")) AND ALL ((governance OR "policy instrument*" OR regulation* OR legislation OR "policy design" OR "institutional design" OR "multi-level governance" OR devolve* OR jurisdiction* OR harmonisation OR fragmentation OR divergence OR interoperab* OR "system interoperability")) AND ALL ((implementation OR rollout OR administration OR coordination OR "compliance architecture" OR "enforcement structure*"))

Search 4 added policy interaction and regulatory complexity to the DRS block:

(("policy interaction*" OR "policy mix" OR "policy layering" OR "policy overlap" OR "policy coherence" OR "policy inconsistency" OR "regulatory overlap" OR "regulatory contradiction*" OR "regulatory stacking" OR "multiple policy instruments" OR "extended producer responsibility" OR EPR OR "producer obligation*" OR PRN OR "packaging recovery note*")) AND TITLE-ABS-KEY ((problem* OR challenge* OR barrier* OR constraint* OR complexity OR burden OR cost* OR coordination OR enforcement OR compliance OR administration OR implementation OR governance)))

2.2.2.3 Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were applied to ensure analytical relevance to producer-level implications of DRS. Studies were retained where they substantively addressed at least one research-aligned domain and excluded where DRS was peripheral or producer-level implications could not be meaningfully assessed. The full criteria are set out in Table 2.1.

Table 2.1 Inclusion and Exclusion Criteria

Inclusion criteria	Exclusion criteria
Studies examining Deposit Return Schemes or closely related container deposit systems	Non-academic or non–peer-reviewed publications
Literature addressing producer-relevant cost, operational, governance, or system-design implications	Studies focused solely on consumer behaviour or recycling technologies
Analysis of policy design, implementation, or system operation with relevance to producers	Papers addressing environmental outcomes only, without producer or system relevance
Peer-reviewed journal articles and review papers	Conference proceedings, opinion pieces, and grey literature
English-language publications	Non-English publications
Publications dated 2010–2026	Publications outside the defined timeframe

2.2.3 Screening Process

Application of the search strings generated 259 records, which were exported to Excel for systematic screening. Screening followed three sequential stages consistent with PRISMA reporting and illustrated in Figure 2.1: (1) duplicate removal, (2) title and abstract screening, and (3) full-text screening.

After removal of 147 duplicate records, 112 unique articles remained. Where duplicates occurred across databases, Scopus entries were retained as the canonical record due to more complete metadata.

Title and abstract screening assessed whether DRS constituted a substantive analytical focus and whether producer-level cost, operational, governance, or compliance implications were explicitly indicated. Studies focused solely on consumer behaviour or aggregate system performance were excluded. This stage retained 52 articles and removed 60.

Full-text screening was undertaken where relevance remained uncertain. Papers were excluded where DRS was peripheral or producer-level implications were not substantively addressed. Five additional articles were removed at this stage, resulting in a final review corpus of 47 studies.

Selective backward citation tracking was conducted as a sensitivity check to confirm that identified gaps were not artefacts of database coverage. These additional sources were used for contextual verification only and were not incorporated into the formal review corpus. Figure 2.1 summarises the screening process.

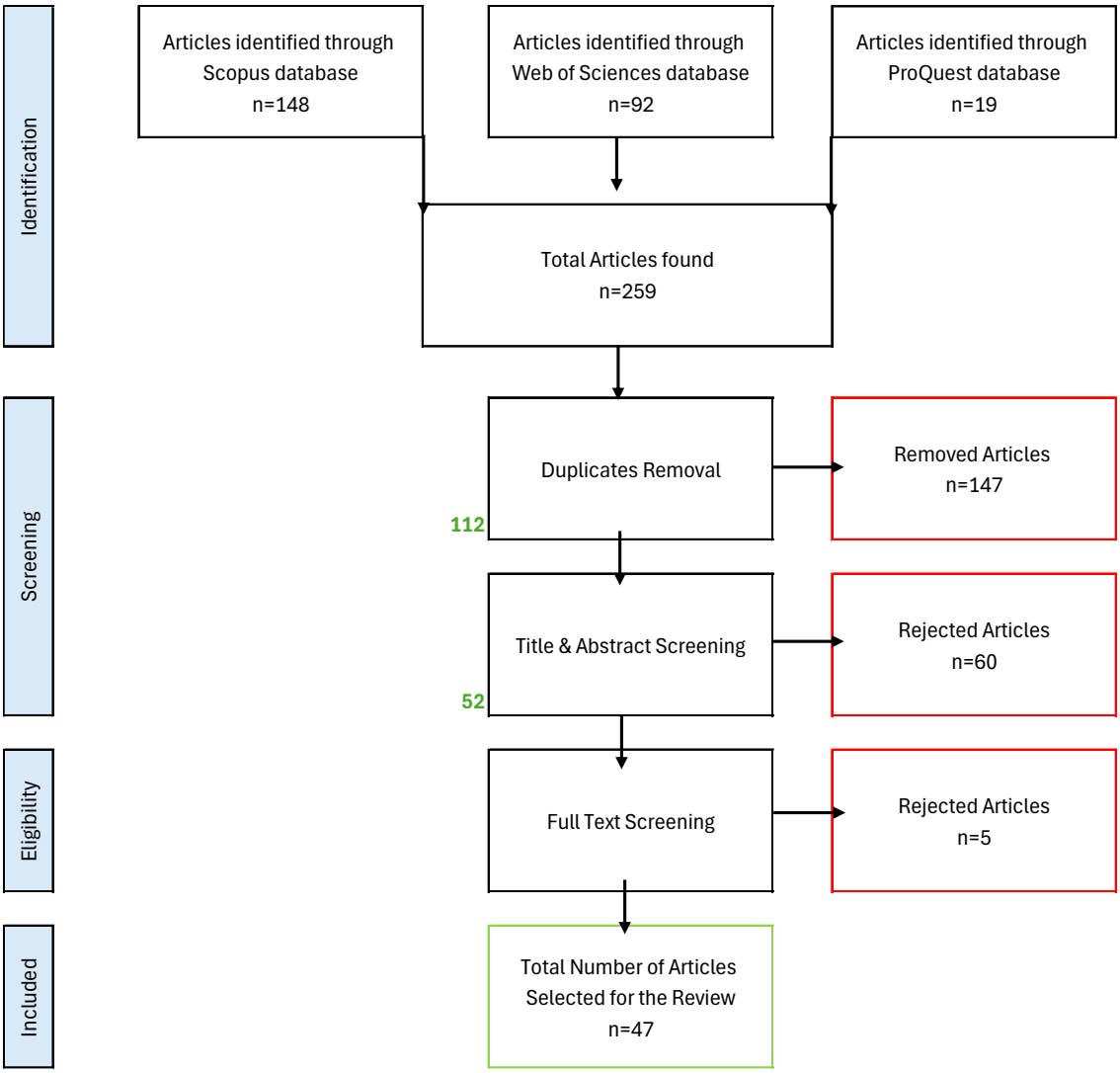

Figure 2.1 Summary Flow of Screening Process

2.2.4 Data Coding and Extraction

The final review corpus of 47 papers was coded using descriptive analytical clusters to organise evidence without imposing causal interpretation.

Six descriptive clusters were applied: policy and governance design; system architecture and operations; cost and financial exposure; comparative and international evidence; reviews and syntheses; and producer obligation and organisational impact. These clusters reflect dominant framing conventions within the DRS literature and structure how schemes are discussed across studies. The clusters function as evidence containers rather than explanatory

constructs. Table 2.2 summarises the typical focus of each cluster and the extent of producer-level treatment.

Table 2.2 Descriptive organisation of the DRS literature by analytical cluster and producer-level treatment

Descriptive cluster	Typical focus in the literature	Producer-level treatment
Policy & Governance Design	Institutional roles, responsibility allocation, scheme ownership, regulatory objectives, alignment with EPR and circular economy policy	Implicit. Producers positioned as obligated actors, internal organisational effects rarely examined
System Architecture & Operations	Scheme structure, collection models, return infrastructure, system performance metrics, logistics design	Implicit. Operational requirements described at system level, not traced into firm processes
Cost & Financial Exposure	Deposit values, handling fees, cost-recovery mechanisms, system-level financial flows	Partial / Implicit. Cost elements are identified, but timing, accumulation, and firm-level absorption are rarely examined
Producer Obligation & Organisational Impact	Compliance duties, reporting requirements, labelling obligations, administrative responsibilities	Intermittent. Obligations listed, but organisational execution and workload effects are under-specified
Comparative / International Evidence	Cross-jurisdictional comparisons, scheme typologies, policy divergence, implementation variation	Absent - implicit. Comparative insights are rarely translated into producer-level exposure or risk
Reviews / Syntheses	Systematic or narrative overviews of DRS	Absent. Used to frame the field rather than analyse producer-level impacts

Descriptive cluster	Typical focus in the literature	Producer-level treatment
	effectiveness, design features, or policy outcomes	

Coding was operationalised through a structured literature map. Each study was recorded within a matrix capturing context, methodology, analytical focus, and relevance to the research questions, following guidance on systematic literature review design in management research (Saunders et al., 2023). Data extraction applied predefined dimensions including governance design, cost allocation, operational impact, and temporal dynamics to enable systematic cross-study comparison.

The literature map facilitated evaluative synthesis by identifying areas of consensus, contradiction, omission and evidential strength across studies, while preserving methodological neutrality at the descriptive stage (Galvan, 2014). Analytical gaps were identified where key analytical dimensions failed to co-occur across studies. The causal interaction and significance of the resulting patterns are examined through thematic synthesis in Chapter 4, consistent with systematic review guidance where descriptive organisation precedes integrative analysis (Braun & Clarke, 2006; Tranfield et al., 2003).

2.2.5 Limitations of the review design

Systematic literature reviews provide transparency and replicability but are subject to limitations relating to database coverage, disciplinary framing, retrieval bias, and synthesis of heterogeneous evidence. These issues are particularly relevant in management and policy research, where study designs and analytical approaches vary.

This review is constrained by keyword-based retrieval. Terminology relating to Deposit Return Schemes varies across jurisdictions and disciplines. Producer roles and cost exposure are not consistently labelled. Relevant studies may therefore have been overlooked where producer implications were embedded

within broader system-level analyses without explicit signalling in titles or abstracts. Database indexing differences, particularly for governance and policy-interaction literature, also influenced retrieval.

In addition, much of the existing literature prioritised system-level performance metrics and policy outcomes, over firm-level empirical analysis of producer operations and cost exposure. Illustratively, governance arrangements in DRS–EPR systems are described in terms of institutional roles, financing responsibilities, and policy coordination, without systematically tracing how specific design choices translate into producer-level reporting requirements, financial exposure, or operational burden (OECD, 2022).

Finally, restriction to English-language publications may limit representation of insights from jurisdictions where DRS is more mature but reported primarily in local languages.

2.3 Patterns and Gaps in DRS Literature

This section identifies recurring patterns and omissions in how producer-relevant cost, operational, compliance, and governance issues are addressed in the DRS literature. Across the reviewed studies, analytical emphasis falls on system-level design and performance, while firm-level operational and financial implications remain fragmented or implicit. These patterns do not explain how producer exposure arises but establish the empirical conditions that require explanatory analysis. Chapter 4 builds on this account by translating these descriptive patterns into coherent causal mechanisms. The following subsections organise the evidence across five analytical domains: cost exposure, operational configuration, compliance burden, governance positioning, and implementation frictions.

2.3.1 System-Level Framing of DRS in the Literature

At the highest level of analysis, the DRS literature conceptualises deposit systems primarily as policy and system-design instruments, emphasising aggregate environmental and system-level outcomes. Studies focus on governance design, scheme architecture, deposit-setting, collection

infrastructure, return rates, recycling performance, and consumer behaviour. Producers are positioned as obligated participants within a designed system rather than as organisations whose internal operations and cost structures constitute primary units of analysis.

For example, policy-oriented analyses detail institutional roles and aggregate financing arrangements while abstracting from firm-level operational adjustment. The Scottish DRS Full Business Case outlines producer fee obligations and compliance requirements in detail yet does not examine how these design choices are translated into internal supply-chain reconfiguration or cost absorption within firms (Scottish Government, 2019).

This system-level orientation limits analysis of how governance design translates into operational workload, liquidity exposure, and cumulative financial strain within producer organisations. Consequently, producer-level dynamics central to Research Questions 1 and 2 remain under-theorised. This gap necessitates the producer-centred analytical lens developed in subsequent chapters.

2.3.2 Fragmented Treatment of Producer Costs

Closer to a firm-level analysis, producer-facing costs under DRS are acknowledged in the literature but examined in fragmented, instrument-specific terms. Studies typically isolate discrete elements such as deposit values, handling fees, allocation mechanisms, pricing effects, and aggregate financial flows, often analysing DRS or EPR separately within static or design-efficiency frameworks.

Individual cost components are identified, but rarely analysed in relation to timing, accumulation, or interaction with operational and compliance processes. Reporting requirements, reverse logistics, liquidity effects, and administrative burden appear intermittently and are not integrated into cost analysis. Governance design, cost allocation, and operational execution are therefore treated as separate domains despite their interdependence in practice. This

fragmentation constrains the literature's ability to address Research Questions 1 and 2.

As a result, existing literature does not explain how DRS-related costs accumulate, interact, or translate into sustained financial and organisational pressure at the producer level. The cumulative nature of producer exposure therefore remains insufficiently synthesised.

2.3.3 Compliance Framed as System Outcome

Moving closer to organisational processes, compliance within DRS is extensively discussed in the literature but is rarely operationalised as an activity experienced within producer organisations.

Governance and compliance are primarily examined through analyses of responsibility allocation, scheme design, institutional arrangements, and incentive structures. Compliance is commonly inferred through aggregate system outcomes, such as return rates or recycling performance, rather than being analysed as a set of enacted organisational practice. The activities required to achieve compliance, including reporting, verification, data management, and administrative coordination, receive limited direct analysis.

As a result, the organisational work required to achieve compliance, including reporting, verification, data management, and administrative coordination, receive limited direct attention. The literature therefore explains why compliance matters within DRS architectures, but not how it is enacted, managed, or experienced by producers.

As a result, there is limited insight into how governance design choices translate into operational burden or compliance-related risk at the firm level, constraining the literature's ability to address Research Questions 2 and 3.

