

Logistics Processes as Enablers in the Transition to a Circular Economy: A Systematic Literature Review

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Abstract

Background: Logistics plays a fundamental role in enabling the Circular Economy (CE), yet existing research has predominantly emphasized reverse logistics (RL) activities, providing limited understanding of how individual logistics processes contribute to different circular strategies. This study examines how logistics processes enable the implementation of R-strategies across supply chains. **Methods:** Following the PRISMA protocol, a qualitative content analysis was conducted on 116 peer-reviewed studies, classifying the literature according to nine logistics processes and ten R-strategies (R0–R9). **Results:** The findings show that research is heavily concentrated on Reverse and Circular Logistics, particularly return, collection, repair, refurbishment, remanufacturing, recycling, and value recovery activities. Reuse (R3), Recycle (R8), and Reduce (R2) are the most frequently addressed strategies, whereas Refuse (R0) and Rethink (R1) are comparatively less represented in the reviewed corpus. **Conclusions:** This review proposes a framework linking logistics processes with R-strategies and highlights the need to extend attention beyond end-of-life recovery toward preventive logistics capable of avoiding waste generation and preserving resource value across product life cycles. The findings should be interpreted in light of the restricted search strategy, which may have excluded studies using alternative terminology for circularity and logistics.

Keywords: circular economy; logistics processes; reverse logistics; R-strategies; sustainable supply chain management; systematic literature review



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1. Introduction

The linear economic model, commonly referred to as the take–make–dispose or cradle-to-grave model, has dominated production and consumption systems for decades. Under this paradigm, natural resources are extracted, transformed into consumer goods, and ultimately discarded, with most waste ending up in landfills, incineration facilities, or the environment, generating significant environmental and social impacts [1]. As resource depletion intensifies and ecosystems face increasing pressure, this model is becoming

progressively unsustainable, highlighting the need for economic systems that reduce dependence on virgin materials [2].

In response, the CE has emerged as an alternative paradigm that seeks to preserve resource value by closing material and energy loops through strategies such as redesign, reuse, and regeneration [3,4]. Beyond its environmental benefits, CE promotes new business models, including Product-as-a-Service (PaaS) and Product-Service Systems (PSS), that encourage value retention throughout product life cycles while reducing resource consumption [5–7]. These approaches are commonly operationalized through hierarchical R-strategies that prioritize resource prevention and value retention over recycling and recovery [8]. Despite its growing relevance, the large-scale adoption of CE remains constrained by the limited economic viability of many circular business models [9].

The urgency of this transition is reinforced by mounting environmental evidence. Current rates of natural resource extraction exceed ecosystem regeneration capacity [10], while rising greenhouse gas emissions associated with industrial production continue to intensify climate and environmental pressures [11]. Together, these challenges demonstrate that the linear model is no longer a viable pathway for sustainable industrial development [12]. Consequently, the transition toward CE has become a strategic priority for governments, international organizations, and businesses seeking to decouple economic growth from resource consumption while strengthening competitiveness and sustainability [13]. This transition has also stimulated the development of circularity metrics, integrated assessment frameworks, and corporate performance indicators that enable organizations to evaluate and monitor CE implementation across value chains [14–16].

The CE can be implemented at three complementary levels: macro, meso, and micro. The macro level encompasses public policies and regulatory frameworks that promote sustainable production and consumption [2]. At the meso level, eco-industrial parks and industrial symbiosis facilitate the exchange of materials, energy, and information among organizations to improve collective resource efficiency [17]. The micro level focuses on firms, products, and consumers, where circular product design, efficient resource utilization, and business models based on reuse, repair, refurbishment, remanufacturing, and sharing practices translate CE principles into operational decisions [18].

Among these levels, the micro level is particularly relevant because organizational decisions determine how resources, materials, and operational flows are managed throughout supply chains [19]. Companies shape production systems, product design, sourcing strategies, and EoL management practices that ultimately define the degree of circularity achieved [20,21]. Consequently, CE implementation depends on operational capabilities supported by traceability, efficient resource management, and digital technologies that enable measurable improvements in sustainability performance [22,23].

Within this operational context, logistics has become a strategic enabler of CE implementation by coordinating material, information, and financial flows across supply chains [24]. Through collaboration, digitalization, and traceability, logistics facilitates resource efficiency, value recovery, and the synchronization of stakeholders required to support circular business models and closed-loop systems [25–29].

Despite this growing recognition, understanding how individual logistics processes contribute to CE implementation remains limited. Existing studies primarily emphasize RL, closed-loop supply chains, and digitally enabled traceability [30], together with interorganizational collaboration and circular business models requiring logistics reconfiguration to recover value and close material loops [31]. However, these contributions remain fragmented across specific logistics activities, providing only a partial understanding of how the complete set of logistics processes enables CE implementation. Therefore, a systematic analysis of emerging research themes and trends is needed to clarify the contribution of

individual logistics processes, identify existing research gaps, and provide a comprehensive foundation for future research and managerial practice.

Previous literature reviews have recognized logistics as an important enabler of CE, but they have examined this relationship from substantially different perspectives and levels of analysis. Several reviews have focused primarily on RL and its relationship with CE, addressing issues such as product returns, recovery activities, implementation barriers, stakeholder involvement, technological enablers, and reverse-logistics system design [32–36]. Other reviews have examined specific logistics-related domains, including sustainable and industrial packaging, logistics service providers (LSPs), or specific sectors such as construction and urban road transport [37–41]. At the SC level, previous studies have addressed the conceptualization of CSCs and the strategic integration of forward and reverse flows [42,43]. These contributions have therefore generated valuable knowledge on specific dimensions of the logistics–CE relationship, but their analytical scopes, units of analysis, sectoral boundaries, and representations of CE strategies differ considerably.

Table 1 compares the main characteristics of these previous reviews, focusing on their scope, methodological coverage, logistics focus, representation of CE strategies, and identified limitations.

Table 1. Comparison of previous literature reviews on logistics and CE.

Review	Scope	Databases/Period	Logistics Focus	CE Strategies/Framework	Main Limitation
[41]	Sustainable packaging in SCM	Journal-based SLR	Packaging logistics	CE design, business models, reverse cycles, enablers	Packaging-specific
[30]	CSC	Scopus, WoS	CSC/SC processes	CE/CSC conceptualizations	Conceptual focus
[32]	RL implementation	2011–2021; 116 studies	RL activities and implementation	Recovery-oriented CE	RL-centric
[39]	CE in construction	SLR	FL + RL phases	R-strategies	Construction-specific
[34]	CE–RL relationship	WoS, Scopus, ScienceDirect, TRID; 277 studies	RL	Recovery, reuse, recycling, remanufacturing	RL-centric
[35]	CE–RL relationship	PRISMA; 20 studies	RL	Reuse, recovery, recycling	Small final sample
[36]	CE + RL in OM	WoS; 2018–2022	RL/OM	CE–RL	OM-specific
[43]	CE in urban road transport	WoS	Transport/logistics	Multiple CE applications	Sector + database limitation
[40]	Industrial packaging	WoS; 2227 initial records	Packaging/logistics	Slowing/closing loops	Packaging-specific
[42]	Logistics in CE	Theoretical review	Network design, sourcing, routing, reverse flows	Reuse, remanufacturing, recycling	Not a systematic review
[37]	LSP circular business models	112 studies	LSPs/logistics networks	Circular business models	LSP/Circular business model specific
This review	Logistics processes and CE	Scopus and WoS; 116 studies	Nine logistics processes	R0–R9	Alternative terminology may be missed

The comparison in Table 1 indicates that existing reviews can be broadly grouped into four complementary streams. The first is centered on RL, where CE implementation is mainly examined through product returns, recovery, reuse, recycling, and remanufacturing activities [32,34–36]. The second addresses specific logistics functions or applications, such as packaging and transportation [40,41,43]. The third adopts a sectoral or actor-specific perspective, including construction and LSPs [37,39]. The fourth examines logistics and circularity primarily at the supply chain (SC) or conceptual level, emphasizing CSC configurations, forward–reverse flow integration, and broader strategic trade-offs [30,42]. Although these streams have substantially advanced the field, they do not provide a common analytical structure for comparing the contribution of individual logistics processes across CE strategies.

In particular, the existing literature does not provide a comprehensive cross-sectoral synthesis that systematically relates individual logistics processes to the full spectrum of CE strategies. While some previous reviews explicitly employ R-strategies or related circularity frameworks, these strategies are generally examined within specific sectors, logistics functions, or reverse-logistics contexts rather than being systematically mapped against logistics processes as the primary analytical dimension. Conversely, reviews that consider logistics more broadly generally do not provide a systematic process-level analysis of the R0–R9 hierarchy. Consequently, the relationship between individual logistics processes and the different levels of circularity represented by the R0–R9 framework remains insufficiently systematized.

Against this background, this review positions logistics processes as an operational layer through which CE strategies can be implemented. The study systematically analyzes 116 studies and maps nine logistics processes against the R0–R9 CE strategy framework. This process–strategy perspective makes it possible to distinguish logistics contributions to preventive and value-retention strategies from those associated with reactive, recovery-oriented circularity. It also enables the identification of cross-process relationships and underrepresented process–strategy combinations that remain less visible when the literature is examined primarily through the lens of RL or CSCs.

Accordingly, the objective of this study is to synthesize the existing evidence on how logistics processes enable CE implementation and to identify the main patterns and research opportunities emerging from this relationship. To achieve this objective, the review addresses the following research questions:

RQ1. Which logistics processes have received the greatest research attention in the literature on CE, and how do they contribute to CE implementation?

RQ2. How are the different logistics processes associated with the R0–R9 CE strategies?

RQ3. What research trends characterize the relationship between logistics processes and CE implementation?

RQ4. What research gaps and future research opportunities emerge from the existing evidence on logistics processes and CE?

The remainder of this paper is organized as follows. Section 2 presents the conceptual framework on logistics and CE. Section 3 describes the systematic literature review methodology. Section 4 reports the main findings concerning logistics processes, CE strategies, enabling technologies, and emerging research trends. Section 5 discusses the theoretical and managerial implications of the results and identifies future research opportunities. Finally, Section 6 presents the main conclusions of the review.

2. Conceptual Framework: Logistics Processes and CE

2.1. Logistics as an Integrated Operational System

Logistics constitutes an integrated operational system responsible for planning, implementing, and controlling the flow of materials, products, services, and information throughout the supply chain to simultaneously achieve cost efficiency and customer service objectives [44]. While classical logistics primarily focused on the movement and storage of goods, contemporary perspectives recognize it as a strategic capability that integrates internal operations, suppliers, and customers through synchronized material and information flows, thereby enhancing operational performance and supporting SCM [45,46].

From this systemic perspective, logistics seeks to deliver the right product, in the right quantity, at the right place, at the right time, and at the lowest possible cost [44]. Achieving these objectives requires the continuous synchronization of physical and information flows, enabling organizations to fulfill service commitments, respond to changing customer requirements, and maintain reliable and uninterrupted operations [47,48]. Consequently, logistics performance depends not only on the efficient execution of individual activities but also on the effective coordination of interconnected processes, which strengthens organizational adaptability, improves supply chain efficiency under dynamic operating conditions, and promotes value creation [49–51].

The growing complexity of global supply chains has further expanded the principles governing logistics systems. Although classical logistics emphasized the integration of activities to balance cost and service performance [52], contemporary logistics increasingly prioritizes agility, resilience, flexibility, and risk management to address uncertainty, disruptions, and sustainability challenges [48,53]. Agility enables organizations to rapidly reconfigure logistics networks, inventories, transportation, and distribution processes in response to changing market conditions [54,55], whereas resilience reflects the ability to anticipate, absorb, adapt to, and recover from disruptions while maintaining operational performance [56]. Accordingly, modern logistics systems incorporate structural flexibility, strategic redundancy, and collaborative risk management practices that enhance decision-making, information sharing, and supply chain continuity across all logistics processes [57–59].

2.2. Core Logistics Processes

Logistics operates through an interconnected set of processes that coordinate material, information, and financial flows across the supply chain, ensuring the efficient movement of resources from suppliers to end customers and, increasingly, back into productive systems [60]. Rather than functioning as isolated activities, these processes constitute an integrated operational architecture in which decisions made within one process directly influence the performance of the others. Such interdependence is particularly relevant in CE contexts, where value creation depends on the coordinated management of forward and reverse flows throughout the product life cycle.

Drawing upon the logistics literature, this study adopts a process-based framework comprising nine core logistics processes: Demand Management and Forecasting, Procurement, Purchasing and Sourcing, Production Logistics Processes, Warehousing, Inventory Management, Material Handling and Packaging, Transportation, Distribution and Order Fulfillment, and Reverse and Circular Logistics. Although terminology varies across authors, these processes are consistently recognized as the operational building blocks of logistics systems and SCM [48,53,55,61]. Collectively, they represent the analytical framework adopted in this review.

Each process fulfills a distinct yet complementary role within the logistics system. Demand Management and Forecasting aligns organizational capabilities with anticipated

market requirements through forecasting and predictive analytics [62]. Procurement, Purchasing and Sourcing secure the timely acquisition of materials and services required to sustain operations [63]. Production Logistics Processes coordinate internal material flows that support efficient manufacturing operations [64]. Warehousing provides the infrastructure for temporary storage while optimizing space utilization and operational performance [65]. Inventory Management establishes policies governing stock levels, replenishment decisions, and inventory positioning, increasingly supported by digital technologies such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain [66].

Similarly, Material Handling and Packaging ensure the efficient movement, protection, and consolidation of products throughout logistics operations while improving resource utilization [67]. Transportation manages the physical movement of materials and products across supply chain nodes [68], whereas Distribution and Order Fulfillment connect production and warehousing systems with customers through order processing and product delivery, directly influencing responsiveness and competitiveness [69]. Finally, Reverse and Circular Logistics coordinates product returns, recovery, refurbishment, remanufacturing, recycling, and resource reintegration, enabling organizations to retain value while minimizing waste generation [70].

Collectively, these nine processes should not be viewed as independent functional areas but as interdependent components of a single operational system. Their integration enables organizations to synchronize material and information flows while supporting the implementation of CE strategies across product life cycles. Accordingly, this process-based framework provides the conceptual foundation for the subsequent analysis by examining how each logistics process contributes to CE implementation. Figure 1 summarizes the proposed architecture, illustrating the integration of the nine core logistics processes within business operations and SCM.

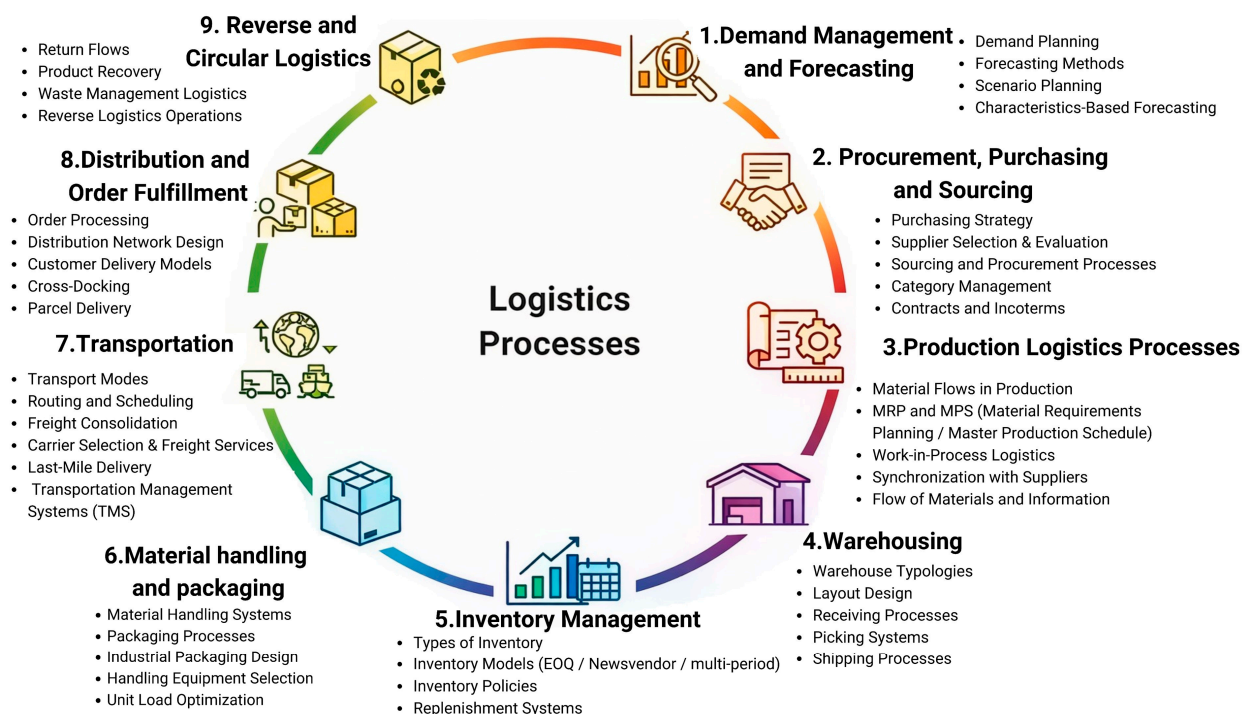


Figure 1. Core logistics processes for SCM and CE implementation.

2.3. CE as an Analytical Framework

CE represents a systemic transition from the traditional linear model of production and consumption toward a regenerative approach that emphasizes resource efficiency,

value retention, and waste prevention [1]. Rather than following the conventional take–make–dispose paradigm, CE seeks to preserve natural capital by extending product life cycles, maximizing resource utilization, and maintaining the value of products, components, and materials through closed-loop systems [71]. Beyond its environmental dimension, CE has evolved into a strategic framework that promotes sustainable production, responsible consumption, technological innovation, industrial competitiveness, and supply chain resilience [72–75].