2.3.4 Governance Divergence as Contextual Variation

Returning to the institutional level, governance design and jurisdictional variation are widely examined as contextual features shaping DRS implementation, particularly in relation to responsibility allocation, and scheme

administration. Studies compare governance models and identify implementation challenges associated with regulatory oversight and administrative complexity.

However, divergence is typically treated as contextual background or an implementation challenge rather than as an analytically central design feature. Jurisdictional variation is described descriptively but is not systematically traced into its producer-facing consequences, such as duplicated reporting, fragmented logistics, or uneven compliance exposure for firms operating across multiple schemes. Governance structure is therefore analysed primarily at an institutional level, while its role in shaping producer-facing operational, compliance, and financial risk remains under-explored.

This constrains the literature's ability to address Research Question 3, which examines how externally generated variation in DRS design and implementation shapes producer-level risk and supply-chain resilience. Addressing this gap requires an analytical lens that links governance design and institutional arrangements directly to differentiated exposure at the firm, providing the foundation for the analysis developed in subsequent chapter.

2.3.5 Lack of Integrated Producer-Level Treatment

At the most granular level, the literature lacks an integrated treatment of producer-level exposure across cost, operational, compliance, and governance dimensions. These elements are examined largely in isolation rather than as interacting components of a single exposure system. Although aspects relevant to Research Questions 1–3 are addressed individually, their separation prevents systematic analysis of how governance design, cost allocation, and operational execution combine to generate sustained producer vulnerability. The field therefore lacks a coherent account of cumulative producer exposure over time. This absence of integration defines the boundary of current knowledge and motivates the mechanism-based framework developed in Chapter 4.

2.4 Summary

This chapter has consolidated the DRS literature to clarify what is well established, what remains partial, and what is absent in relation to producer-level cost exposure, operational adaptation, and governance-driven risk. While existing research provides substantial insight into system design, governance structures, and aggregate performance outcomes, it does not provide an integrated account of how these elements translate into cumulative operational and financial burden for producers.

Taken together, Sections 2.3.1–2.3.5 demonstrate that although costs, operations, compliance, and governance are each addressed within the literature, they are typically examined in isolation rather than as interacting dimensions of producer exposure. The gaps identified in this review therefore emerge not as discrete omissions within individual studies, but as cross-cutting analytical absences that become visible only through systematic comparison across sections.

Table 2.3 consolidates these analytically derived gaps and structures them explicitly in relation to the research questions. Rather than cataloguing missing topics, it identifies where the literature consistently fails to integrate cost exposure, operational execution, and governance variation into a coherent producer-level explanation. In doing so, it defines the boundary of current knowledge and provides the evidential foundation for the analytical framework and thematic analysis developed in subsequent chapters.

Table 2.3 Conceptual gaps arising from the literature, mapped to research questions

Gap	Theme	Current Literature Focus	What remains underdeveloped	Study Implication	RQ1 Cost and Financial Exposure	RQ2 Operational and Organisational Impact	RQ3 DRS Design and Variance Risk
1	**Core Producer Exposure**	DRS cost allocation and system design are widely discussed at scheme level rather than at the producer firm level	Cost, operational and compliance demands are not integrated into a unified producer-level burden.	Producer exposure is under-specified, limiting understanding of firm-level cost and operational restructuring.	GAP	GAP	
2	**Governance-to-Organisation Link**	Governance models, scheme architecture, and institutional arrangements are analysed extensively.	Translation of governance design into internal producer processes and workload is not traced.	The link between policy design and organisational impact remains weakly specified.		GAP	GAP
3	**Risk Formation**	Risk is described retrospectively, typically after implementation failures.	Pre-implementation risk formation at the design stage and its accumulation across actors is not analysed.	Ex-ante fragility and resilience under DRS remain insufficiently understood.			GAP
4	**Policy Divergence Effects**	UK devolution and non-harmonisation are treated as contextual background conditions.	Jurisdictional divergence is not analysed as a source of operational, compliance, or financial risk.	Cross-jurisdiction producer exposure remains unexplained.			GAP
5	**Cost Integration**	Individual cost elements are identified but not analysed as a cumulative producer-level exposure.	Timing, interaction, and cumulative financial exposure are rarely examined.	Total producer-level exposure is fragmented across studies	GAP		
6	**Operational Integration**	Material and logistics flows are modelled at system level.	These flows are not translated into internal producer workload or process adaptation.	Firm-level operational burden remains implicit.		GAP	

Taken together, the reviewed literature establishes producer exposure as a recognised consequence of deposit return scheme design, but fails to integrate governance structure, cost allocation, and operational execution into a coherent explanatory account.

3 Descriptive Analysis

3.1 Introduction

The reviewed studies vary widely in their geographical focus, methodological approach, and analytical emphasis. This variation reflects the fragmentation identified in Chapter 2, in which producer-level exposure is dispersed across disconnected strands of analysis rather than examined as a coherent process.

To make this fragmentation visible, this chapter examines the evidence across a set of descriptive dimensions that capture where analytical attention is concentrated and where it thins. These dimensions include geographical context, industry scope, journal orientation, research methodology, and substantive analytical focus.

This approach reveals how producer-relevant analysis is positioned within the wider evidence base, and where system-level perspectives dominate at the expense of organisational and financial detail. These distributions establish the analytical foundation for the thematic and mechanism-based synthesis developed in Chapter 4.

3.2 Chronological Distribution

The chronological distribution of the reviewed literature reveals a rapid intensification of research activity driven by cumulative regulatory mandates rather than separate analytical development. Figure 3.1 illustrates a marked increase in publication volume after 2020, with papers dated 2025 and 2026 representing approximately 40% of the total corpus.

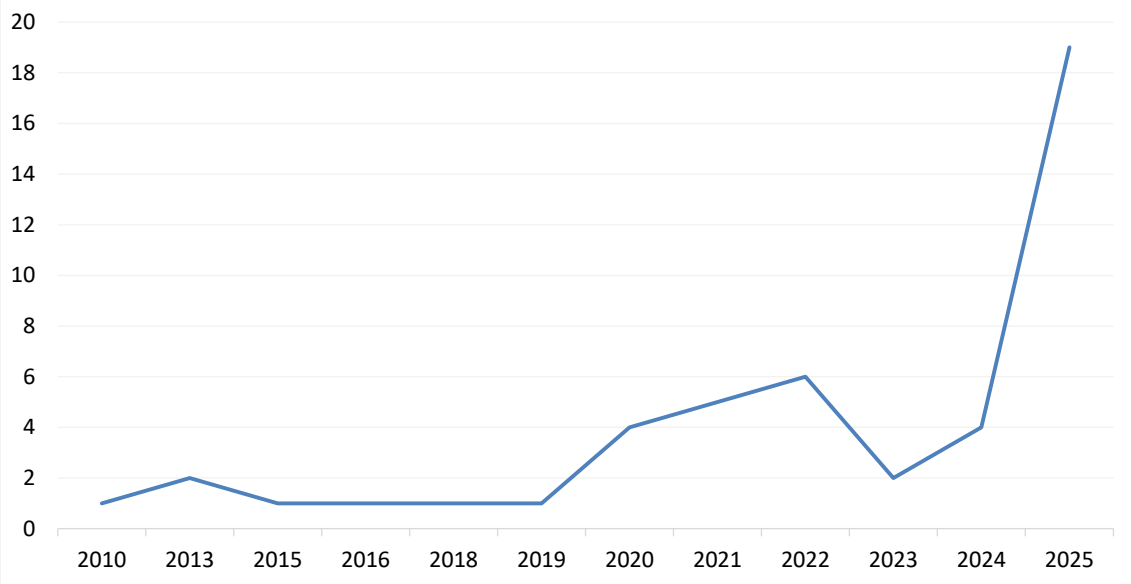

Figure 3.1 Chronological Distribution of Articles

This publication surge aligns temporally with the consolidation of EU packaging policy, transitioning from the Single-Use Plastics Directive adopted in 2019 to the Packaging and Packaging Waste Regulation enacted in December 2024 (Directive (EU) 2019/904, 2019; Regulation (EU) 2025/40, 2024). The Directive introduced binding recycled-content and separate collection targets for beverage packaging, while the Regulation consolidates and extends these obligations within a directly applicable legal framework, including interoperability requirements for deposit return schemes from 2029. The timing of this regulatory tightening suggests that legally binding circularity targets have acted as a catalyst for increased scholarly attention.

Figure 3.2 disaggregates the post-2020 publication surge by geographical context, illustrating how the temporal increase in research activity manifests across regions rather than being confined to a single jurisdiction.

This distribution further indicates that, while European mandates drive primary volume, a contemporaneous rise in publications is observed across North American and multi-country contexts. The uneven regional composition of this

temporal expansion, however, raises questions about the geographical concentration of evidence, which are examined explicitly in Section 3.3.

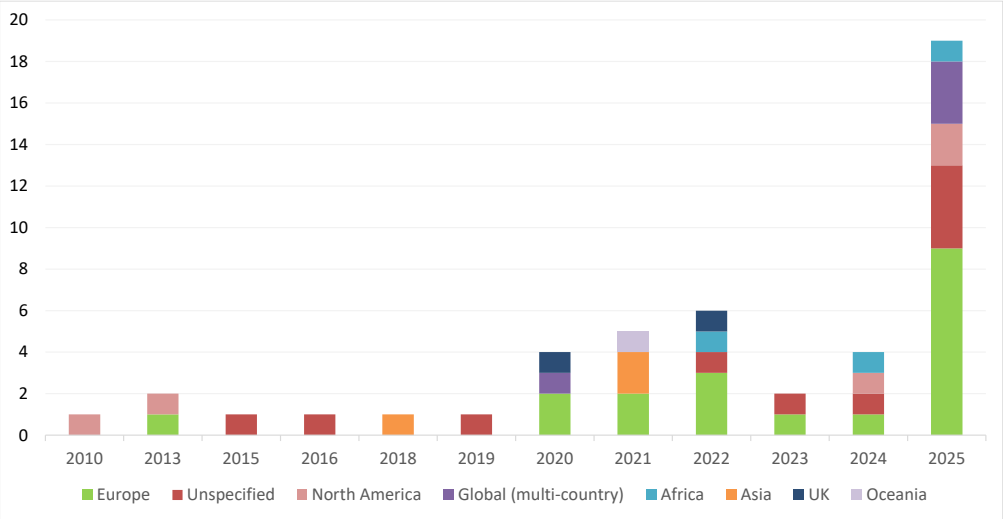

Figure 3.2 Temporal Distribution of Articles by Geographical Context

This parallel growth suggests that the European Union functions as a global agenda-setting signal, focusing scholarly attention on deposit return systems across multiple regulatory environments. However, the multi-regional literature remains analytically siloed within individual jurisdictions and prioritises system-level performance while leaving firm-level operational sequencing and cost absorption comparatively under-examined. This resulting emphasis reflects a distinct policy-anticipation bias in which research models aggregate environmental objectives rather than the internal supply-chain adaptations required to deliver those targets in practice. Consequently, this evidential configuration defines the analytical limits of existing scholarship and establishes the analytical necessity for the interpretive, mechanism-based synthesis developed in Chapter 4.

3.3 Classification by Geographical Context

Where Section 3.2 established the timing of publication growth, this section examines how its geographical composition shapes the analytical limits of the evidence base. The geographical composition of the reviewed literature is dominated by European case studies, as shown in Figure 3.3, which account for

approximately 40% of the corpus, with the remaining studies distributed across North America, Asia, Africa, Oceania, and multi-country contexts. As shown previously, in Figure 3.2, the post-2020 surge in publications is driven primarily by European case studies.

Studies that examined multiple national contexts were classified as multi-country to avoid double-counting

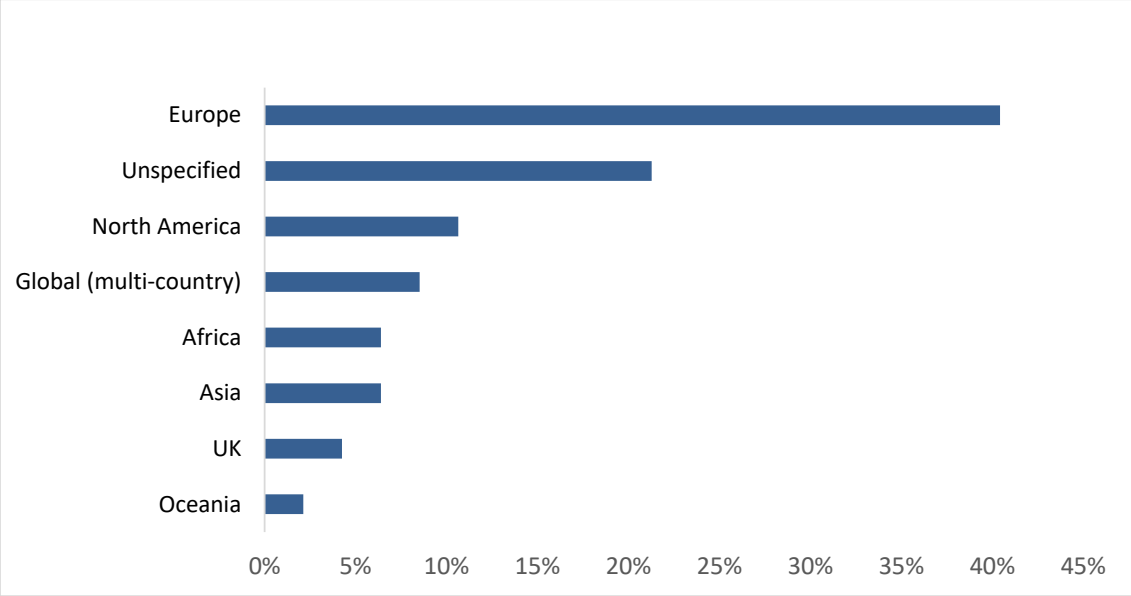

Figure 3.3 Aggregate Distribution of Articles by Geographical Global Context

Rather than functioning as neutral coverage, this European dominance configures the analytical boundaries of the evidence base, by favouring findings derived from stabilised regulatory environments. Dace et al. (2013) explicitly demonstrate the regulatory-maturity bias inherent in this comparative approach, showing that reliance on evidence from established European systems limits transferability to contexts with different institutional and economic structures. This non-transferability illustrates how comparative research frequently relies on mature reference systems while systematically omitting the governance fragmentation and policy ambiguity present in less stabilised jurisdictions.