At the organizational level, CE is commonly operationalized through the family of R-strategies, which prioritize actions according to their ability to preserve product and material value throughout the life cycle [76]. Although several taxonomies have been proposed, ranging from the traditional 3R framework to more comprehensive R0–R9 classifications [77–83], they all share a common objective: prioritizing value retention over waste management by favoring preventive and restorative actions before recycling or energy recovery. Among these approaches, the R0–R9 framework provides the most comprehensive representation of CE strategies because it encompasses the full spectrum of value-retention mechanisms. It includes Refuse (R0), Rethink (R1), and Reduce (R2), which seek to avoid unnecessary resource consumption; Reuse (R3), Repair (R4), Refurbish (R5), Remanufacture (R6), and Repurpose (R7), which extend the useful life of products and components; and Recycle (R8), Recover (R9), and, in extended versions, Re-mine (R10), which recover material or residual value when higher-value strategies are no longer feasible [8,84].

The successful implementation of these strategies depends on logistics systems capable of coordinating material, information, and financial flows across supply chains. Logistics enables product returns, resource exchanges, industrial symbiosis, and closed-loop operations while providing the traceability, visibility, and coordination required to retain value throughout multiple product life cycles [37,85,86]. Moreover, achieving CE objectives requires logistics decisions to be aligned with sustainability goals through the redesign of planning, execution, and control processes that support circular business models [87,88].

Accordingly, this study adopts the R0–R9 framework as the CE dimension of analysis and integrates it with the nine core logistics processes. Together, these two complementary frameworks constitute the conceptual foundation of this review, enabling a systematic examination of how individual logistics processes support specific CE strategies across supply chains. In this review, the circularity framework refers consistently to the R0–R9 framework, comprising ten R-strategies from Refuse (R0) to Recover (R9). Although some studies and extensions of the R-strategy taxonomy propose additional strategies, including an R10 category, these extensions are outside the scope of the present review and are not included in the coding framework. Accordingly, throughout the manuscript, we use the R0–R9 framework and ten R-strategies (R0–R9) consistently.

3. Methodology

3.1. Research Design and Review Protocol

This study employs a SLR to systematically identify, evaluate, and synthesize scientific literature on the role of logistics processes in enabling CE implementation. SLRs provide a rigorous and transparent methodology for consolidating existing knowledge, identifying research trends, revealing knowledge gaps, and establishing future research agendas within a specific scientific domain [89]. The review protocol follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines [90], which provide a standardized framework to ensure transparency, reproducibility, and methodological rigor throughout the review process (Table S1). Following the PRISMA protocol, the review was conducted through four sequential phases: identification, screening, eligibility, and inclusion.

Beyond identifying relevant studies, this review aims to explain how logistics processes contribute to CE implementation across supply chains. Accordingly, the methodological design combines systematic document retrieval with a structured qualitative content analysis, allowing the literature to be examined from both descriptive and analytical perspectives.

3.2. Search Strategy and Data Sources

The identification phase was conducted by searching the Scopus and Web of Science (WoS) databases, two internationally recognized bibliographic sources distinguished by their extensive coverage of peer-reviewed journals, rigorous indexing standards, and comprehensive citation metadata [91]. These databases are widely considered the most reliable sources for systematic literature reviews because they provide high-quality scientific publications, standardized bibliographic information, and robust citation tracking, thereby enhancing the transparency, reproducibility, and reliability of evidence synthesis.

The search strategy included terms associated with demand and forecasting, planning, procurement and sourcing, material and product flows, scheduling, warehousing and storage, inventory, packaging, material handling, transportation, delivery, distribution, fulfillment, RL, returns, and customer-related logistics activities. Particular emphasis was placed on the TITLE field because the title generally reflects the primary research focus of a publication. The TITLE field was deliberately selected to maximize thematic specificity, ensuring that CE and at least one logistics process constituted the central topic of the study rather than secondary concepts mentioned only marginally. In addition, the term logistics was required within the TITLE-ABS-KEY field to ensure that the retrieved studies were explicitly framed within the logistics domain and not merely associated with isolated operational activities. Accordingly, database-specific search equations were applied as follows:

- Scopus (*TITLE* (circular* AND (demand OR forecast* OR planning OR procurement OR purchas* OR sourcing OR supplier OR “material flow” OR “product* flow” OR schedul* OR warehous* OR storag* OR inventory OR “stock management” OR pack* OR “Material Handling” OR transport* OR delivery OR last-mile OR distribution OR fulfil* OR reverse OR return OR customer)) AND *TITLE-ABS-KEY* (logistics))
- WoS (*TI*=(circular* AND (demand OR forecast* OR planning OR procurement OR purchas* OR sourcing OR supplier OR “material flow” OR “product* flow” OR schedul* OR warehous* OR storag* OR inventory OR “stock management” OR pack* OR “Material Handling” OR transport* OR delivery OR last-mile OR distribution OR fulfil* OR reverse OR return OR customer)) AND *TS*=(logistics))

The search was performed in December 2025 without imposing a lower publication-year limit in order to capture the complete evolution of the literature on logistics processes and CE. The initial search retrieved 175 records from Scopus and 129 records from Web of Science. After combining the records retrieved from both databases, 202 records were identified, comprising 73 Scopus-only records, 102 records indexed in both databases, and 27 Web of Science-only records.

Before screening, the combined dataset was checked for duplicate or non-independent records. Three records were removed at this stage. Two corresponded to different publication versions of studies for which a subsequent full journal article was available; in these cases, the peer-reviewed journal version was retained as the most complete version of the study. The third record was an erratum and was therefore removed because it did not constitute an independent study for the purposes of the review. After this consolidation process, 199 records remained for screening, comprising 71 Scopus-only records, 101 records indexed in both databases, and 27 WoS-only records. To facilitate transparency

and reproducibility, the subsequent document selection process is summarized through the PRISMA flow diagram presented in Figure 2.

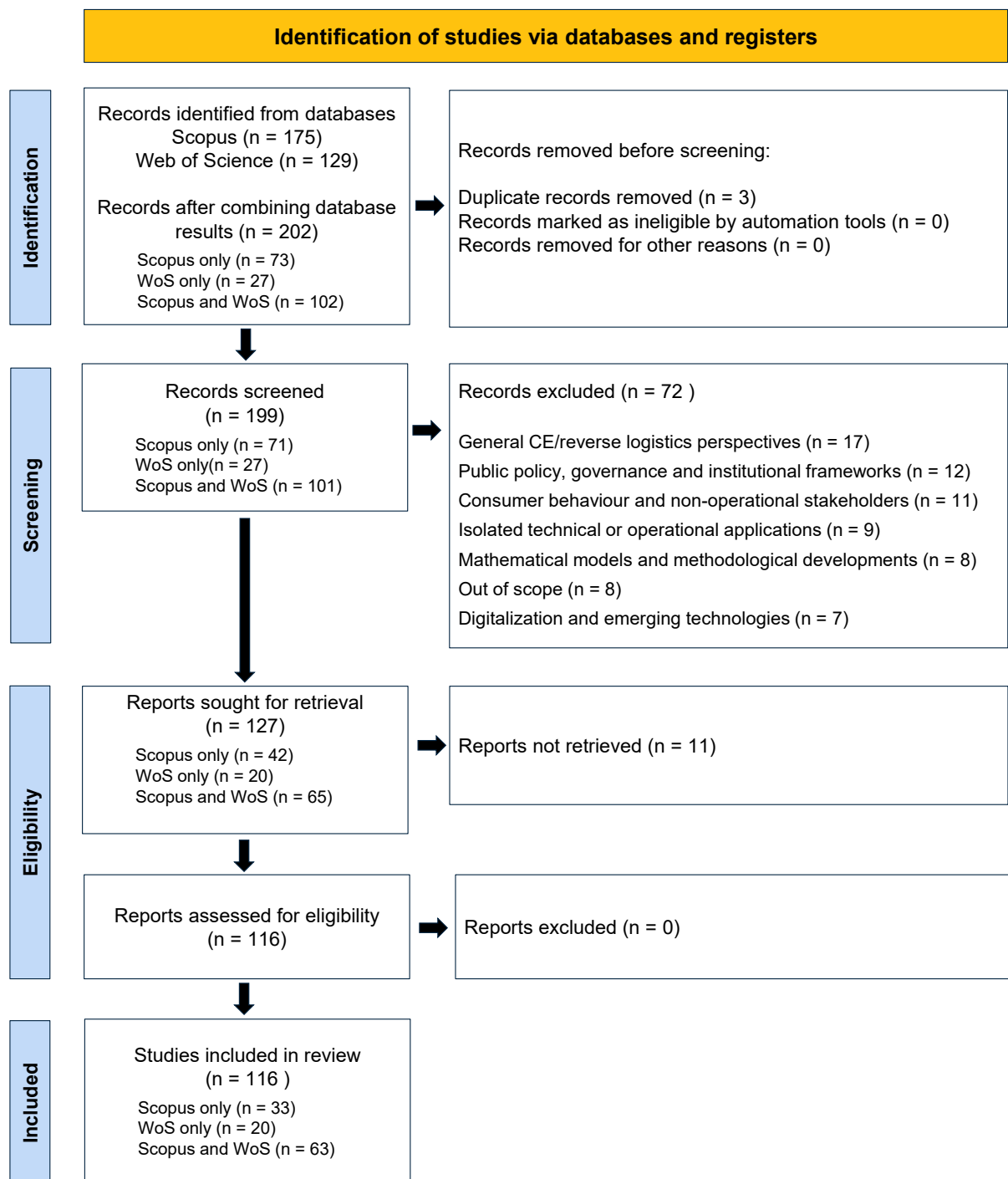


Figure 2. PRISMA flowchart for the SLR.

3.3. Study Selection

The screening and eligibility phases were conducted following the PRISMA 2020 protocol to ensure that only studies directly addressing the relationship between logistics processes and CE were included in the review. The objective of the selection procedure was not to identify all studies related to CE and logistics, but rather to retain studies in which at least one logistics process constituted an explicit analytical focus within a CE context.

The 199 records remaining after duplicate and record-type removal were screened based on their titles, abstracts, and keywords. Studies were retained when they explicitly addressed CE or circularity together with one or more of the logistics processes included in the analytical framework. Studies were excluded when their primary contribution concerned adjacent topics without examining logistics processes as operational enablers of CE. The predefined exclusion categories and their corresponding rationales are reported in Table 2.

Table 2. Exclusion categories applied during the screening phase.

Exclusion Category	Reason for Exclusion	Excluded Documents
General CE or RL perspectives	Studies discussing CE, RL, waste management, environmental performance, or recycling from a conceptual or descriptive perspective without analyzing specific logistics processes or operational decision-making.	17
Public policy, governance, and institutional frameworks	Studies addressing CE policies, regulatory frameworks, public procurement, governance mechanisms, or institutional environments without analyzing logistics operations or supply chain processes.	12
Consumer behavior and non-operational stakeholders	Studies focused on consumer behavior, stakeholder perceptions, participation, purchasing preferences, or user acceptance without examining logistics processes, logistics networks, or supply chain operations.	11
Isolated technical or operational applications	Studies investigating individual operational topics such as warehousing, packaging, transportation, routing, alternative fuels, or material flows without integrating these activities within a CE framework.	9
Mathematical models and methodological developments	Research centered on optimization models, econometric analyses, regression techniques, inventory models, or methodological developments without addressing CE implementation through logistics processes.	8
Out of scope	Studies unrelated to the research objective (e.g., unrelated engineering applications, biomedical studies, migration studies, errata, or documents that did not constitute independent scientific evidence).	8
Digitalization and emerging technologies	Studies examining AI, blockchain, digital transformation, Industry 4.0, or eco-design as standalone topics without explicitly linking these technologies to logistics processes supporting CE implementation.	7

A total of 72 records were excluded during screening. These exclusions comprised 29 Scopus-only records, 36 records indexed in both databases, and 7 WoS-only records, leaving 127 records for the subsequent retrieval and eligibility stage. The exclusions were distributed across seven principal categories: general CE or RL perspectives (17 records); public policy, governance, and institutional frameworks (12); consumer behavior and non-operational stakeholders (11); isolated technical or operational applications (9); mathematical models and methodological developments without a direct CE-logistics focus (8); studies outside the scope of the review (8); and digitalization and emerging technologies examined without an explicit logistics-process and CE linkage (7). These categories were applied according to the primary reason for exclusion identified during title, abstract, and keyword screening.

The screening and coding procedures were conducted by two of the six authors, selected based on their expertise and familiarity with logistics processes and circular economy. These two authors were responsible for screening and refining the records to establish the final

corpus of 116 studies and subsequently for the content coding. One author performed the initial coding of the studies according to the nine logistics processes, the R0–R9 strategies, and the industry or sector context, while the second author reviewed the proposed coding to ensure consistency with the selection and screening criteria. The remaining four authors reviewed and discussed the resulting classifications and analyses. When disagreements or uncertainties arose regarding the assignment of a code or its interpretation, all six authors discussed the alternatives and their supporting arguments until a consensus was reached. Thus, the coding procedure combined an initial coding and review process with collective discussion and consensus among the authors.

The 127 remaining records were then assessed for full-text retrieval. Eleven records could not be retrieved in full text through the institutional or open-access sources available to the research team and were therefore excluded from the review. The remaining 116 studies were successfully retrieved and assessed as the final evidence base for the qualitative synthesis. No additional studies were excluded after full-text assessment. The final corpus therefore comprised 116 peer-reviewed studies published between 2007 and 2025. Of these, 33 were indexed exclusively in Scopus, 20 exclusively in Web of Science, and 63 were indexed in both databases. The resulting distribution is reported in Table 3, while the complete identification, screening, retrieval, and inclusion process is summarized in Figure 2.

Table 3. Distribution of the studies included in the SLR by database source.

Database/Source	Number of Studies	Percentage	Documents
Scopus only	33	28.4%	[35,92–124]
Web of Science only	20	17.2%	[41,125–143]
Indexed in both databases	63	54.3%	[9,31,32,34,39,40,118,144–199]

3.4. Content Analysis and Coding Procedure

Following the PRISMA selection process, the 116 full-text studies were subjected to a structured qualitative content analysis. The content analysis enabled an in-depth examination of how logistics processes contribute to CE implementation, the circular strategies they support, the enabling technologies involved, and the emerging research themes identified across the reviewed studies. The content analysis adopted a hybrid coding strategy that combined deductive and inductive thematic analysis. Deductive coding was guided by the conceptual framework developed in Section 2, particularly the nine core logistics processes and the R0–R9 framework, which constituted the predefined analytical categories. Subsequently, an inductive coding procedure was applied to identify emerging technologies, dominant research themes, and future research directions that were not established a priori but consistently appeared during the full-text review.

Each of the 116 studies were read in full and systematically coded according to the logistics process or processes explicitly addressed. The logistics dimension comprised the nine core processes proposed in the conceptual framework: (1) Demand Management and Forecasting, (2) Procurement, Purchasing and Sourcing, (3) Production Logistics Processes, (4) Warehousing, (5) Inventory Management, (6) Material Handling and Packaging, (7) Transportation, (8) Distribution and Order Fulfillment, and (9) Reverse and Circular Logistics. Because many studies addressed multiple operational activities, each study could be assigned to more than one logistics process whenever appropriate.

In parallel, each study was classified according to the CE strategies investigated. The coding followed the R0–R9 framework, including Refuse (R0), Rethink (R1), Reduce (R2),

Reuse (R3), Repair (R4), Refurbish (R5), Remanufacture (R6), Repurpose (R7), Recycle (R8), and Recover (R9). The coding was based on the primary circular action described in the study rather than on the terminology used by the authors alone. Refuse (R0) was coded when the intervention aimed to eliminate the need for a product, material, activity, or resource altogether; Rethink (R1) when the intervention involved a fundamental change in how a product, service, or logistics activity was used or delivered, including access-based or product-service models; and Reduce (R2) when the intervention decreased the quantity of materials, resources, energy, movements, or logistics activities required while maintaining the same essential function. Reuse (R3) was assigned when a product or logistics asset was used again for the same or substantially equivalent function without significant restoration; Repair (R4) when maintenance or corrective actions restored a defective product or component to continued use; Refurbish (R5) when a used product was restored or upgraded to extend its useful life while retaining its original function; Remanufacture (R6) when a used product or component underwent a structured industrial process to restore it to a condition comparable to a new product; Repurpose (R7) when a product, component, or material was redirected to a substantially different function or application; Recycle (R8) when materials were processed into secondary raw materials for subsequent use; and Recover (R9) when residual material or energy value was extracted from products or materials for which higher-value circular options were no longer feasible.

When a study explicitly addressed more than one R-strategy, all applicable strategies were recorded rather than assigning a single exclusive category. The same rule was applied when a study addressed multiple logistics processes. Accordingly, the coding was non-mutually exclusive at both dimensions since one study could contribute to several logistics process–R-strategy combinations when the full-text evidence established those relationships. For example, a study describing the collection, inspection, repair, and subsequent reuse of returned products could be coded as Reverse and Circular Logistics in combination with R4 (Repair) and R3 (Reuse), whereas a study involving the collection and processing of non-reusable materials into secondary raw materials could be coded as Reverse and Circular Logistics with R8 (Recycle). This approach preserves the multidimensional nature of circular logistics interventions and avoids artificially reducing studies that address sequential or complementary circular strategies to a single R-category.

In addition, the industry, sector, or application context of each study was recorded to assess the cross-sectoral applicability of the proposed framework. Classification was based on the main context explicitly identified in the title, abstract, keywords, and full-text analysis. Studies addressing a specific industrial sector were assigned to that sector, while studies addressing logistics processes or SC configurations across multiple industries were classified as cross-industry/general. When a study was primarily focused on a logistics application, such as packaging, transportation, or logistics services, it was classified according to its dominant application context. This classification was used descriptively to characterize the reviewed corpus and identify sectoral concentrations, rather than as an additional dimension of the process–strategy framework.

Moreover, an iterative thematic analysis was conducted to identify the principal research themes and emerging research directions discussed across the literature. Rather than relying on predefined categories, these themes emerged through repeated comparison of the coded studies, allowing recurrent topics, methodological trends, research gaps, and future research opportunities to be systematically synthesized.

To ensure consistency throughout the review, a standardized coding matrix was applied to every study. As shown in Table 4, each study was systematically classified according to the logistics process addressed, the CE strategy analyzed, the interaction between logistics processes and R-strategies, enabling technologies, research themes, and future research

directions. The resulting coded database constituted the basis for the descriptive analyses, thematic synthesis, and cross-tabulations presented in Section 4 Results.

Table 4. Content analysis coding framework applied to the reviewed studies.