Despite the United Kingdom's prominence in DRS policy debates, the reviewed literature contains very limited peer-reviewed analysis focusing explicitly on the period of the Scottish DRS prior to its pause in 2023. This evidential skew

under-represents producer-level operational and cost exposure under devolved governance conditions within the current evidence base. This imbalance constrains the transferability of international findings to the UK's devolved landscape, where policy fragmentation and implementation uncertainty constitute defining structural features. Consequently, this geographical bias warrants a mechanism-based synthesis capable of explaining producer exposure under conditions of regulatory ambiguity, as developed in Chapter 4.

3.4 Classification by Industry Context

The industry distribution of the literature reveals a concentration on beverage packaging and cross-sector waste policy framings, foregrounding system-level application in the treatment of producer exposure over organisational differentiation.

Studies were classified by the primary industry or product system addressed, with analyses focusing on waste or recycling systems rather than on a defined product category, thereby distinguishing system-level framings from industry-specific applications. Figure 3.4 illustrates this distribution, with beverage packaging representing the dominant industry focus at approximately 47% of the reviewed evidence base

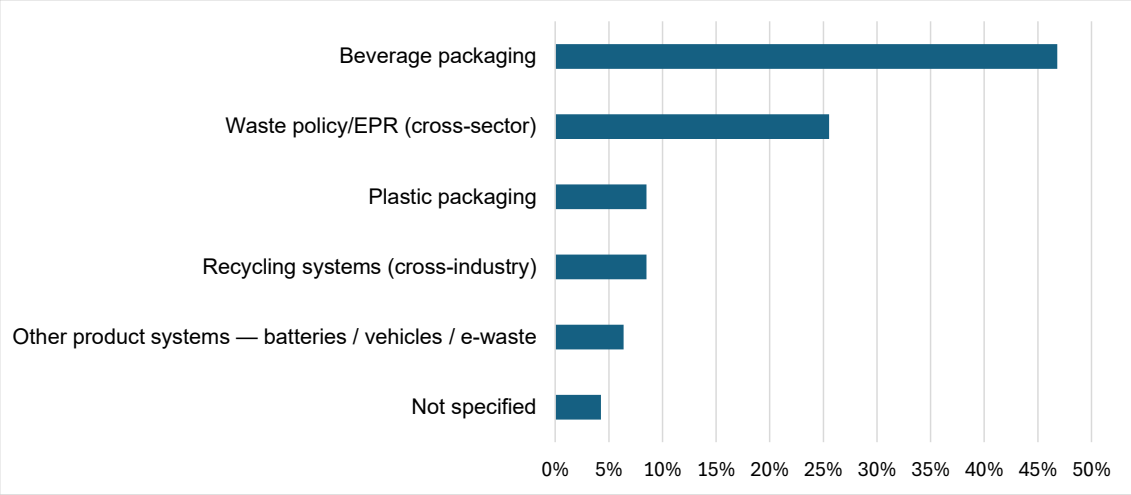

Figure 3.4 Industry Context Distribution

. Figure 3.5 shows a marked increase in publication volume from 2020 onwards, with beverage-focused studies accounting for most of this growth. The temporal clustering of publications following regulatory consolidation suggests that binding circularity targets have increased academic and policy attention within the beverage packaging domain.

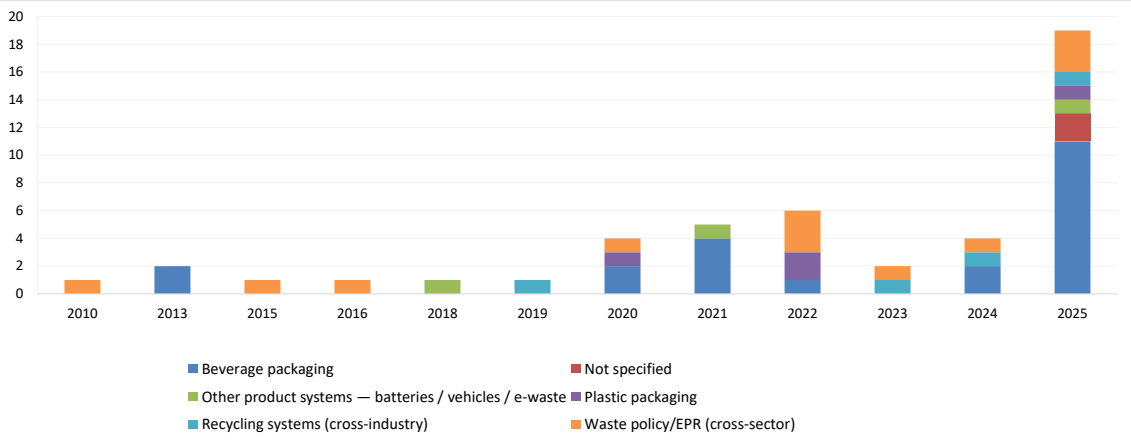

Figure 3.5 Temporal Distribution of Articles by Industry Context

This industry concentration reflects a narrow analytical orientation in which deposit return schemes are assessed predominantly through container recovery performance, thereby obscuring organisational variation in cost structures, operational sequencing, and compliance execution that shape producer exposure and are examined in Chapter 4. This framing treats beverage producers as a largely homogeneous analytical unit, thereby obscuring variation in organisational scale, SKU complexity, and compliance exposure across firms. This prevalence of cross-sector classifications prioritises system-level comparability over sector-specific execution, limiting visibility of how producer obligations are operationalised within distinct organisational settings. This post-2020 concentration reinforces sectoral narrowing by favouring policy-ready contexts, which limits evidence on coordination challenges in less stabilised industry settings. Consequently, this evidential skew constrains the literature's capacity to explain how producer exposure varies across organisational forms, necessitating the mechanism-based synthesis developed in Chapter 4.

3.5 Distribution of Academic Sources

The reviewed sources are classified by publication outlet and subject orientation to situate the literature within its academic publishing context. SCImago Journal and Country Rank (SJR) classifications are used to characterise journal positioning and disciplinary orientation rather than to assess individual study quality. All sources were retrieved through peer-reviewed database searches. One peer-reviewed policy commentary produced by the C.D. Howe Institute is retained as a conceptual anchor but excluded from journal-level descriptive and thematic analysis to preserve comparability across academic publication outlets. The remaining 46 sources are included in this journal analysis, comprising 40 journal articles and 6 review articles.

3.5.1 Journal Distribution

The dispersion of publications across 33 journals reflects the inherently interdisciplinary nature of research on DRS and CE governance. However, Table 3.1 shows that publication volume is concentrated in high-impact, first-quartile environmental and sustainability journals, where editorial norms favour aggregate performance indicators and policy efficacy as reflected in the predominance of modelling, system-design, and policy-evaluation studies within the reviewed corpus. This distribution reinforces a system-level analytical bias within the evidence base.

Table 3.1 Journal Distribution by Publication and SCIMago Journal and Country Rank Indices

	Journal Title	Number of Papers	Percentage	Scimago H-Index	Scimago Q1-4 Rank
1	Sustainability	3	6.5%	207	Q1
2	Journal of Industrial Ecology	3	6.5%	141	Q1
3	Cleaner Waste Systems	3	6.5%	14	Q2
4	Science of the Total Environment	2	4.3%	399	Q1
5	Journal of Cleaner Production	2	4.3%	354	Q1
6	Waste Management	2	4.3%	239	Q1
7	Resources, Conservation and Recycling	2	4.3%	218	Q1
8	Waste Management & Research	2	4.3%	107	Q1
9	Environments	2	4.3%	51	Q1
10	Journal of Material Cycles and Waste Management	2	4.3%	67	Q2
11	Environmental Science & Technology	1	2.2%	504	Q1
12	Journal of Marketing	1	2.2%	296	Q1
13	International Journal of Production Economics	1	2.2%	248	Q1
14	Marine Pollution Bulletin	1	2.2%	245	Q1
15	Computers and Operations Research	1	2.2%	194	Q1
16	Business Strategy and the Environment	1	2.2%	173	Q1
17	International Journal of Environmental Science and Technology	1	2.2%	110	Q1
18	Environment, Development and Sustainability	1	2.2%	96	Q1
19	Management of Environmental Quality	1	2.2%	60	Q1
20	Recycling	1	2.2%	41	Q1
21	Review of European, Comparative and International Environmental La	1	2.2%	32	Q1
22	Circular Economy and Sustainability	1	2.2%	29	Q1
23	Environmental Research: Infrastructure and Sustainability	1	2.2%	15	Q1
24	JOM	1	2.2%	144	Q2
25	Managerial and Decision Economics	1	2.2%	66	Q2
26	Journal of Regulatory Economics	1	2.2%	60	Q2
27	Journal of Sustainable Development of Energy, Water and Environme	1	2.2%	26	Q2
28	Journal of Sustainability Research	1	2.2%	13	Q2
29	Central European Journal of Operations Research	1	2.2%	45	Q3
30	Economic Papers	1	2.2%	27	Q3
31	Journal of Agricultural and Environmental Law	1	2.2%	5	Q3
32	Environmental Research and Technology	1	2.2%	7	Q4
33	Marketing and Management of Innovations	1	2.2%	not available	not available

This concentration includes journals such as Sustainability, the Journal of Industrial Ecology, and Cleaner Waste Systems, which together account for nearly 20% of the reviewed corpus. As a result, producer exposure is frequently treated as a fixed system parameter rather than as an organisational outcome shaped by internal supply-chain adaptation and strategic response. This disciplinary framing limits visibility of producer-level cost exposure and operational burden, thereby reinforcing the need for the mechanism-based synthesis developed in Chapter 4.

3.5.2 Distribution of Publication Subject Areas

The distribution of publication subject areas indicates that the DRS literature is primarily situated within environmental science, policy, and system-level governance domains. Figure 3.6 illustrates this distribution, with environmental science emerging as the most prominent category, reflecting the dominance of

sustainability-oriented journal outlets within the corpus.

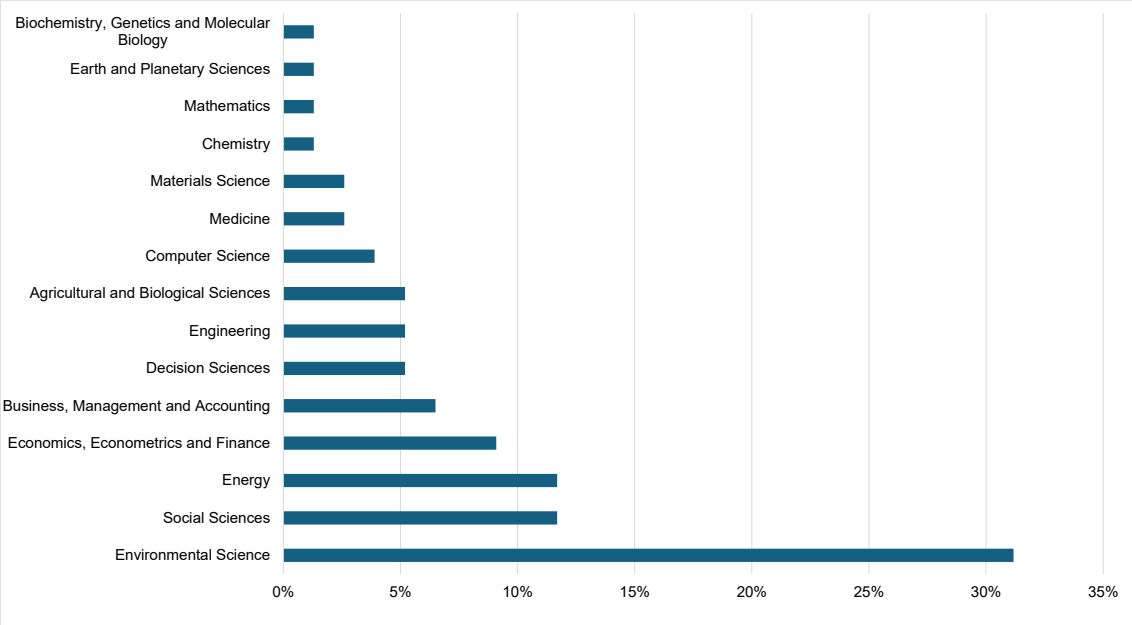

Figure 3.6 Subject Area Classification of Journals Represented in the Review

This subject-area configuration orients the evidence base toward environmental outcomes and aggregate system performance, thereby reducing analytical visibility of firm-level operational processes. Perspectives focused on organisational execution and cost exposure consequently appear less frequently within the reviewed literature. This thematic concentration reinforces an emphasis on system functioning rather than on how producer obligations are implemented and managed within firms, aligning with the journal-level patterns identified above and further constraining insight into producer-level operational adaptation.

3.6 Classification by Research Methodology

Existing research exhibits a clear methodological concentration in quantitative and system-level analytical modelling approaches. Figure 3.7 illustrates this methodological skew, in which empirical quantitative designs and theoretical modelling collectively account for approximately 50% of the reviewed evidence base.

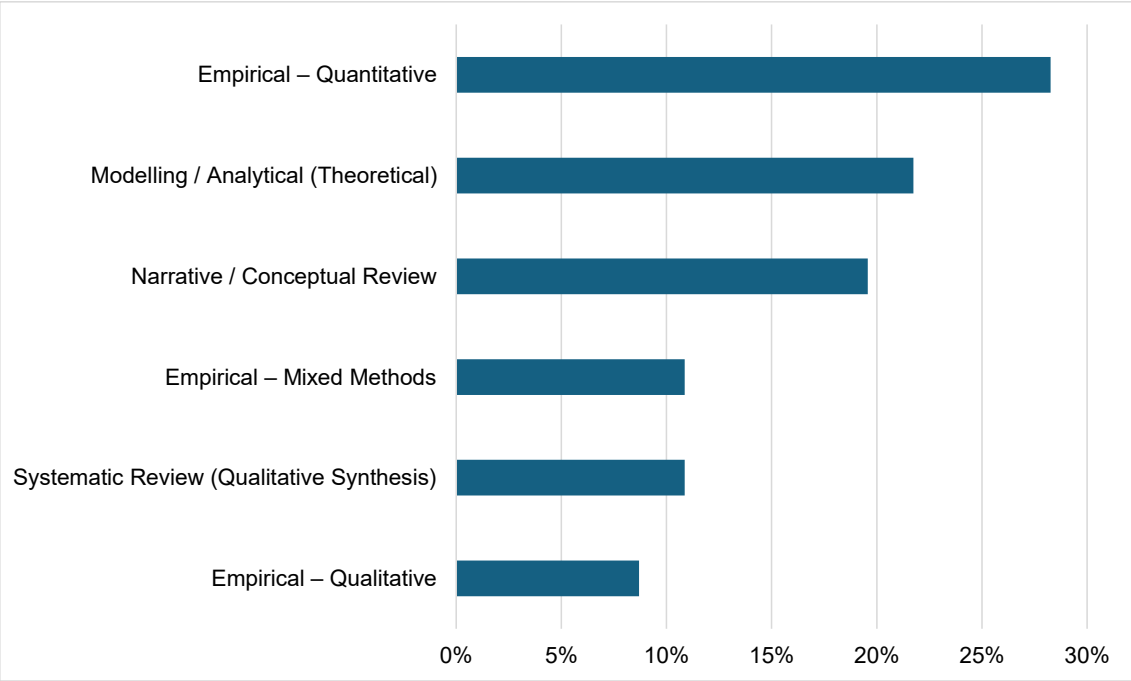

Figure 3.7 Classification by Research Methodology

This methodological configuration reflects the fragmented and context-sensitive nature of management research, which often favours abstracted analytical approaches to integrate evidence from heterogeneous sources (Tranfield et al., 2003).

Within this landscape, systematic review traditions often privilege large-scale quantitative studies for their ability to demonstrate aggregate effect sizes, leaving the precise mechanisms of organisational process to be examined through qualitative or case-based inquiry (Petticrew & Roberts, 2006).

This reliance on abstract modelling limits the specification of producer behaviour within the literature, reducing visibility of internal decision-making, cost absorption, and operational sequencing. Consequently, this methodological imbalance constrains the literature's capacity to explain how producer exposure emerges in practice, necessitating the interpretive, mechanism-based synthesis developed in Chapter 4.

3.7 Classification of Paper Research Focus Areas

The reviewed literature exhibits a substantive focus on policy and governance design. To examine how analytical attention is distributed across the literature, the reviewed studies were classified into research focus categories reflecting their primary analytical orientation.

Figure 3.8 illustrates this distribution, showing that research centred on macro-level system architecture and governance dominates the evidence base, accounting for approximately 45% of the reviewed corpus. This thematic profile indicates that scholarly attention remains focused on policy intent and aggregate system performance rather than on the granular financial and operational dynamics required to address producer-level exposure.

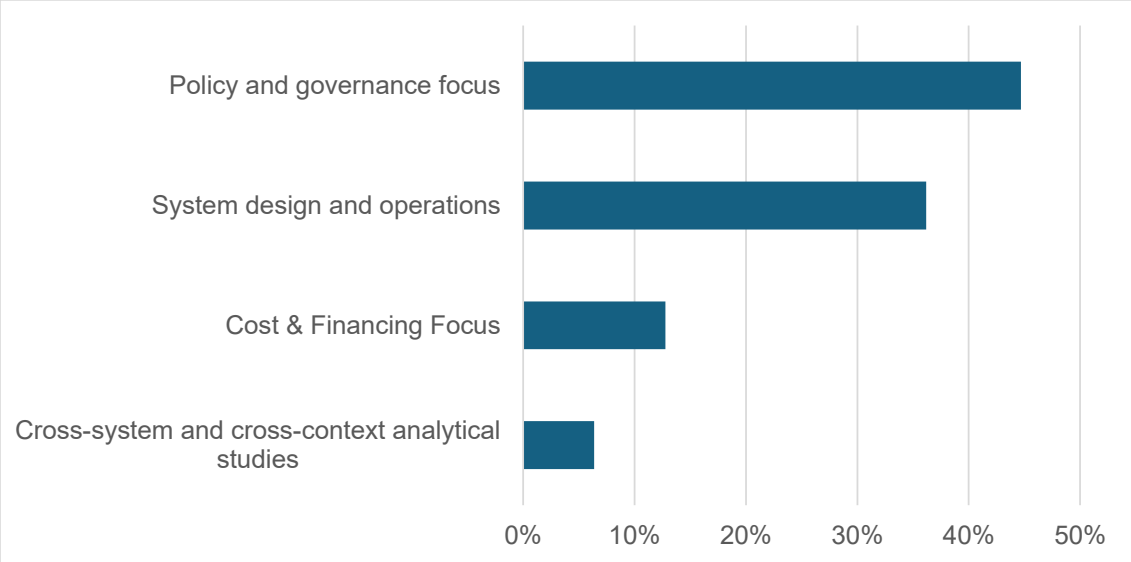

Figure 3.8 Classification of Research Focus in Papers

Within the subset of studies engaging with governance, this analytical orientation is further characterised by a strong preference for relational governance dynamics among relevant actors over formal compliance risk or enforcement structures. Figure 3.9 shows that approximately 80 per cent of governance-focused analyses examine interaction dynamics, while only a minority explicitly interrogate the structural origins of compliance risk.

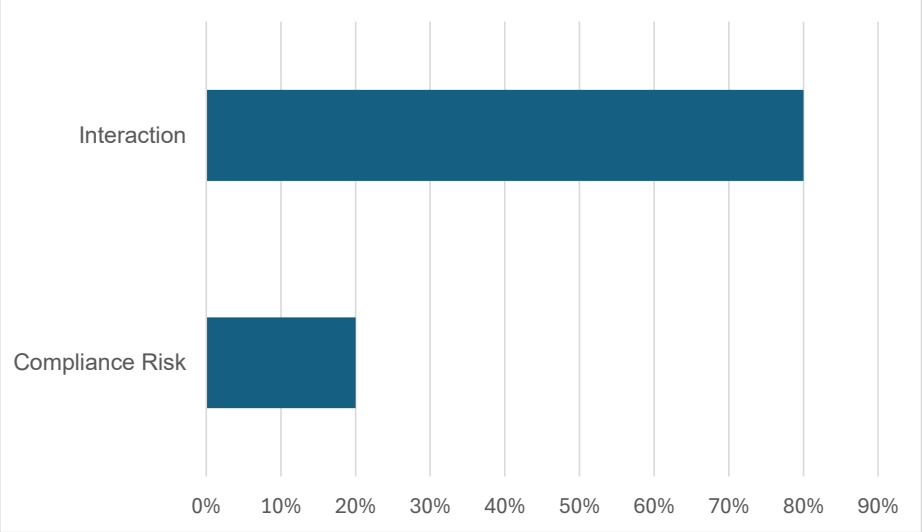

Figure 3.9 Classification of Governance Lens included in Policy and Governance Focus Areas

This interaction-focused framing reinforces the fragmentation identified in Chapter 2 by treating institutional arrangements primarily as contextual features rather than as analytically operative determinants of producer obligation

As a result, this analytical configuration limits the literature's capacity to explain how governance design choices translate into concrete producer-level financial exposure, thereby establishing the need for the interpretive synthesis undertaken in Chapter 4.

3.8 Summary

The descriptive patterns mapped in this chapter demonstrate that the DRS literature is structurally fragmented across geographical, methodological, and analytical dimensions.

The concentration of research in mature European jurisdictions, policy-ready beverage sectors, system-oriented journals, and quantitative modelling traditions produces an evidence base that privileges aggregate system performance and policy intent over firm-level operational and financial experience. While existing scholarship establishes producer responsibility for scheme financing as a settled premise, it provides limited insight into how producers manage, sequence, or absorb this exposure within organisations,

particularly under devolved and uncertain governance arrangements. Consequently, critical dimensions of cost, operational adaptation, compliance execution, and governance variation are addressed in parallel literatures rather than integrated into a coherent producer-level account. This structural non-integration defines the limits of descriptive mapping and establishes the analytical requirement for the mechanism-based synthesis developed in Chapter 4.

4 Thematic Analysis

4.1 Introduction

Building on the thematic synthesis in Chapter 2, this chapter reorganises recurring findings by causal function to reconstruct the logic of producer burden transmission. This reconstruction shows how separate thematic strands interlock within a single exposure transmission system.

Producer exposure is treated as structurally endogenous to scheme architecture, arising from allocation rules and liquidity timing rather than firm inefficiency.

Section 4.2 explains the translation from themes to mechanisms. Section 4.3 develops the four exposure-generating mechanisms. Section 4.4 examines why these mechanisms have not previously been assembled into a cumulative account, highlighting disciplinary fragmentation and dominant analytical framings that obscure producer exposure. Section 4.5 maps the analysis to the research questions and prepares the transition to Chapter 5.

4.2 Thematic Structure of the DRS Literature

This section reconstructs the reviewed literature by causal function rather than topical category. Governance design, cost allocation, operational execution, and temporal dynamics are treated as analytical lenses through which recurring exposure structures are traced. Producer exposure is therefore examined as the outcome of interacting institutional conditions, allocation rules, and timing processes rather than as isolated thematic effects.

Building on the coding framework in Section 2.2.4, descriptive clusters are reclassified by exposure function and examined for recurring transmission sequences. Where similar configurations of design, allocation, and timing produce comparable forms of producer liability, they stabilise as mechanisms.

For example, cost-recovery rules coded descriptively under “financial exposure” in Chapter 2 are reinterpreted as residual cost assignment structures when analysed across settlement cycles and liquidity dynamics. This reclassification

illustrates the shift from thematic description to exposure-generating mechanism.

The analysis proceeds hierarchically from upstream institutional architecture and allocation structures, where liability is configured, to downstream firm-level financial transmission, where that liability becomes operationally binding. Figure 4.1 formalises this reconstruction as a layered progression from institutional configuration to producer-level transmission.

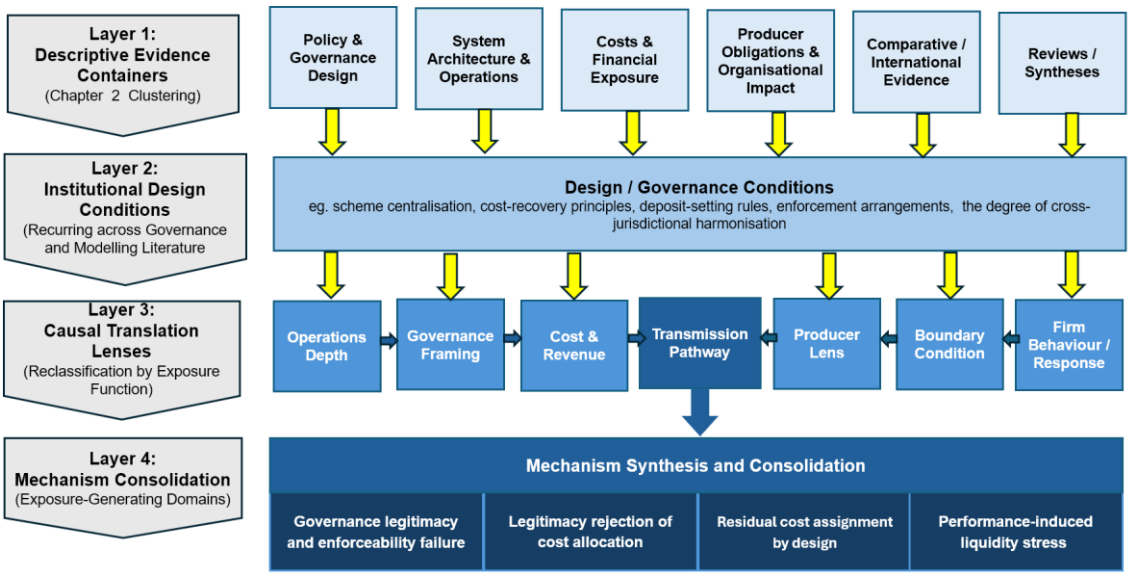

Figure 4.1 From Thematic Fragmentation to Exposure-Generating Mechanisms: Analytical Reconstruction of the DRS Literature

Layer 1 reflects the thematic clusters identified in Chapter 2. The transition to Layer 2 distils these clusters to identify recurrent institutional design features that cut across studies, isolating governance, allocation, enforcement, and coordination structures as analytically comparable dimensions. Intermediate layers therefore synthesise recurring design features observed across the literature.

The movement from Layer 2 to Layer 3 shifts from descriptive institutional features to analytically reclassified exposure functions. Design conditions are reorganised according to how they operate within producer systems, distinguishing operations depth, governance framing, cost and revenue allocation, producer positioning, and boundary conditions. Transmission

pathways provide the integrative logic linking these functions, tracing how institutional arrangements propagate through operational systems to generate producer-level exposure.

The transition from Layer 3 to Layer 4 consolidates these functions into four higher-order mechanisms, identifying recurrent patterns of financial transmission and liability concentration. Mechanisms are identified through causal positioning rather than frequency. Anchor studies theorise how allocation rules generate producer exposure, reinforcement studies reproduce similar structures under alternative empirical conditions, and boundary-setting studies clarify which dimensions dominant frameworks treat as exogenous.

Figure 4.1 therefore performs a methodological consolidation, demonstrating that exposure mechanisms are structurally latent within the DRS literature and become visible once allocation and transmission logics are reclassified by exposure function.

Figure 4.2 embeds these mechanisms within the wider causal architecture of the DRS system, distinguishing upstream institutional determinants from downstream evaluated outcomes. The upstream architecture reflects rule-setting and compliance scholarship, system-dynamics elements draw on modelling of collection logistics and settlement calibration, and the evaluated outcomes block corresponds to welfare research assessing recycling rates and aggregate cost.