Analytical Dimension	Purpose of the Coding
Logistics processes	Identify the logistics process(es) analyzed in each study according to the nine-process framework.
CE strategies	Identify the CE strategies implemented or discussed in each study.
Logistics process × CE strategies	Examine how individual logistics processes enable specific CE strategies.
Industry/sector	Identify the industrial or application context in which logistics processes and CE strategies are examined
Research themes	Identify the dominant topics and thematic clusters emerging across the literature.
Future research directions	Synthesize the principal research gaps and opportunities proposed by the reviewed studies.

4. Results

4.1. Logistics Processes Enabling CE

The content analysis of the 116 studies shows that CE implementation is addressed across all nine logistics processes considered in this review, although the intensity of research attention varies considerably among them. Reverse and Circular Logistics is by far the most frequently examined process, appearing in 107 studies, followed by Production Logistics Processes (66), Material Handling and Packaging (52), Transportation (47), and Distribution and Order Fulfillment (44). Procurement, Purchasing and Sourcing is addressed in 35 studies, Inventory Management in 34, Warehousing in 20, and Demand Management and Forecasting in 17. These results indicate that the reviewed literature extends beyond reverse flows and encompasses logistics activities distributed across planning, sourcing, production, storage, inventory, material handling, transportation, distribution, and recovery operations.

Table 5 presents the detailed intersection between the nine logistics processes and the R0–R9 CE strategies, where higher cell intensity indicates a higher number of studies. The complete reference mapping underlying the cross-mapping presented in Table 5 is shown in Table A1 (Appendix A). The distribution of studies across this matrix shows that individual processes are associated with multiple circular strategies rather than with a single R-category. Demand Management and Forecasting is mainly represented through R1 (Rethink) and R2 (Reduce), while Procurement, Purchasing and Sourcing spans strategies from R0 to R9, with comparatively greater representation in R2 and R8. Production Logistics Processes also shows a broad distribution across the R-strategy spectrum, including R2, R6, R8, and R9. Similarly, Material Handling and Packaging, Transportation, and Distribution and Order Fulfillment are associated with both value-retention and recovery-oriented strategies. Reverse and Circular Logistics presents the broadest coverage, with studies distributed across R0–R9 and particularly strong representation of R3 (Reuse), R4 (Repair), R5 (Refurbish), R6 (Remanufacture), R8 (Recycle), and R9 (Recover).

The results therefore reveal substantial variation in the process–strategy combinations reported in the literature. Preventive strategies are visible in upstream processes such as demand management and procurement, whereas life-extension and recovery strategies are more extensively represented across production, material handling, transportation, distribution, and RL. However, the observed relationships are not mutually exclusive: several logistics processes are associated with multiple R-strategies, and the same R-strategy may be enabled by different processes. Figure 3 conceptually summarizes how different

logistics processes support different R-strategies, whereas Table 5 captures these overlapping relationships and provides the empirical basis for examining the process–strategy patterns in the following subsections.

Table 5. Cross-mapping of logistics processes and R-strategies in the reviewed literature.

Logistics Process	R-Strategy									
	R0	R1	R2	R3	R4	R5	R6	R7	R8	R9
Demand Management and Forecasting	2	9	6	3	2	1	1	0	1	0
Procurement, Purchasing and Sourcing	1	6	12	5	1	1	1	2	13	4
Production Logistics Processes	2	7	23	6	5	5	21	1	14	4
Warehousing	0	1	5	8	3	2	1	1	3	1
Inventory Management	1	2	11	11	3	3	1	1	0	2
Material handling and packaging	1	10	18	21	0	0	3	1	15	1
Transportation	1	5	26	7	1	1	2	1	9	5
Distribution and Order Fulfillment	1	5	8	19	4	3	3	1	5	0
Reverse and Circular Logistics	1	9	9	55	25	20	32	5	71	36

Note: Values indicate the number of studies identified for each logistics process–R-strategy combination. Because studies may address multiple logistics processes and R-strategies, the cells are not mutually exclusive and row/column totals should not be interpreted as unique-study totals.

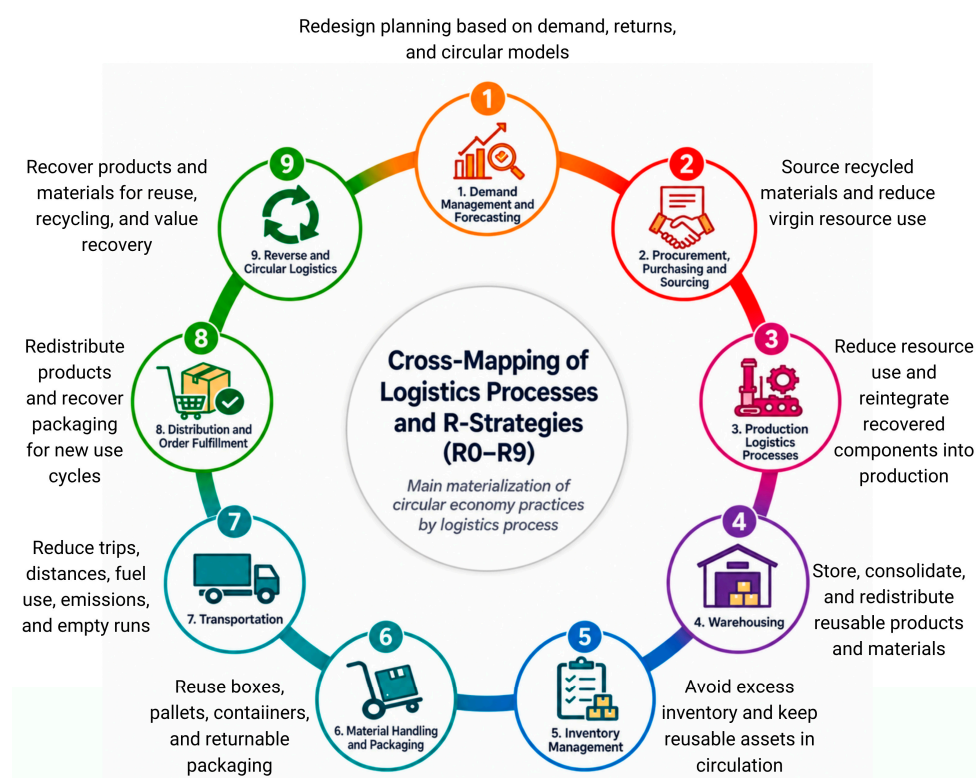


Figure 3. Logistics Processes and R-strategies.

4.1.1. Demand Management and Forecasting

Demand Management and Forecasting is addressed in 17 of the 116 studies and is primarily associated with preventive circular strategies, particularly Rethink (R1) and Reduce (R2), although the reviewed literature also reports connections with value-retention and recovery strategies. For Rethink (R1), forecasting is used to account for demand and return uncertainty in remanufacturing and other circular business models, including sharing and service-based approaches [131,150,181,194]. For Reduce (R2), predictive analytics and advanced forecasting models are applied to improve production planning, identify operational inefficiencies, and support predictive maintenance, thereby reducing unnecessary resource consumption and waste [105].

The reviewed studies also associate demand forecasting with downstream circular activities. Forecasting electronic-waste streams supports the planning of reuse and recycling activities [160], while demand estimation for recovered components can facilitate their reintegration into secondary markets and subsequent product cycles [39]. Similar applications are reported for pharmaceutical returns, where return forecasts are incorporated into collection systems and reverse network planning [160,193]. Forecasting also supports higher-value retention strategies: spare-part demand estimation contributes to refurbishment (R5) [159], while return-rate forecasting supports remanufacturing (R6) planning [165].

The evidence shows that Demand Management and Forecasting is not restricted to conventional market-demand estimation. The reviewed studies incorporate information on product use, return flows, secondary-market demand, and recoverable products or materials, resulting in associations with multiple R-strategies.

4.1.2. Procurement, Purchasing and Sourcing

Procurement, Purchasing and Sourcing is addressed in 35 of the 116 studies and shows a broad association with the R0–R9 framework. The literature most frequently relates procurement to Reduce (R2) and Recycle (R8), while also reporting applications across preventive, value-retention, and recovery-oriented strategies. For R0–R2, circular procurement is associated with the selection of materials, suppliers, and products according to resource-efficiency, environmental, and circularity criteria. Rethink (R1) is particularly reflected in sourcing models based on access rather than ownership, including PSS, leasing, and shared-use arrangements [127,135], while Reduce (R2) is associated with lower virgin-material consumption, resource-efficient inputs, supplier selection, and sourcing strategies aimed at reducing environmental impacts [102,109,118,130,131,138,148,175,186].

Procurement is also associated with strategies aimed at retaining product and component value. Reuse (R3) is supported through the sourcing of reusable, reclaimed, second-hand, remanufactured, and recovered products or components [118,127,139,186]. Repair (R4), Refurbish (R5), and Remanufacture (R6) are linked to purchasing decisions involving maintainable products, replacement parts, and suppliers with the technical capabilities required to recover and restore components [125,186]. These relationships indicate that procurement-related decisions extend beyond the initial acquisition of conventional inputs and are also present in activities involving the continued use and restoration of products and components.