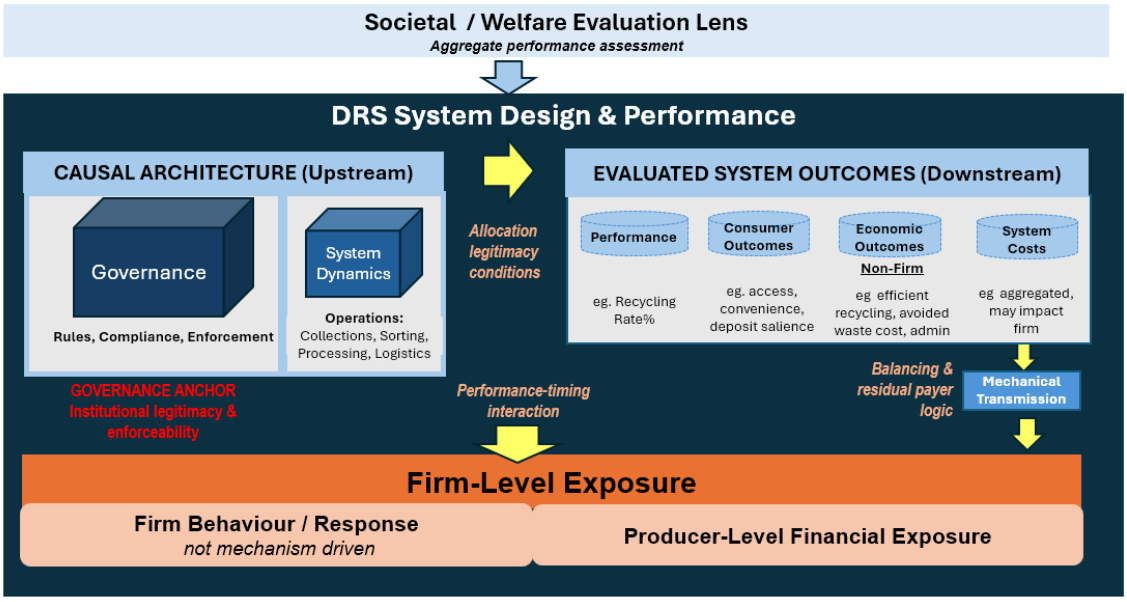

Figure 4.2 Causal architecture and transmission pathways for producer exposure under deposit return schemes.

While the societal welfare lens evaluates aggregate outcomes, the causal architecture demonstrates that firm-level liability arises through structured allocation and settlement design. Legitimacy frameworks, balancing rules, and timing structures convert system performance conditions into producer-level financial exposure. This interpretation is grounded in cost-allocation and modelling studies specifying how deficits and timing mismatches are assigned to producers. The figure specifies the structural space within which the mechanisms operate and interlock, without representing the mechanisms independently.

The following section examines each mechanism within this structural space.

4.3 Exposure-Generating Mechanisms: Institutional Architecture and Financial Transmission

Section 4.3 disaggregates the consolidated architecture into four analytically distinct exposure-generating mechanisms. Each subsection specifies the upstream design conditions, transmission logic, and producer-level consequences associated with the mechanism.

4.3.1 Institutional Architecture and Cost Allocation Structures

This section specifies the upstream institutional mechanisms that structure producer exposure before financial transmission occurs.

4.3.1.1 Governance Legitimacy and Enforceability Structure

Governance legitimacy and enforceability refers to the institutional architecture through which compliance responsibility, enforcement authority, and accountability are formally specified within a DRS. As an upstream mechanism, it determines how obligations are constituted and enforced prior to cost allocation or operational execution. Exposure is therefore structured as the level of governance design.

The DRS literature typically treats governance as contextual architecture describing regulatory intent and institutional arrangements as background conditions rather than generative structures shaping liability. Green and Trebilcock (2010) demonstrate that regulatory systems generate predictable outcomes only where authority, responsibility, and accountability are clearly specified and enforceable. However, much of the DRS literature does not analyse enforcement configuration as an independent causal layer shaping downstream liability. Governance arrangements are described as institutional context, while producer exposure is typically attributed to implementation complexity, policy ambition, or operational scale rather than to enforcement architecture itself.

This framing obscures how fragmented or ambiguous authority displaces coordination and risk-management burdens onto regulated actors. Formal obligations remain, but producers must internalise uncertainty associated with monitoring, verification, and liability attribution. Exposure therefore arises from institutional configuration rather than operational inefficiency.

For example, where statutory enforcement authority is distributed across multiple regulators while operational compliance is administered centrally, unclear responsibility for verification or dispute resolution requires producers to maintain parallel documentation, reconciliation, and audit processes across

institutional interfaces. Exposure manifests as recurring administrative overhead generated by enforcement delegation rather than fee magnitude.

Governance architecture thus constitutes the first causal layer through which producer exposure is generated, establishing enforcement and shaping how subsequent allocation and financial transmission mechanisms operate, without attributing exposure to behavioural failure or implementation inefficiency.

4.3.1.2 Legitimacy of Cost Allocation Rules

Legitimacy of cost allocation rules refers to the institutional acceptance of formally specified financial obligations within a DRS. Allocation rules determine which actors bear particular financial burdens and under what conditions. Producer exposure depends not only on the formal assignment of costs, but on whether those assignments are perceived as procedurally justified and consistent with actor roles. Allocation legitimacy therefore operates as a conditioning mechanism linking formal design to stable compliance.

The dominant DRS literature analyses cost allocation primarily through structural efficiency and welfare-aggregation frameworks. Studies such as Dace et al. (2013), Schneider et al. (2021), and Lu et al. (2022) assess distributional effects and system performance, treating payer identity as fixed once specified. Compliance is generally assumed. Allocation rules are therefore judged by efficiency rather than by institutional durability.

This focus underplays the role of legitimacy in sustaining compliance within multi-actor systems. Pokorný and Fiala (2025) demonstrate that formally defined allocation rules do not automatically secure durable participation. Where payer identity is perceived as opaque, asymmetric, or misaligned with actor roles, coordination demands increase and enforcement becomes more contingent. Monitoring, dispute resolution, and renegotiation expand, shifting organisational burden onto producers who remain system participants. Exposure thus arises through instability in rule acceptance, not merely through nominal fee levels.

Cross-jurisdictional variation further shows that durability depends on governance configuration rather than cost magnitude (Bhaskar & Turaga, 2018; Green & Trebilcock, 2010). Where producers fund collection and processing costs while retailers or operators control infrastructure standards, limited producer influence over cost drivers may weaken perceived procedural legitimacy. Formal obligations persist, but disputes over cost recovery or settlement timing may increase, generating administrative and financial strain independent of fee size.

Allocation legitimacy therefore constitutes a causal layer linking formal allocation rule specification to compliance stability. Producer exposure emerges from the interaction between rule design and institutional acceptance rather than from inefficiency or enforcement failure.

4.3.1.3 Residual cost assignment structure

Residual cost assignment refers to the structural designation of producers as default bearers of unresolved system costs within DRS settlement architecture. In non-profit, break-even designs, balancing rules require total revenues and expenditures to reconcile within predefined accounting constraints. Where realised costs diverge from projections, variance must be absorbed through pre-specified allocation rules. Under such configurations, producers occupy the residual position within the settlement structure.

Producer exposure encompasses deposit pre-financing, administrative fees, reconciliation adjustments, and associated compliance expenditures. These include both direct transfers and indirect compliance expenditures. During transition, duplication of preparation and provisional reconciliation may temporarily intensify these pathways. Appendix B consolidates the structural cash-flow and allocation components through which exposure is generated and transmitted.

Schneider et al. (2021) formalise this residual payer logic through a “positive-zero” accounting model in which annual reconciliation ensures that any system deficit is recovered through revised industry fees. However, much of the

literature reports producer fees, or balancing adjustments, without interrogating the settlement rules that generate residual assignment (Dace et al., 2013; Schneider et al., 2021; Steenmans, 2025). Efficiency-focused analyses treat non-profit designs as financially neutral and do not examine how cost-recovery constraints translate system variance into producer-level liability (Calabrese et al., 2026; Lu et al., 2022).

This treatment obscures the structural mechanism through which residual liabilities are produced. In break-even architectures, variance cannot remain within the system and must be resolved through mandatory reconciliation. Settlement logic therefore assigns the gap between projected and realised performance to producers by design. Exposure arises from accounting structure rather than operational inefficiency, taking the form of reconciliation payments and balancing adjustments linked to forecasting error, demand volatility, or material price fluctuation.

For example, if collection or processing costs exceed projections or material revenues fall short, the resulting deficit is reconciled through revised producer fees. This occurs even where return targets are achieved and compliance remains high. Exposure thus reflects residual cost assignment embedded in settlement design.

Residual payer logic is therefore a structural feature of scheme accounting architecture, converting system-level variance into mandatory producer-level financial obligation.

4.3.2 Firm-Level Exposure and Financial Transmission

This section examines the downstream manifestation of exposure within firms, focusing on transmission, timing, and liquidity dynamics. Whereas Section 4.3.1 examined how exposure is generated through institutional design and allocation structures, this section examines how those formally assigned obligations are transmitted through operational and financial processes. The analytical shift is from liability assignment to financial transmission: how timing architecture converts assigned obligations into liquidity pressure and coordination demands

across supply-chain and finance functions. The mechanism does not change who bears cost; it explains how obligations become operationally binding within firms.

Non-harmonised policy environments intensify this transmission pathway. Producers may manage parallel SKU configurations across jurisdictions, increasing forecasting, planning, and inventory complexity. Distinct labelling, deposit values, or material specifications can necessitate separate production runs, warehousing arrangements, and demand allocation strategies. These adaptations increase coordination requirements between supply-chain, finance, procurement, and regulatory functions. Where placement volumes and deposit flows must be tracked and reconciled across multiple jurisdictions, forecasting precision becomes critical and procurement strategies become more exposed to material price volatility and volume misalignment. Divergence does not alter the underlying allocation logic, but it amplifies the coordination and working-capital burden associated with compliance

4.3.2.1 Performance-induced liquidity stress

Performance-induced liquidity stress operates as a dynamic mechanism where high return targets interact with deposit pre-financing and delayed reconciliation rules (Calabrese et al., 2026). Producers advance deposits, handling fees, and associated costs when placing goods on the market, while reimbursement occurs only after redemption and verification, creating structural timing misalignment. As return rates and throughput increase under fixed settlement cycles, cash outflows accelerate. Exposure therefore emerges from the interaction between performance intensity and timing architecture rather than net cost alone.

Non-harmonised policy environments intensify this channel. Parallel SKU configurations and jurisdiction-specific requirements expand deposit pre-financing and working-capital commitments across product portfolios.

The dominant literature analyses DRS performance primarily through environmental effectiveness and aggregate cost neutrality (Yu, 2021). Financial

stability is inferred from long-run break-even conditions where total revenues match total costs. Timing features such as pre-financing, reconciliation lag, or deposit float management are usually treated as operational details rather than as structural exposure pathways.

This framing overlooks how fixed settlement sequencing generates recurring liquidity strain even when aggregate costs balance. Because settlement operates through rolling verification cycles, liquidity exposure persists across operating periods, transforming what appears as a transient flow in aggregate models into a recurring working-capital requirement (Lu et al., 2022).

In a high-performing scheme, substantial deposits must be pre-financed upon product placement. Although reconciled later, reimbursement follows verification and settlement cycles, creating a rolling stock of tied-up liquidity across accounting periods. As performance improves or volumes expand, this liquidity stock increases.

Liquidity stress therefore arises from performance–timing interaction embedded in scheme design.

4.3.2.2 Exposure Modulators and Conditioning Factors

The four mechanisms identified generate producer exposure through institutional design, allocation rules, and timing structures. In addition, a set of conditioning factors influences how that exposure materialises across firms and operating contexts. These factors do not constitute independent mechanisms, as they do not create liability in their own right. Rather, they shape the intensity, distribution, and timing profile of exposure once a mechanism is in operation.

Exposure modulators amplify, dampen, or redistribute burdens generated by the upstream mechanisms. Their effect depends on an existing rule structure. In the absence of governance fragmentation, residual assignment, or timing mismatch, these factors do not independently produce exposure.

The literature identifies several recurrent modulators, including scheme scale, settlement frequency, forecasting variance, capital intensity, producer liquidity

position, and cross-jurisdictional complexity. These factors explain variation in how exposure is experienced. For example, higher settlement frequency may reduce short-term liquidity strain without altering the residual payer rule, while larger producers may absorb working-capital pressure more readily than smaller firms under identical timing conditions.

Crucially, these factors explain why exposure varies, not why it exists. They clarify why identical allocation rules produce uneven financial consequences across producers, but they do not alter who bears liability or why that liability exists.

Distinguishing mechanisms from modulators preserves analytical clarity. Mechanisms generate exposure through rule structure and transmission logic; modulators shape how that exposure becomes financially acute, particularly under high performance or volatile operating conditions.

Taken together, these mechanisms demonstrate that producer exposure under DRS is generated through an integrated sequence of institutional design, allocation logic, settlement architecture, and financial transmission. Exposure is not attributable to isolated implementation frictions, but to the structured interaction of governance configuration, residual cost assignment, and timing rules embedded within scheme design.

Yet despite the presence of these component elements within the literature, they have rarely been assembled into a single sequential causal account. Section 4.4 therefore examines why producer exposure remains analytically fragmented within existing scholarship and clarifies the integrative contribution of this chapter.

4.4 Structural and Disciplinary Fragmentation in the DRS Literature

Producer exposure under deposit return schemes remains under-integrated within the literature not because relevant components are absent, but because those components are rarely assembled into a sequential causal account. Governance design, cost allocation, operational execution, and financial stress

are examined within distinct strands of scholarship yet seldom traced together from institutional configuration through settlement logic to firm-level financial transmission.

This fragmentation reflects the historical development and disciplinary positioning of the field. Early scholarship established DRS primarily as an environmental policy instrument, emphasising pollution reduction, return rates, and welfare outcomes (Calabrese et al., 2021)). Within this framing, producer costs were treated as secondary to environmental effectiveness. Subsequent economic analyses incorporated cost–benefit modelling and pricing effects but retained an aggregate orientation, examining incidence at system level rather than tracing firm-level transmission pathways. Operational and supply-chain perspectives emerged later and unevenly, often concentrating on logistics and implementation feasibility rather than on how payer identity and reconciliation rules translate into financial exposure.

Although more recent work begins to examine governance-cost linkages and temporal financial dynamics, these insights remain dispersed (Calabrese et al., 2026; Lu et al., 2022; Schneider et al., 2021; Yu, 2021).

Governance studies rarely follow costs downstream into settlement dynamics; cost-allocation analyses treat institutional configuration as exogenous once rules are specified; operational studies prioritise efficiency and compliance feasibility over liability concentration; and financial stress is typically framed as an implementation challenge rather than as a design-induced outcome. The gap is therefore architectural rather than evidentiary.