The reviewed studies further show a strong relationship between procurement and the circulation of secondary resources. Repurpose (R7) is associated with the sourcing of recovered, renewable, and bio-based materials for new applications [129,140]. Recycle (R8) is particularly prominent, with studies addressing the procurement of recycled polymers, metals, packaging materials, and other secondary raw materials, as well as supplier criteria related to recycled content and recyclability [9,94,97,122,139,167,179,186,199]. Recover (R9)

is addressed through sourcing arrangements that facilitate the valorization of residual materials, industrial by-products, and agricultural residues [127,140,172,186].

4.1.3. Production Logistics Processes

Production Logistics Processes is addressed in 66 of the 116 studies and shows one of the broadest distributions across the R0–R9 CE strategies. The literature associates production logistics with preventive strategies, product and component life extension, and material recovery. Within the preventive strategies, Reduce (R2) is particularly prominent and is addressed through product and process redesign, resource-efficient manufacturing, cleaner production technologies, digital production systems, and production planning approaches that reduce material, energy, and water consumption [35,41,93,95,99,104,118,140,152,155,156,175,176].

Rethink (R1) is associated with the redesign of manufacturing systems to incorporate recovered resources, facilitate future recovery, and support more durable, modular, and disassemblable products [104,123,129,133,135,147,190]. Production logistics is also strongly associated with value-retention strategies. Reuse (R3) involves the reintegration of recovered components and secondary materials into manufacturing systems [102,109,121,176,190,192], while Repair (R4) and Refurbish (R5) are supported through dedicated repair operations, spare-parts availability, service orders, and production planning for returned products [102,121,130,155,159,174,187,194,199]. Remanufacture (R6) receives substantial attention and involves the inspection, classification, disassembly, restoration, reassembly, and quality verification of returned products and components, together with the coordination of inventories, production schedules, spare parts, and reverse flows [35,39,100,101,134,136,150,155,169,171,174,181,187,191,194,199].

The reviewed studies further associate Production Logistics Processes with Repurpose (R7), Recycle (R8), and Recover (R9). Repurpose is comparatively less frequent and is mainly linked to the use of industrial by-products and discarded components in alternative manufacturing applications [150]. Recycling is more extensively represented through the reintegration of secondary raw materials into production, recovery of material fractions, and coordination of inspection, dismantling, separation, quality control, and reverse material flows [40,97,106,115,131,137,155,171,180,182,191,194,195,198]. Recover (R9) is less frequently reported and concerns the recovery of energy or valuable substances from materials that cannot be directly reused or recycled [97,118,142,194].

4.1.4. Warehousing

Warehousing is addressed in 20 of the 116 studies and is associated with several R0–R9 strategies, although less frequently than Production Logistics Processes and Reverse and Circular Logistics. Reduce (R2) is one of the most frequently reported relationships and includes practices aimed at reducing material losses, energy consumption, packaging waste, and non-value-added activities through improved warehouse design, handling, packaging, and operational controls [94,103,110,151,196]. Rethink (R1) is associated with the redesign of warehouse functions and layouts to accommodate both forward and reverse flows and to support more flexible logistics operations [107]. The literature also identifies Warehousing as an enabling process for value-retention strategies. Reuse (R3) is supported through the temporary storage, inspection, consolidation, and redistribution of returned products, reusable packaging, second-hand goods, and recovered materials [114,121,126,150,164,170,200]. Repair (R4), Refurbish (R5), and Remanufacture (R6) are associated with dedicated storage and handling of repairable products, spare parts, returned products, and recovered components before or during restoration and remanufacturing activities [39,150,187]. These relationships indicate that warehouse operations

can support the movement and temporary allocation of products and components between successive circular activities.

Warehousing is also associated with Repurpose (R7), Recycle (R8), and Recover (R9). Studies report temporary storage of recovered components for alternative applications as well as collection depots and transfer facilities that consolidate recyclable materials before treatment or recovery [120,122,126,150,164]. Thus, the reviewed evidence links warehousing primarily to the physical handling, temporary storage, consolidation, and redistribution required to maintain circular material flows across different recovery activities.

4.1.5. Inventory Management

Inventory Management is addressed in 34 of the 116 studies and is primarily associated with Reduce (R2), although the reviewed literature also identifies relationships with R0, R1, and several value-retention and recovery strategies. Reduce (R2) is supported through inventory policies that integrate forward and reverse flows, reduce excessive stock, avoid material deterioration, and decrease dependence on virgin resources [39,103,107,136,144,171,172,174,192]. Digital technologies, including RFID, IoT sensors, Warehouse Management Systems, and AI, are reported as mechanisms for improving inventory visibility, stock-level optimization, and synchronization between production and demand. Additive manufacturing is also used to reduce the need for large inventories of spare parts by enabling localized on-demand production [159]. Refuse (R0) and Rethink (R1) are less frequently represented and involve, respectively, preventing unnecessary inventory accumulation and reconceptualizing returned products and components as recoverable stocks rather than waste [179,196,199].

Reuse (R3) constitutes another important relationship identified in the literature. Circular inventories include reusable packaging, returned containers, reusable textiles, recovered components, and other assets that can be allocated to subsequent use cycles [114,126,131,150,164,166,168,181,188,191]. Inventory decisions also support Repair (R4) and Refurbish (R5) by maintaining repairable products, spare parts, service components, and replacement parts required for restoration activities [32,40,123,150]. Remanufacture (R6) is associated with the management of recovered cores and remanufacturable components, allowing these resources to remain available for subsequent production activities [121].

The reviewed studies also identify more limited relationships with Repurpose (R7) and Recover (R9). Repurpose is supported by inventory systems that identify products or components suitable for alternative applications [196], whereas Recover is associated with decentralized collection inventories that temporarily accumulate recoverable materials before subsequent recovery processes [154,164]. The evidence shows that Inventory Management is associated not only with conventional stock-level decisions but also with the availability, classification, and allocation of products, components, and materials across successive circular activities.

4.1.6. Material Handling and Packaging

Material Handling and Packaging is addressed in 52 of the 116 studies and is associated with a broad range of R0–R9 strategies. The preventive strategies are primarily reflected in the redesign of and reduction in packaging and material-handling requirements. Refuse (R0) is associated with eliminating unnecessary packaging components, while Rethink (R1) includes redesigned packaging systems, shared packaging pools, reusable transport assets, and alternative configurations that improve asset utilization and facilitate circular flows [40,41,93,105,124,133,151,155]. Reduce (R2) is extensively represented through lightweight packaging, material-efficient designs, collapsible containers, improved space

utilization, and the replacement of disposable packaging with durable returnable transport items [40,117,145,146,175,182,195].

Reuse (R3) is particularly prominent in the reviewed literature. Studies report closed-loop systems in which boxes, containers, pallets, bags, trays, and other transport units are collected, inspected, cleaned, and reintroduced into subsequent logistics operations [40,94,99,140,145,146,168,175,190,191,198]. Traceability technologies such as RFID and IoT sensors are used to monitor the location and condition of reusable assets and support their repeated circulation across supply chains [105]. Material handling and packaging are also associated with Remanufacture (R6) and Repurpose (R7), particularly when recovered components require inspection, packaging, traceability, and preparation for subsequent manufacturing or alternative applications [169,176,179].

Recycle (R8) is supported through the collection, sorting, storage, handling, and preparation of discarded materials for reintegration into new production cycles [150,179]. The literature further links recycling performance to packaging and product characteristics that facilitate material separation and recovery, as well as to labeling, traceability, and coordination among collection, sorting, and recycling actors [35,95,117,118,123,137,152,161,169]. Recover (R9) is less frequently represented and is mainly associated with the handling and movement of end-of-life products and components toward recovery facilities [39]. The reviewed evidence shows that Material Handling and Packaging contributes to circularity through the physical preparation, protection, identification, reuse, and recovery of products, materials, and logistics assets across successive flows.

4.1.7. Transportation

Transportation is addressed in 47 of the 116 studies and is associated with a broad range of R0–R9 strategies, with particularly strong representation of Reduce (R2) and circular strategies involving the movement of reusable, recoverable, and end-of-life products. Rethink (R1) is reflected in the redesign of transportation systems to accommodate circular business models and integrated forward–reverse flows, including leasing, PSS, and transportation configurations that combine delivery and return activities [140,144,150]. Reduce (R2) is extensively addressed through route and network optimization, transport consolidation, improved vehicle and loading utilization, shorter transport distances, reduced empty trips, lightweight logistics assets, and alternative energy or vehicle technologies [103,106–108,133,135,141,146,155,157,161,163,185,189,191,198].

Transportation also supports the circulation and life extension of products and logistics assets. Reuse (R3) is associated with the redistribution of reusable products, returnable packaging, pallets, and other transport assets, including backhaul systems and synchronized delivery–return operations [108,114,126,135,163,168]. Repair (R4) involves transporting products and components to maintenance and repair facilities, while Refurbish (R5) includes transportation activities associated with the restoration and continued use of logistics assets [152]. Remanufacture (R6) and Repurpose (R7) require reverse transportation of products and components toward specialized facilities or alternative applications; examples include the movement of end-of-life batteries toward remanufacturing and second-life applications [163,169].

Recycle (R8) and Recover (R9) are associated with transportation networks that connect collection points with recycling, material-processing, and recovery facilities. The literature reports integrated routes for recyclable materials, end-of-life batteries, and other recoverable products, supported in some cases by digital visibility technologies and network optimization [32,108,122,143,163]. Recover (R9) is less frequently represented and concerns the transportation of materials unsuitable for higher-value circular options toward energy-recovery or other specialized treatment facilities [110,122,150,179]. The reviewed

evidence links Transportation to the physical movement required to connect circular activities across locations, from product redistribution and returnable assets to recycling and recovery infrastructure.

4.1.8. Distribution and Order Fulfillment

Distribution and Order Fulfillment is addressed in 44 of the 116 studies and is associated with preventive, value-retention, and recovery-oriented R-strategies. Rethink (R1) is reflected in redesigned fulfillment models such as subscription services, servitization, local distribution configurations, and systems in which providers retain responsibility for product maintenance and recovery [99,140,182]. Reduce (R2) is associated with freight consolidation, improved vehicle utilization, off-peak deliveries, optimized distribution networks, coordinated delivery and collection activities, and measures aimed at reducing unnecessary returns and last-mile transport impacts [133,137,141,147,164,196]. Reuse (R3) is particularly prominent and includes the redistribution of returned products through second-hand markets, secondary distribution channels, and fulfillment centers, as well as the repeated circulation of reusable packaging and transport items through pooling and collection systems [100,104,113,114,123,146,155,166,194]. Repair (R4) and Refurbish (R5) are associated with distribution networks that connect customers with repair facilities and redistribute restored products through conventional or secondary channels [159,167,178,179,187,191].

Distribution and Order Fulfillment also supports Remanufacture (R6), Repurpose (R7), and Recycle (R8). Remanufacturing activities require collection and consolidation of returned products and coordination of their subsequent redistribution, while Repurpose (R7) includes the movement and redistribution of products toward alternative applications, such as second-life batteries [97,167,169,178]. Recycling (R8) is associated with take-back systems, collection centers, and distribution arrangements that direct packaging waste and damaged products toward appropriate recycling facilities and subsequently connect recovered materials with downstream users [32,97,108,156]. The reviewed evidence shows that Distribution and Order Fulfillment is associated not only with outbound product delivery but also with redistribution, take-back, reusable packaging circulation, and the reintegration of recovered products and materials into subsequent flows.

4.1.9. Reverse and Circular Logistics

Reverse and Circular Logistics is the most extensively represented process in the reviewed literature, appearing in 107 of the 116 studies. The studies associate this process with the full R0–R9 spectrum, although the strongest concentration is observed in Reuse (R3), Repair (R4), Refurbish (R5), Remanufacture (R6), Recycle (R8), and Recover (R9) (see Table 5). Preventive strategies are also reported. Refuse (R0) is associated with prioritizing waste prevention over physical recovery, while Rethink (R1) includes redesigned CSC configurations, Short Supply Chains, packaging-sharing arrangements, and PaaS models [39,155,193,198]. Reduce (R2) is addressed through forward–reverse transport integration, route and facility-location optimization, localized recovery infrastructures, improved loading, and digital optimization of return operations [108,109,135,163,185,201].

Reuse (R3), Repair (R4), and Refurbish (R5) constitute a major group of applications in which reverse flows are directed toward continued product and component use. Reuse is supported by collection, inspection, sorting, repackaging, and redistribution systems that identify products suitable for direct resale or subsequent use [101,102,108,114,197]. Repair involves reverse flows toward maintenance facilities, local workshops, and specialized service networks, while Refurbish includes condition assessment, restoration, and redistribution of returned products through secondary or conventional markets [9,40,102,139,140,147,150,155,166–168,178,194,197]. These activities

are supported in some studies by data analytics, IoT, traceability systems, and dedicated reverse-logistics infrastructure [94,98–100,111].

The literature also reports extensive applications of Remanufacture (R6), Repurpose (R7), and Recycle (R8). Remanufacturing requires reverse systems for collecting, inspecting, disassembling, and routing products and components toward specialized facilities, with studies emphasizing transportation planning, supplier capabilities, product-condition assessment, and Industry 4.0 technologies [32,102,125,139,163,174,178,196]. Repurpose (R7) involves identifying components and products that can be redirected toward alternative applications, including second-life applications for batteries and other industrial assets [31,103,104,155,169]. Recycle (R8) is associated with collection and sorting systems that direct end-of-life products toward specialized recycling infrastructure and enable the transformation of recovered materials into secondary raw materials [93,106,117,161,176].

Recover (R9) is less frequently represented than recycling and concerns the routing of residual materials toward energy or other recovery facilities when higher-value circular options are no longer feasible. The reviewed studies report applications involving used cooking oil, contaminated packaging, industrial residues, non-recyclable materials, and other residual flows [95,97,102,106,114,120,121,123]. Across these strategies, the recurring reverse-logistics activities identified in the literature include collection, inspection, classification, consolidation, routing, redistribution, and delivery to specialized recovery or transformation facilities.

4.1.10. Industry and Sectoral Patterns

The 116 studies were also characterized according to the main industry, sector, or application context explicitly addressed in each study. Approximately 30.2% of the studies address logistics and CE from a cross-industry or general SC perspective, whereas 69.8% focus on an identifiable sector or application context. Packaging and packaging systems represent the largest sector-specific group (17.2%), followed by transport and logistics services (8.6%), industrial manufacturing and materials (7.8%), automotive and electric-vehicle/battery systems (6.9%), electronics and WEEE (6.9%), and pharmaceutical, healthcare, and medical applications (6.0%). Smaller groups include food and bio-based products (4.3%), construction (3.4%), retail and e-commerce (3.4%), renewable energy (2.6%), textiles and fashion (1.7%), and mining (0.9%).

This distribution indicates that the proposed framework is applicable across diverse industrial contexts, but the relevance of individual logistics processes and CE strategies is context-dependent. For example, studies in automotive, battery, electronics, and energy applications frequently emphasize reverse flows, collection, recovery, recycling, and network design, whereas packaging-related studies place greater emphasis on reuse, returnable systems, transport, handling, and product or packaging life extension. Construction studies emphasize the coordination of forward and reverse flows, material transport, stakeholder collaboration, and procurement, while pharmaceutical and healthcare studies highlight traceability, returnable transport items, digitalization, and regulatory requirements. Thus, the nine logistics processes and R0–R9 strategies provide a common analytical structure across industries, while their operational relevance and implementation challenges vary according to product characteristics, material flows, life cycle conditions, and sector-specific requirements.

4.2. Emerging Research Themes and Future Directions

Beyond the operational implementation of CE strategies across logistics processes, the reviewed literature reveals several emerging research themes that are shaping the evolution of circular logistics. Rather than focusing on isolated logistics activities, recent

studies increasingly investigate systemic challenges involving supply chain coordination, optimization of closed-loop networks, value recovery systems, and the design of reusable logistics assets. These themes demonstrate a gradual shift from operational improvements toward strategic and integrated approaches capable of supporting circular business models.

4.2.1. Circular Sourcing and Sustainable Procurement

Circular sourcing has emerged as one of the primary research streams addressing how organizations secure circular resources while establishing long-term supplier relationships capable of supporting CSCs. Unlike conventional procurement, circular sourcing extends supplier evaluation beyond economic performance by incorporating environmental, operational, and circularity criteria into purchasing decisions. A substantial portion of the literature focuses on supplier selection methodologies. Several studies develop multi-criteria decision-making frameworks for evaluating suppliers according to their ability to support CE objectives, including environmental performance, resource recovery capabilities, and operational efficiency [102,118,131,148,186]. Among these approaches, the Circular Assessment of Suppliers framework combines CE principles with the Kraljic purchasing portfolio to classify suppliers according to their strategic importance and circular capabilities [127]. Likewise, stochastic fuzzy decision models have been proposed to support supplier evaluation under uncertainty, particularly in project-based supply chains where information is often incomplete [186].

Another important research direction investigates procurement as a strategic enabler of circular business models. Rather than functioning solely as a purchasing activity, circular procurement facilitates transitions from ownership-based transactions toward leasing, PSS, and industrial collaboration, enabling firms to scale circular business models through coordinated purchasing decisions [130,139]. Supporting this transition, several conceptual frameworks provide guidance for integrating circularity principles into procurement processes and purchasing policies [116,127,139].

Despite these advances, research also emphasizes the barriers limiting the implementation of circular sourcing. Organizational resistance, insufficient strategic commitment, regulatory uncertainty, and legal constraints remain significant obstacles, particularly in industries such as construction, where circular procurement practices are still at an early stage of adoption [9]. These findings suggest that future research should increasingly examine governance mechanisms, buyer–supplier collaboration, and institutional conditions that facilitate the large-scale implementation of circular procurement strategies.

4.2.2. Closed-Loop Supply Chain Design and Optimization

Closed-loop supply chain (CLSC) optimization represents one of the most mature and rapidly expanding research areas within circular logistics. Existing studies increasingly move beyond isolated optimization problems toward integrated models capable of simultaneously coordinating production, inventory, transportation, facility location, remanufacturing, and RL decisions under multiple sources of uncertainty. Network design constitutes the dominant research direction. Several optimization models determine the optimal configuration of forward and RL networks by integrating collection centers, remanufacturing facilities, recycling plants, and distribution nodes into unified decision frameworks [144,166,170,172,178,181,199]. Mixed-integer linear programming (MILP), robust optimization, and multi-objective optimization are frequently employed to balance economic, environmental, and operational objectives while accounting for uncertainty in product returns and customer demand [125,181].