Disciplinary concentration reinforces this segmentation. As shown in Chapter 3, the evidence base is located predominantly within environmental policy, recycling, and sustainability journals, where analytical attention prioritises system effectiveness, environmental legitimacy, and aggregate performance. Within these outlets, producer-level financial execution and liquidity dynamics are frequently treated as secondary or exogenous considerations. Economic and operational perspectives exist but are unevenly integrated, often appearing

in adjacent fields without systematic reconnection to governance design and institutional structure.

These disciplinary patterns shape analytical framing. Break-even, non-profit architectures are commonly interpreted as financially neutral, with settlement rules treated as equilibrium-restoring devices rather than as residual liability assignment structures. Timing features such as deposit pre-financing and reconciliation lag are typically abstracted within aggregate models, limiting attention to liquidity as a recurring balance-sheet obligation. Governance architecture is similarly presented as contextual scaffolding rather than as a generative layer conditioning enforceability and risk displacement.

These framings do not deny producer costs, but they influence how those costs are conceptualised. Exposure consequently appears transitional, pass-through, or efficiency-adjustable rather than structurally embedded within allocation geometry, settlement architecture, and liquidity timing. The absence of a cumulative transmission account therefore reflects analytical compartmentalisation rather than evidentiary absence.

The contribution of Chapter 4 is integrative and reconstructive. It does not introduce new variables; rather, it reassembles existing evidence into a coherent mechanism-based architecture that traces exposure from governance configuration through residual cost assignment to firm-level liquidity transmission. By clarifying how these elements interlock, the chapter establishes the analytical foundation for Chapter 5, where exposure is examined as a structurally endogenous and temporally amplifying system outcome.

4.5 Summary: Reassembling Fragmented Accounts of Producer Exposure

This chapter has reassembled fragmented accounts of producer exposure under deposit return schemes into a coherent causal sequence. It has shown how governance architecture structures obligation, how allocation rules assign payer identity, how residual cost assignment concentrates liability by design,

and how financial transmission mechanisms render exposure dynamically visible within firms.

In relation to Research Question 1, cost allocation legitimacy and residual cost assignment identify the new supply-chain and compliance cost categories arising under DRS and demonstrate how settlement rules systematically concentrate financial exposure on producers. In relation to Research Question 2, firm-level transmission and performance-induced liquidity stress show how timing architecture and reconciliation sequencing reshape core supply-chain and financial control functions. In relation to Research Question 3, governance fragmentation and cross-jurisdictional divergence demonstrate how externally generated institutional variation amplifies operational, compliance, and financial risk conditions.

The intensity and distribution of these effects are further shaped by contextual modulators, including return-rate performance, material price volatility, settlement frequency, and portfolio complexity, which condition but do not alter the underlying exposure architecture. These mechanisms, and their modulation, establish that producer exposure arises as a structurally embedded outcome of scheme design rather than a transitional adjustment. Chapter 5 examines how this exposure accumulates over time, becomes strategically consequential, and shapes organisational and policy response options.

5 Discussion

5.1 Introduction

UK soft drinks producers currently navigate a pre-implementation landscape defined by devolved policy divergence, unresolved governance arrangements, operational uncertainty, delay and revision, requiring producers to commit resources in the absence of design stability (DEFRA 2024b; Jones, 2026).

Chapter 4 demonstrated that producer exposure under a UK-style DRS arises from governance allocation architecture rather than firm inefficiency. Exposure is generated through temporal misalignment in settlement cycles, residual payer allocation of system volatility, and a structural trade-off between environmental performance and liquidity resilience. Producer exposure is therefore a structurally endogenous outcome of system design, accumulating over time as allocation rules and financial transmission mechanisms interact.

This chapter interprets those cumulative dynamics within the current policy environment. With launch approaching and parameters unsettled, exposure is configured before performance is observable.

5.2 Reframing Producer Exposure as a System Outcome

Producer exposure under UK DRS is not a temporary compliance cost. It is generated by institutional design and is structurally endogenous. Dominant economic appraisals of DRS frame producer exposure as transitional friction or neutral pass-through. Welfare optimisation models (e.g. Dace et al. (2013) and Yu (2021)) treat producer payments as balancing variables expected to adjust through price transmission or equilibrium restoration. Producer obligations therefore appear as adjustable parameters within aggregate welfare functions rather than concentrated institutional liabilities.

This abstraction masks the allocation architecture established in Chapter 4, which embeds financial responsibility within the design. Under the UK configuration, producers are designated residual cost bearers, responsible for reconciling funding gaps generated by revenue variability, operational cost

rigidity, and return-rate performance. Exposure is therefore structurally endogenous to the scheme's allocation architecture rather than a function of external market conditions (Calabrese et al., 2026; Pokorny & Fiala, 2025).

Financial fragility follows from this designation. Producers must absorb timing mismatches and revenue volatility irrespective of operational efficiency. (Calabrese et al., 2026). Within Minsky's framework, fragility arises when fixed payment commitments must be validated by uncertain or delayed cash inflows (Minsky, 1986). DRS architecture reflects this condition, as non-discretionary payment commitments precede uncertain validating inflows, consistent with the temporal misalignment mechanism identified in Chapter 4.

This thesis departs from DRS optimisation modelling by reclassifying liquidity from a neutral flow variable to a cumulative balance-sheet condition. Such models evaluate efficiency at aggregate level and treat liquidity as a flow that equilibrates over time. In practice, settlement obligations accumulate until validated. Exposure therefore behaves as a stock of obligation rather than a transient transaction (Meadows, 2009, pp. 18–24). Governance rules institutionalise producers as the system's financial balancing agents, meaning compliance does not eliminate liquidity risk because residual designation remains embedded in design (Schneider et al., 2021).

Cumulative liability arises from the interaction of allocation geometry, temporal misalignment, and residual payer designation identified in Chapter 4. Figure 5.1 clarifies this dynamic by showing that exposure originates upstream in governance configuration rather than in firm response. Governance structure, DRS parameters, and regime interactions pre-allocate liability before operational decisions occur. Exposure is therefore an ex-ante property of system design, not an ex-post consequence of managerial behaviour.

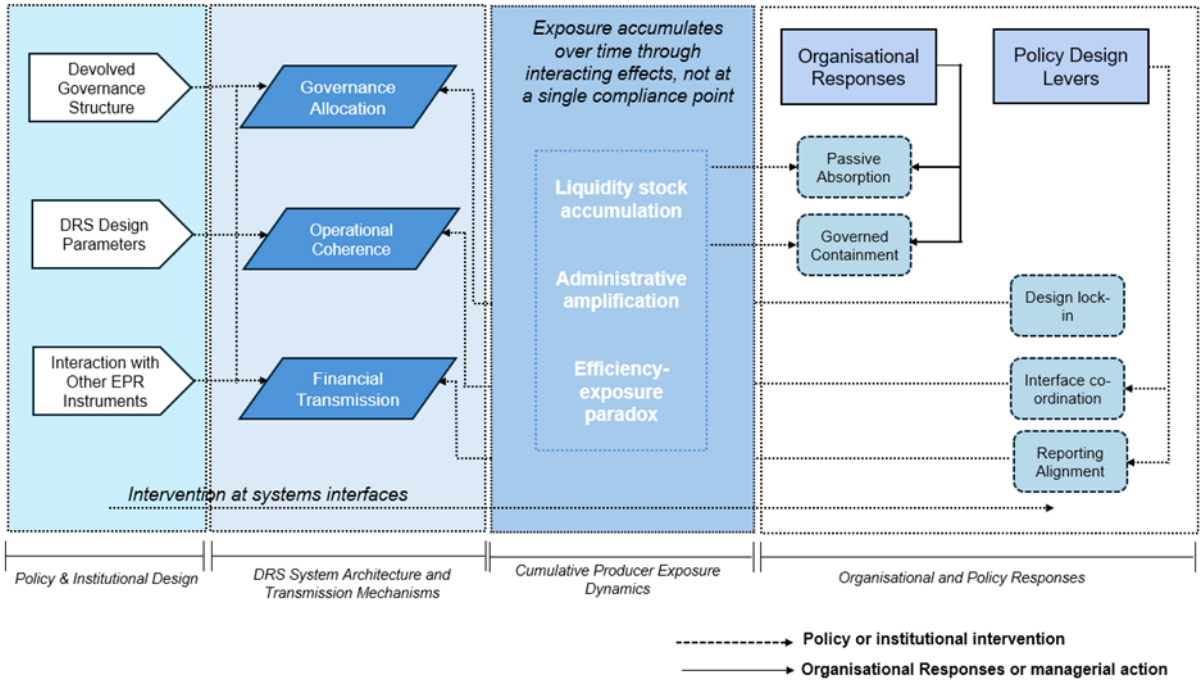

Figure 5.1 Conceptual framework linking DRS design and cumulative producer exposure, and organisational and policy responses

Figure 5.1 traces exposure from its origin in policy and institutional design. Devolved governance structure, DRS design parameters, and interaction with other EPR instruments establish the upstream configuration within which liability is allocated. Governance allocation then concentrates that liability, operational coherence shapes administrative burden, and financial transmission converts system variability into producer obligations. Liquidity stock accumulation and administrative amplification follow, producing cumulative exposure across settlement cycles. By sequencing institutional design before organisational response, the framework demonstrates that exposure is structurally generated and only subsequently governed.

The figure therefore consolidates the thesis' central claim by linking upstream institutional design to cumulative producer exposure and to the managerial and policy responses that follow.

An alternative interpretation treats producer exposure under DRS as a transitional or equilibrium-adjusting regulatory cost. Producer fees and liquidity commitments would function as pass-through instruments within competitive

markets, with firms adjusting prices, contracts, portfolios, or logistics as part of routine regulatory internalisation. As return rates stabilise, fee volatility would decline and working capital requirements would become standard treasury management rather than systemic risk.

This interpretation assumes managerial discretion that is structurally constrained within the UK configuration. Competitive dynamics, retailer bargaining power, and non-harmonised jurisdictional requirements limit unilateral adjustment. Core stabilisers lie outside producer control. Unredeemed deposits contract as performance improves, while commodity values fluctuate exogenously. Collection and settlement are externally managed, yet producers remain residual funders within a cost-recovery design. Stabilisation may moderate volatility, but it does not remove the structural sequencing asymmetry whereby fixed obligations precede validating inflows. Producer exposure under UK DRS is therefore not a transitional adjustment but structurally embedded in governance design.

5.3 Integrated Transmission Pathways: The UK DRS as a "Risk-Transfer System"

Sections 5.1 and 5.2 established that producer exposure is structurally endogenous, generated by governance and allocation rules rather than firm inefficiency. The remaining question is how that exposure is transmitted and amplified within the UK configuration. This section consolidates the mechanisms identified in Chapter 4 into four interacting transmission pathways through which exposure accumulates: allocation geometry, break-even financial architecture, capital rigidity, and liquidity timing rules.

Allocation geometry defines liability concentration. Break-even calibration converts residual deficits into fee volatility. Capital rigidity embeds those liabilities into fixed cost structures. Liquidity timing enforces upfront payment. Exposure therefore materialises through interaction rather than through any single design element.

Allocation geometry determines structural liability distribution, operationalising governance allocation architecture identified in Chapter 4. Decisions regarding deposit ownership, handling fees, and system scale determine where residual deficits crystallise. Under the UK configuration, producers are designated residual cost bearers (Calabrese et al., 2026; Schneider et al., 2021).

Under devolved governance, fragmentation acts as a stress multiplier. Divergence does not alter allocation rules but reshapes when and how liabilities crystallise through differences in reconciliation timing and jurisdictional interfaces. Devolution therefore amplifies exposure without creating a new mechanism, intensifying the interaction between allocation geometry, residual payer designation, and temporal misalignment. This amplification becomes financially material within the scheme's break-even architecture.

Break-even financial architecture constitutes the second pathway. The UK administrator operates on a not-for-profit, cost-recovery basis (Schneider et al., 2021). Within this design, unredeemed deposits function as a temporary stabilising buffer. As return rates increase, this buffer contracts and volatility is transferred into producer fees. Break-even calibration therefore operationalises residual payer logic by converting revenue variability directly into fee recalibration (Calabrese et al., 2026). Producers therefore underwrite system-level revenue volatility within this architecture.

The Scottish DRS Business Case projection of £1.08 billion in producer fees over 25 years illustrates the scale of this embedded deficit guarantor function (Scottish Government, 2019).

Capital rigidity forms the third pathway. Reverse vending machines, counting centres, and logistics networks create a fixed-cost infrastructure that does not contract proportionally with throughput (Dace et al., 2013; Lu et al., 2022). Financial exposure is therefore embedded in capital structure rather than variable cost. Because residual payer designation assigns downside variance to producers, demand fluctuation does not reduce fixed obligations. Capital rigidity thus converts allocation geometry into persistent cost exposure, intensifying cumulative liability over successive settlement cycles.

Liquidity timing completes the architecture. Producers pre-finance deposits and administration fees at market placement, often months before reconciliation (Calabrese et al., 2026; Yu, 2021). This reflects the temporal misalignment mechanism identified in Chapter 4, in which fixed payment commitments precede validating inflows. The requirement embeds a recurring working capital stock within the system. Unlike a conventional tax, the obligation scales with system expansion, positioning producers as the default liquidity providers and converting settlement sequencing into cumulative balance-sheet exposure.

Taken together, these pathways form a risk-transfer system. Allocation architecture concentrates liability. Break-even calibration transfers revenue volatility through residual payer designation. Capital rigidity embeds obligations in fixed infrastructure. Liquidity timing enforces pre-financing through temporal misalignment. Producer exposure is therefore the structural output of their interaction rather than any single mechanism in isolation.

5.4 Emergent Risk and the Efficiency-Exposure Paradox

Sections 5.2 and 5.3 established that producer exposure is structurally endogenous and transmitted through integrated pathways. This section extends that analysis by examining how exposure accumulates across successive settlement cycles. Exposure accumulates across successive settlement cycles. Instead, repeated settlement and rising return rates generate a structural trade-off in which environmental success increases financial strain for producers.

Financial fragility emerges not from system failure, but from the successful achievement of the scheme's core objectives. As return rates rise towards the 90% policy target, revenue from unredeemed deposits, which functions as an implicit financial buffer at lower return rates, contracts. Because the fixed-cost base in infrastructure, logistics, and administration does not decline proportionally with volume, the shortfall is reconciled through higher producer fees. Break-even calibration transfers performance gains directly into producer liability. This dynamic operationalises the performance-induced liquidity stress mechanism identified in Chapter 4. Improvements in collection efficiency reduce internal shock absorption and increase the proportion of system cost allocated

through residual payer logic. Environmental effectiveness and financial resilience therefore move in opposite directions under current design conditions.

This volatility is compounded by the timing of financial obligations. The "advance payment" structure identified in Yu (2021) requires producers to fund deposits and administration fees upon placing goods on the market. This creates a recurring stock of working capital embedded within the system to bridge the gap between payment and reconciliation. Because this requirement scales with throughput, liquidity exposure expands as performance improves.

These dynamics constitute an efficiency–exposure paradox. This paradox is not merely an empirical tension, but a mechanical trade-off embedded in cost-recovery DRS architecture. Where unredeemed deposits function as a balancing revenue component within a break-even settlement model, improvements in return performance reduce internal financial buffers. Under residual payer designation, this contraction increases producer fee recalibration pressure and liquidity exposure. Environmental optimisation therefore tightens financial resilience within the same governance configuration. The resulting vulnerability is intrinsic to deposit-funded, residual-allocated systems rather than a transitional implementation artefact. Under devolved non-harmonised configurations, this trade-off is further intensified because return performance and fee calibration may diverge across jurisdictions, increasing volatility within multi-market producer portfolios.

At this point, it is necessary to distinguish between two analytically separable layers shaping producer exposure: a policy configuration layer and a managerial adaptation layer. The policy configuration layer defines the allocation and timing of financial risk through governance design. The managerial layer operates within that configuration and concerns how firms recognise, contain, and sequence exposure. Managerial action can influence amplification and containment, but not the structural generation of exposure. Policy design determines the exposure envelope; managerial practice determines how that envelope is navigated.

5.5 Managerial Recommendations

Sections 5.2–5.4 established exposure as structurally generated and cumulative. Once DRS reallocates residual cost and liquidity risk to producers, the managerial problem shifts from cost minimisation to preventing amplification through governance and commercial decisions. This section addresses Research Question 3 by translating that architecture into managerial recommendations.

Recommendations are grouped into three intervention domains, summarised in Table 5.1: (1) Framing and Governance, (2) Analytical and Modelling Practices, and (3) Portfolio and Commercial Management. The table identifies the key managerial questions posed by structurally generated DRS exposure and links each to the specific exposure dynamics it addresses. It clarifies ownership within the firm and distinguishes where intervention can mitigate amplification without altering residual allocation. Detailed recommendations are developed in Sections 5.5.1–5.5.3.

Table 5.1 Managerial Recommendation Clusters

Recommendation cluster	Managerial Focus	Exposure dynamics addressed	Decision Domain	MR IDs
Framing and governance	Recognition and ownership of structurally imposed exposure.	• Normalisation and silent absorption delay escalation. • Governance determines surfacing and response.	Senior ownership. Escalation logic. Governance posture.	MR1, MR6, MR7
Analytical and modelling practices	Anticipation of cumulative exposure before commitment.	• Timing mismatch and variance. • Residual payer concentration. • Non-harmonisation distorts expected-case modelling	Financial modelling. Scenario analysis. Planning assumptions.	MR3, MR5
Portfolio and commercial management	Points of irreversibility in commercial decisions.	• Margin trading and capital commitment hard-code exposure.	Portfolio design. Pricing.	MR2, MR4

Recommendation cluster	Managerial Focus	Exposure dynamics addressed	Decision Domain	MR IDs
		• Portfolio complexity embeds cost. • Reversal requires additional exposure.	Investment sequencing.	

Figure 5.2 translates the recommendations into an organisational response matrix. The vertical axis reflects exposure intensity determined by governance allocation and timing design. The horizontal axis reflects organisational response quality.

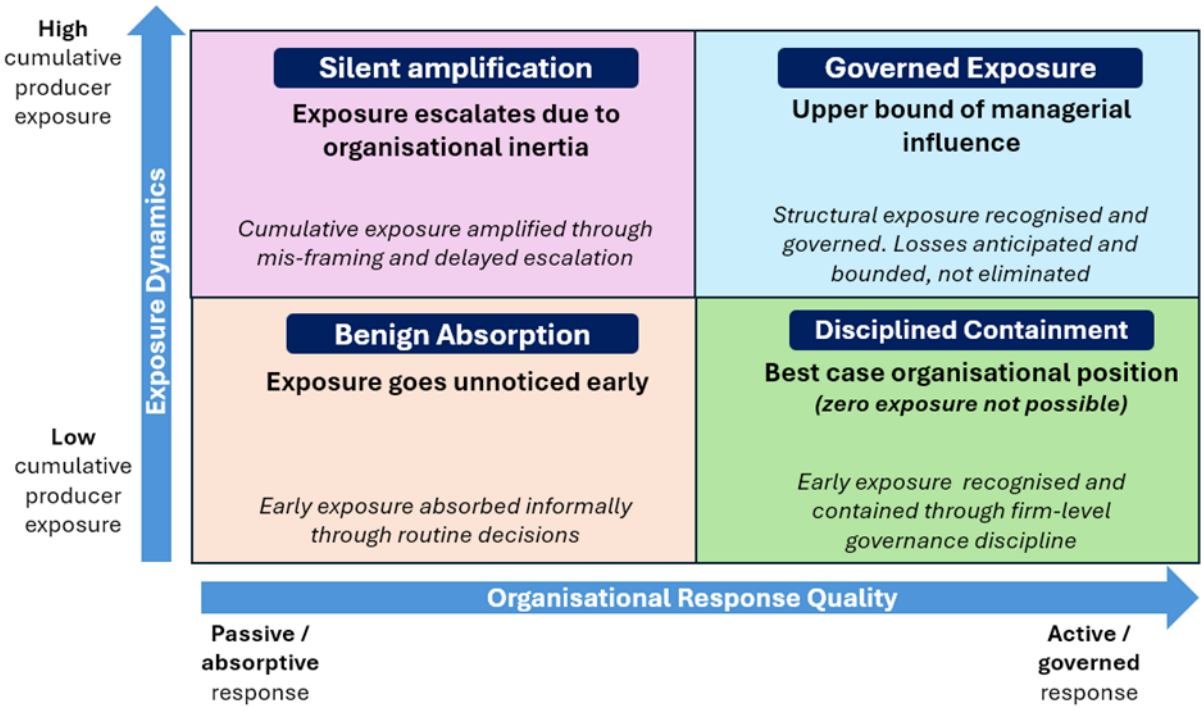

Figure 5.2 Organisational response matrix

The left-hand quadrants show the consequences of weak governance response. In benign absorption, early exposure is carried informally within routine decisions. In silent amplification, delayed escalation allows cumulative exposure to intensify.

The right-hand quadrants define the boundary of managerial influence. In disciplined containment, exposure is recognised early and bounded through governance discipline and analytical control. In governed exposure, high

cumulative exposure is formally acknowledged and managed, though not eliminated. Movement across the matrix improves response quality but does not reduce structurally generated exposure.

The figure clarifies the central distinction: exposure intensity is determined by governance design, while organisational posture determines how that exposure is surfaced and governed. Managerial action affects response discipline, not exposure generation. This distinction underpins the recommendations that follow.

5.5.1 Framing and Governance Recommendations

Producer exposure under DRS is first amplified or contained through managerial governance discipline. When structurally imposed liquidity and cost volatility are mis-framed as routine compliance expenditure, exposure is normalised and absorbed without escalation. Managerial oversight therefore determines whether structural risk is surfaced or carried. This group of recommendations classifies endogenous exposure as an explicitly governed financial risk within the firm.

Managerial Recommendation 1: Treat DRS as balance-sheet and liquidity exposure.

DRS participation should be governed as a balance-sheet and working-capital exposure, not as a compliance cost. Ownership should sit within Finance, with Supply Chain as operational co-owner. Deposit pre-financing, fee recalibration, and reconciliation lags must be mapped onto the P&L, balance sheet, and cash flow. Reporting should prioritise net cash absorption and liquidity draw rather than annualised cost neutrality.

Managerial Recommendation 7: Set explicit decision thresholds and escalation rules.

Firms should establish liquidity tolerance bands and cash-flow variance thresholds that trigger automatic escalation. Predefined responses, such as forecast revision or discretionary spend freezes, prevent gradual normalisation of structural exposure.

Managerial Recommendation 6: Treat high system performance as a financial risk signal.

Under break-even calibration, improved recovery reduces unredeemed buffers and can increase fee volatility. Firms should re-run downside liquidity scenarios when performance improves, focusing on cash position rather than environmental indicators.

5.5.2 Analytical and Modelling Recommendations

Effective managerial oversight requires analytical realism. Under residual payer designation and temporal misalignment, downside variance is internalised by producers while upside gains are capped, shared, or deferred. Firms should therefore model the full downside exposure envelope rather than rely on expected or average-case projections.

Scenario analysis should stress-test margin and liquidity under under-recovery, volatile material prices, reconciliation delays, and fee recalibration. Administrative burden, reporting complexity, parameter drift, and jurisdictional coordination costs should be treated as recurring structural conditions rather than peripheral overhead. Persistent non-harmonisation should be modelled as a standing operating environment, with parallel reporting and jurisdiction-specific reconciliation embedded in forecasts. Fraud risk, attribution disputes, and cross-border misallocation should be incorporated as delayed and imperfect recovery shocks in cash-flow scenarios.

The objective is to identify financial constraint thresholds before irreversible commercial commitments are made.

Managerial Recommendation 3: Model costs assuming residual payer exposure.

Financial models should test asymmetric volatility allocation. Downside outcomes should be assumed fully borne by producers, while upside gains are treated as capped or deferred. Margin erosion, liquidity draw, and fee escalation should be assessed under pessimistic but plausible assumptions.

Managerial Recommendation 5: Plan deliberately for UK non-harmonisation.

Non-harmonisation should be treated as structural rather than transitional. Liquidity should be stress-tested under the most complex multi-jurisdiction configuration rather than an averaged UK scenario.

This group of recommendations shift modelling from optimisation to containment. The task is not to demonstrate cost neutrality, but to define the financial boundary conditions within which the firm can operate safely.

5.5.3 Portfolio and Commercial Management

Exposure is realised at points of commercial commitment. Allocation geometry and liquidity timing translate into binding consequences when margin is traded, SKUs proliferate, or capital is committed. Once embedded in pricing or fixed assets, exposure cannot be reversed without loss.

Investment sequencing should prioritise liquidity protection during early system operation. Capital commitments should follow stabilisation of fee calibration, return rates, and reconciliation timing. Data visibility and working-capital control should take precedence over asset optimisation while parameters remain uncertain.

Portfolio decisions should be evaluated through a DRS-adjusted unit economics lens incorporating administrative complexity, jurisdictional variation, recovery uncertainty, and liquidity drag. Low-margin or high-complexity SKUs dependent on optimistic recovery or harmonisation assumptions should be flagged for redesign or controlled exit. These recommendations recognise that exposure becomes irreversible once embedded in the portfolio. The managerial task is disciplined sequencing and selection.

Managerial Recommendation 4: Align SKU and portfolio decisions with DRS cost geometry.

SKU-level analysis should apply jurisdiction-specific downside assumptions. Fixed administrative and reporting costs should be separated from volume-driven costs to identify products where complexity drives margin erosion.

Managerial Recommendation 2: Sequence investments to protect early-stage liquidity.

Irreversible expenditure should follow stabilisation of fees and settlement timing. Where downside liquidity scenarios exceed tolerance bands, discretionary DRS-linked investment should be deferred.

5.6 Policy Recommendations

Section 5.5 examined firm-level containment. This section addresses policy design within the UK circular economy and extended producer responsibility frameworks, to achieve environmental, cost and administrative efficiency goals. While firms govern exposure recognition and containment, exposure magnitude depends on regulatory configuration beyond firm control. Policy does not create new mechanisms but can amplify or mitigate those embedded in system architecture

This cost internalisation and cash flow amplification may reduce producers' discretionary capacity to fund recycled content and packaging redesign investment, creating tension between short term compliance financing obligations and long-term circular economy objectives (Calabrese et al., 2026; OECD, 2022). The magnitude of this amplification varies according to the degree of inter-jurisdictional harmonisation and the extent of regime integration versus layering.

Within the UK context, devolved divergence and regulatory stacking operate as structural stress multipliers. The UKs Internal Market Act (IMA) exclusion in February 2026 for Wales illustrates this divergence and is analysed in detail below (DEFRA, 2026; Welsh Government, 2026).

5.6.1 Devolved Fragmentation: The "Glass Gap" as a Stress Multiplier

Devolved divergence does not create new exposure mechanisms within the UK DRS framework. It amplifies those associated with governance allocation and residual cost assignment identified in Chapter 4. The February 2026 IMA exclusion permitting Wales to retain glass within scope formalises this

amplification. Although synchronised launch remains scheduled, glass in Wales will carry a zero-value deposit and remain exempt from labelling until October 2031. Regulatory inclusion is therefore separated from financial activation within a single market, preserving residual allocation asymmetry while introducing operational differentiation.

Producers must absorb this divergence through parallel SKU pathways and differentiated labelling. Early modelling for the Scottish scheme projected producer set-up costs of between £46 million and £65 million solely for market-specific labelling (Scottish Government, 2019). While framed as transitional, persistent fragmentation converts such divergence costs into recurring structural overheads.

Wales' withdrawal from the joint DMO, combined with staged glass activation, creates asymmetric enforcement and reconciliation within a single market. Producers must navigate multiple reporting interfaces and compliance interpretations, increasing administrative burden independently of scheme performance.

International evidence shows that producer exposure varies with governance configuration. Centralised operator models, such as the 'Archetype A' systems identified in Scandinavia, consolidate material flows and financial clearing within a single entity, reducing fragmentation in cost allocation and reconciliation (Calabrese et al., 2021). By contrast, systems layered onto existing collection infrastructures exhibit parallel operational layers and cost duplication, increasing producer service charge pressures (Dace et al., 2013). Exposure intensity therefore varies with inter-jurisdictional harmonisation and regime integration rather than on deposit return design per se. The UK's devolved and layered configuration occupies a higher-friction position on this spectrum, implying that coordination reforms can attenuate exposure without altering environmental objectives.

5.6.1.1 Policy recommendation: Interface co-ordination and interoperability

Uncoordinated operational interfaces are a significant source of amplification. Fragmented reporting and reconciliation structures increase administrative duplication and weaken enforcement coherence. A unified interface, facilitated through the UK DMO, would improve allocative coherence by aligning producer responsibility mechanisms with circular material flows while limiting avoidable financial volatility.

5.6.1.2 Policy Recommendation: Design durability and lock-in

Exposure is further amplified by scheme design instability. Where material scope, operator models, or reporting requirements remain open to late-stage revision, producers must provision against multiple configurations simultaneously. Establishing formal cross-jurisdictional lock-in points, beyond which core parameters cannot be revised without defined transition windows, would reduce exposure driven by policy volatility rather than substantive design divergence.

5.6.2 Regulatory Stacking: Aligning Overlapping Compliance Regimes

Beyond devolved fragmentation, exposure amplification arises from the interaction of DRS with adjacent regulatory regimes. The concurrent rollout of DRS alongside reform of other EPR instruments, transitioning from Packaging Recovery Notes (PRNs) to packaging EPR (pEPR), creates overlapping liquidity and reporting obligations. Producers therefore face concurrent settlement regimes with distinct cash-flow structures: PRN compliance relies on periodic certificate-based settlement, whereas DRS imposes continuous pre-financing of deposits and infrastructure. This timing asymmetry increases planning uncertainty and administrative burden, particularly given historically volatile PRN prices (RECOUP, 2023). The result is a regime-overlap stressor in which system-level efficiency gains coincide with heightened firm-level financial fragility.

5.6.2.1 Policy Recommendation: Align Reporting Periods and Reconciliation Cycles

Aligning reporting periods and reconciliation cycles across DRS and packaging EPR would reduce administrative friction and liquidity strain without altering substantive scope. Greater interface coherence would attenuate amplification driven by timing misalignment rather than policy intent.

5.6.2.2 Policy Recommendation: Clarify boundary definitions at the DRS–pEPR interface

Clearer boundary definitions would reduce exposure amplification by limiting classification uncertainty at the DRS–pEPR interface. Primary containers fall under DRS, while associated secondary packaging remains subject to pEPR reporting and fee obligations. This non-integration requires parallel data tracking within a single product unit, increasing administrative error risk. Strengthening boundary coherence would mitigate avoidable operational burdens without altering the fundamental allocation of responsibility.

5.6.3 Institutional and Political Feasibility

The policy recommendations are technically coherent within the exposure architecture identified in this thesis, but implementation is shaped by institutional and political constraints. The current UK configuration reflects devolved divergence and additive regulatory sequencing. In institutional terms, exposure intensity therefore varies along two dimensions: inter-jurisdictional harmonisation and regime integration versus layering.

UK DRS reflects prolonged intergovernmental negotiation within a devolved constitutional framework. Non-harmonisation in material and operator arises because devolved administrations possess constitutional authority to diverge and have exercised that authority in line with distinct policy preferences. Achieving interoperable interfaces and durable design stability therefore depends on intergovernmental agreement rather than technical optimisation alone.

DRS and packaging EPR were legislated through separate statutory pathways and implementation timetables, producing partial coordination rather than structural integration. Their temporal overlap reflects legislative sequencing shaped by negotiation and administrative capacity constraints. Together, they operate as a layered institutional arrangement.

The recommendations should therefore be interpreted as exposure-mitigation adjustments within existing constitutional and legislative parameters. Implementation depends on intergovernmental alignment and statutory amendment cycles, making incremental coordination more feasible than comprehensive structural redesign.

5.7 Summary

This chapter has demonstrated that producer exposure under the UK DRS is structurally embedded within system architecture and cumulative over time. Sections 5.2 and 5.3 established exposure as an endogenous system outcome transmitted through allocation geometry, financial architecture, capital rigidity, and liquidity timing.

Section 5.4 introduced the efficiency–exposure paradox, showing that within a break-even, residual-funded system, environmental success and financial resilience move in opposing directions because of governance configuration. Sections 5.5 and 5.6 translated this structural diagnosis into managerial containment and policy attenuation.

In contrast to dominant DRS analyses that prioritise aggregate welfare and system efficiency, this chapter positions producer exposure as a predictable outcome of governance configuration. Vulnerability is therefore not incidental but contingent on institutional design choices within circular economy policy. Deposit return systems do not merely optimise material recovery; they allocate financial risk. The distribution and timing of that risk are shaped by decisions concerning harmonisation, residual designation, and regime integration. Governance architecture jointly shapes recovery performance and the

distribution of financial fragility, rendering environmental optimisation and financial resilience structurally interdependent.

6 Conclusion

6.1 Analytical Framing of Producer Exposure

This thesis examined how a UK DRS will shape the operational configuration and financial exposure of soft-drinks producers within an evolving and partially specified regulatory environment. At the time of analysis, key elements of scheme design, fee calibration, and settlement architecture remain unsettled, while policy confirmed divergence across UK jurisdictions introduces further uncertainty.

The motivating concern was not only potential cost magnitude but the absence of a coherent structural explanation for how exposure would be generated and amplified under fragmented governance design.

Through systematic reconstruction of governance, allocation, and settlement rules, the study demonstrates that producer burden is structurally produced rather than incidentally incurred. Fragmented policy architectures operate as exposure multipliers rather than administrative variations. Producer exposure under UK-style DRS therefore emerges as a cumulative financial dynamic shaped by institutional configuration rather than a marginal compliance cost.

6.2 Structural Determinants of Producer Exposure

Chapter 4 established that producer exposure under UK DRS is generated through governance, allocation, and settlement design rather than arising incidentally from firm-level behaviour. The analysis identified a set of causal pathways through which policy architecture converts operational obligations into financial transmission effects for producers.

Residual allocation rules position producers as balancing agents within non-profit systems. Settlement timing and deposit pre-financing embed liquidity misalignment within routine operations. These rules also require enhanced data governance, forecasting precision, and cross-instrument coordination.

Exposure accumulates across accounting cycles and intensifies as return performance improves. Fragmented governance replicates these pathways

across jurisdictions, amplifying administrative and financial complexity. The scale and timing of exposure are therefore conditioned by design rather than by individual firm performance. Producer burden emerges as the structured outcome of identifiable institutional rules rather than as a one-off compliance charge.

6.3 Integrated Transmission Architecture

Chapter 5 moved from mechanism identification to system-level interpretation. It demonstrated that the pathways identified in Chapter 4 form an integrated transmission architecture through which exposure accumulates over successive settlement cycles rather than dissipating as implementation stabilises.
This dynamic is visible in the efficiency–exposure paradox, where improvements in environmental performance intensify financial pressure under fixed allocation rules. Producer burden therefore constitutes a persistent design condition rather than a transitional issue.

The chapter extended this interpretation into managerial and policy positioning, linking exposure dynamics to commercial planning, liquidity management, operational reconfiguration, and the coordination challenges created by devolution and overlapping EPR instruments.

6.4 Contribution: Structural Generation of Producer Exposure under UK DRS Design

The central contribution of this thesis is to demonstrate that producer exposure under UK-style DRS architecture is structurally generated through governance, allocation, and settlement design rather than arising as a fixed compliance cost or incidental implementation effect.

By integrating fragmented accounts in the literature, the analysis reconstructs these design features into a coherent explanatory framework through which operational obligations convert into cumulative and potentially volatile financial exposure.

The thesis shifts attention from distributive accounting questions concerning cost magnitude to architectural questions concerning how scheme design concentrates financial balancing functions. It shows that DRS design reshapes both exposure and operational configuration through governance and timing rules, and that UK policy divergence amplifies these dynamics through non-harmonised structures.

Explanation is therefore repositioned from firm conduct to institutional configuration. Producers bear residual financial responsibility under rules over which they exercise limited design authority, creating misalignment between liability concentration and structural control. Effective interpretation and management of exposure require engagement with these institutional conditions.

6.5 Implications for Producer Strategy and Policy Design

For managers, DRS should be interpreted as an endogenous financial dynamic embedded within governance and settlement design rather than as a fixed compliance obligation. Exposure operates as a residual risk-transfer mechanism and may intensify as return performance improves. Financial planning must therefore account for cumulative and potentially volatile exposure across settlement cycles.

Operationally, this requires coordination across forecasting, data governance, liquidity management, and cross-jurisdictional product configuration. Interaction with parallel EPR instruments and non-harmonised UK implementation replicates design pathways and increases complexity. The strategic challenge lies in managing architectural volatility within commercial planning frameworks.

For policymakers, allocation and settlement rules are central determinants of exposure distribution rather than administrative detail. Fragmented or non-harmonised architectures function as exposure multipliers. Policy coordination therefore influences balance-sheet stability within producer systems and carries financial consequences beyond headline cost projections. However, adjustment of these design features is institutionally complex, as DRS operates within devolved governance arrangements, intergovernmental negotiation

processes, and established statutory instruments. Architectural modification therefore requires coordinated political alignment rather than technical recalibration alone.

6.6 Limitations and Future Research

This section clarifies the limits of the claims made and identifies areas for future research. Limitations are structured across policy architecture, managerial and technological capability, and research design.

6.6.1 Policy-Level

This thesis analyses exposure within the current UK Deposit Return Scheme governance architecture and does not model compounded interaction with parallel regulatory instruments. The analysis does not include structured comparison with other international DRS governance models. Exposure dynamics are therefore interpreted within the specific institutional configuration of the UK rather than benchmarked against centralised or harmonised systems in other jurisdictions.

Cumulative financial and liquidity effects arising from interaction between DRS and packaging Extended Producer Responsibility regimes are not quantified. Potential escalation of minimum recycled content requirements under emerging EU pathways may further interact with deposit-financed material flows and influence cost allocation dynamics.

The analysis also abstracts from financial modelling of devolved divergence. While non-harmonisation between Wales and the rest of the UK is recognised, the consequences of managing cross-jurisdictional product portfolios, including glass exclusions and participation across distinct Deposit Management Organisations, are not quantified. Fraud risk and cross-border leakage are likewise not incorporated into the exposure model.

Future research should include quantitative modelling of multi-regime interaction, devolved portfolio complexity, and comparative evaluation of centralised versus fragmented governance allocation models. Such work would

allow empirical testing of the divergence-related exposure mechanisms identified here.

6.6.2 Managerial and Technological Level

The analysis does not consider variation in technological infrastructure and managerial capability across supply chain actors. Differences in digital maturity, liquidity monitoring systems, and cross-functional coordination may moderate realised exposure.

These factors do not alter the structural architecture identified but may influence outcome magnitude. Empirical investigation of technological integration and managerial capability would clarify how organisational maturity interacts with governance design to shape exposure control.

6.6.3 Research Design Limitations

The study is confined to UK-style DRS governance architecture and is necessarily pre-operational. It relies on systematic informed review and conceptual mechanism development rather than primary empirical data or financial modelling.

The thesis therefore offers architectural clarification of exposure pathways rather than predictive measurement of financial impact. Post-implementation financial analysis applying these pathways would enable empirical testing of liquidity effects, fee recalibration volatility, and interaction across devolved jurisdictions and parallel regulatory regimes.

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Appendices

Appendix A Ethical approval letter

24 January 2026

Dear Miss McLean ,

Reference: CURES/27018/2026
Project ID: 30439
Title: Deposit Return Schemes and Producer Exposure in the UK Soft Drinks Sector: A Systematic Literature Review

We are pleased to inform you that you have successfully declared that your research project is a **Literature Review – based solely on openly available literature which is in the public domain, and you are undertaking desk-based research not involving any other form of data or information.**

You have also confirmed that your project **does not meet** any of the literature review specified exceptions, listed both within the relevant section of the CURES form and below:

1) Your supervisor has requested that you apply for approval through CURES because:

- The journals or data are in a sensitive area (please discuss this with your supervisor)
- The project will be embargoed **i.e. will not be publicly available via the Cranfield library immediately or longer term**

2) Approval is/will be specifically required by another external body e.g. journal publishers

Therefore, **you do not require ethical approval** and your CURES application will be automatically closed.

Please keep a copy of this letter safe, if this exception is in relation to your thesis project, you will need to include a copy with your final thesis submission.

If you have any queries, please contact CURES Support.

We wish you every success with your project.

Regards,

CURES Team

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Appendix B Structural Map of Producer Exposure under UK DRS

Category	Exposure Component	Cash-Flow Direction	Functional Direction	Timing	Variability Driver	Allocatioin / Risk Note
Deposit	Statutory deposit per container	Outflow (initial)	Deposit applied to each in-scope container placed on market	Pre-financed	Fixed per unit	Refunded to consumers upon return
Handling fees	Retail handling fee	Outflow	Compensation to retailers for collection and handling of returned containers	Ongoing	Volume-linked	Includes labour and space
Handling fees	RVM handling fee	Outflow	Payment for automated return infrastructure	Ongoing	Volume-linked	Rate may vary by return infrastructure type
Operating costs	Scheme operating fee	Outflow	Contribution to DMO for administration, IT, logistics	Periodic	Scheme-dependent	Structure varies by scheme design
Compliance	Registration & reporting	Outflow	Data reporting, audits, reconciliation	Periodic	Low	Indirect and recurrent
Operations	Supply chain adjustments	Outflow	Packaging, labelling, barcode changes	Transitional / ongoing	Firm-specific	Cost recovery not guaranteed
Revenue	Unredeemed deposits	Inflow / offset	Deposits from unreturned containers	Delayed	Return-rate dependent	Allocation contingent on scheme design
Revenue	Material sales revenue	Inflow	Sale of collected PET, aluminium, etc.	Lagged	Market-dependent	Subject to commodity price volatility
Balancing	Fee rebates / adjustments	Inflow (conditional)	Corrections from prior periods	Delayed	Scheme-dependent	Not consistently implemented across schemes
Residuals	Residual cost allocation	Outflow	Costs not covered by deposits or revenues	End-of-cycle	High	Typically allocated to producers under balancing rules
Liquidity	Timing mismatch exposure	Exposure (not line item)	Structural timing mismatch between outflows and inflows	Continuous	Scale-dependent	Drives cash-flow stress
Scaling	Volume amplification	Exposure driver	Growth in absolute cash flows per cycle	Cumulative	System-driven	Amplifies aggregate exposure across cycles