Another major stream focuses on the optimization of specialized material recovery systems. High-value products, including WEEE, electric vehicle batteries, and compos-

ite materials, require dedicated RL infrastructures capable of preserving material value throughout multiple recovery pathways [142,160,162,180]. Consequently, recent studies increasingly investigate optimal facility locations, dismantling centers, and remanufacturing infrastructures specifically designed for these complex material streams. Production and inventory coordination also receive considerable attention. Rather than optimizing forward production independently, recent research simultaneously considers remanufacturing activities, inventory policies, deteriorating products, carbon emission constraints, and recovered component availability to improve overall supply chain performance [125,136,192]. This integrated perspective reflects the growing recognition that inventory management, production planning, and recovery operations should be optimized jointly rather than sequentially.

Recent studies increasingly incorporate transportation and network optimization into CLSC models. Vehicle routing, fleet configuration, facility location, and infrastructure planning are addressed through mathematical programming, simulation, and system dynamics approaches to improve resource utilization while supporting long-term circular transitions [163,169,174,193]. This research theme indicates a clear movement toward integrated optimization models capable of simultaneously supporting multiple CE objectives instead of optimizing individual logistics functions independently.

4.2.3. Reverse Logistics and Value Recovery Systems

Another prominent research theme investigates how RL systems can maximize value recovery throughout multiple post-consumption pathways. Rather than viewing RL exclusively as a mechanism for waste management, recent research increasingly conceptualizes it as a strategic capability that enables products, components, and materials to re-enter economic cycles through reuse, repair, remanufacturing, refurbishment, and recycling. One major research stream focuses on the design and management of collection systems. Several studies develop methodologies to improve the organization of collection networks, customer return systems, and recovery infrastructures capable of efficiently channeling returned products toward their most appropriate recovery option [108,115,154]. In parallel, e-commerce research investigates customer return patterns using clustering algorithms and geographically constrained optimization models to improve RL network performance [197].

Another significant body of literature examines value recovery within specific industrial sectors. WEEE, remanufacturing systems, special waste streams, and recovered components receive particular attention because of their high residual value and technical complexity [104,110,120,121,176,179]. Similar developments are observed in construction, where material passports, planned deconstruction, and integrated project logistics enable buildings to function as future material banks rather than demolition waste [39,93].

Operational management of recovered products represents an additional research direction. Simulation models, process optimization, and sorting system design have been proposed for applications such as textile recovery centers, allowing recovered products to be classified and redirected toward resale, recycling, or remanufacturing according to their residual value [114]. At the same time, several studies emphasize that effective value recovery depends not only on technical recovery operations but also on visibility, stakeholder collaboration, and coordinated decision-making across the entire reverse supply chain [171]. These studies indicate that future research is progressively shifting from isolated RL activities toward integrated value recovery systems capable of coordinating multiple recovery strategies within a common CSC.

4.2.4. Circular Packaging and Returnable Transport Systems

Packaging has evolved from being considered a disposable logistics component to becoming a strategic asset that enables resource circulation throughout supply chains. Con-

sequently, research increasingly investigates RTIs, reusable packaging systems, refill models, and packaging portfolio management as mechanisms for improving logistics circularity. The largest research stream focuses on the design and management of reusable transport items. Numerous studies investigate returnable pallets, reusable boxes, containers, and RTI pooling systems capable of extending packaging life cycles while reducing dependence on single-use transport packaging [92,113,145,146,155,157,168,188]. Rather than optimizing individual packaging units, recent research increasingly analyzes shared packaging pools and collaborative logistics systems that maximize asset utilization across multiple supply chain actors.

A second research direction examines packaging as an integrated logistics system rather than a standalone product. Sustainable packaging research increasingly addresses packaging design, logistics performance, regulatory compliance, and environmental impacts simultaneously [40,41,95,117,189]. Within this perspective, reusable packaging consistently receives greater attention than simple material reduction strategies, reflecting a broader shift toward circular resource management. Material recirculation constitutes another rapidly growing topic. Several studies investigate plastic recycling systems, HDPE recovery chains, industrial symbiosis, and closed-loop material flows capable of reintegrating recovered packaging materials into new packaging production [129,137,143,175,195,198]. These studies also emphasize the importance of integrating informal waste collectors and regional recycling systems to improve material quality and value retention throughout CSCs.

Recent research increasingly explores packaging portfolio management and design-for-circularity approaches. Instead of optimizing individual packaging solutions, organizations are encouraged to develop strategic packaging portfolios that combine reusable packaging, refill systems, lightweight materials, recycled content, and life cycle optimization according to different logistics requirements [94,99,123,175,182]. This evolution suggests that future research will increasingly consider packaging as an integrated logistics asset whose value extends far beyond its traditional protective function.

4.2.5. Digitalization for Logistics Circularity

Digitalization has emerged as a cross-cutting research theme that enables the implementation and coordination of circular logistics systems. Rather than focusing on individual Industry 4.0 technologies, recent research increasingly examines how digital capabilities enhance traceability, visibility, information sharing, and decision-making across CSCs. These capabilities support the coordination of forward and RL processes by improving the management of products, reusable assets, and recovered materials throughout multiple life cycles [39,105,167].

A major research stream focuses on traceability and end-to-end visibility as key enablers of circular logistics. Studies investigate digital mechanisms that improve the monitoring of products, reusable transport items, batteries, construction materials, and waste streams from distribution to EoL recovery. Research also highlights the growing importance of digital product histories and material passports to facilitate inventory control, asset recovery, remanufacturing, and recycling decisions while reducing uncertainty in RL operations [9,107,146].

Another emerging direction examines digital platforms and interorganizational data sharing to strengthen collaboration among manufacturers, logistics providers, retailers, remanufacturers, recyclers, and consumers. Rather than optimizing isolated organizations, the literature increasingly explores collaborative digital infrastructures that synchronize forward and RL activities, improve transparency, and enable information exchange across multiple stakeholders. These studies position interoperability and collaborative information sharing as essential conditions for scaling circular business models [106,181,197].

Research is progressively shifting toward data-driven decision support for circular logistics planning and optimization. Current studies investigate how predictive analytics, simulation, optimization models, and digital representations of logistics systems improve forecasting, collection planning, network design, remanufacturing decisions, and reusable asset management under uncertainty. Collectively, this research suggests that future work should move beyond the adoption of isolated digital technologies toward the development of integrated digital ecosystems that support evidence-based decision-making, end-to-end visibility, and coordinated CSCs [103,113,202].

5. Discussion

5.1. Theoretical Interpretation of the Logistics–CE Relationship

The findings provide evidence that the relationship between logistics and the CE extends substantially beyond RL. Although Reverse and Circular Logistics is by far the most frequently represented process in the reviewed literature, the 116 studies also identify meaningful relationships between CE strategies and the other eight logistics processes. This concentration is consistent with previous reviews that have predominantly examined CE implementation through product returns, collection, recovery, reuse, recycling, and remanufacturing activities [32,34–36]. However, the broader distribution of evidence identified in the present review extends this perspective by showing that circularity is also operationalized through upstream and internal logistics processes that have received comparatively less attention in previous review literature.

In response to RQ1, the review shows that research attention is unevenly distributed across the nine logistics processes. Reverse and Circular Logistics dominates the literature, followed by Production Logistics Processes, Material Handling and Packaging, Transportation, and Distribution and Order Fulfillment, while Demand Management and Forecasting and Warehousing receive comparatively less attention. This uneven distribution is consistent with the dominant role traditionally attributed to RL in CSC research, where closing material loops and recovering value from used products have been central concerns [32,34,42]. However, the present review adds a process-level perspective by identifying a functional differentiation among the nine logistics processes. Demand Management and Forecasting is primarily associated with the anticipation of demand, return flows, and future availability; Procurement, Purchasing and Sourcing with the selection and acquisition of circular inputs; Production Logistics Processes with the transformation and reintegration of recovered resources; Warehousing with the temporal and spatial buffering of circular flows; Inventory Management with the availability and allocation of circular resources; Material Handling and Packaging with the physical preparation and circulation of products and logistics assets; Transportation with spatial connectivity; Distribution and Order Fulfillment with customer-facing circular flows; and Reverse and Circular Logistics with the orchestration of alternative recovery pathways.

This functional differentiation extends the dominant reverse-logistics perspective found in previous reviews. Existing review studies have primarily conceptualized logistics in relation to closing loops and recovering products, components, and materials, while more recent work has begun to consider broader CSC configurations and logistics actors [30,37]. The present synthesis connects these perspectives by positioning individual logistics processes as operational mechanisms through which different forms of circularity are implemented. Thus, circularity is not necessarily attributable to a single logistics function; rather, it emerges from the interaction of complementary processes distributed across the supply chain.

In response to RQ2, the process–strategy analysis further indicates that the relationship between logistics processes and the R0–R9 strategies is not one-to-one. Individual logistics processes can enable several circular strategies, while the same R-strategy can be supported

by different logistics processes. This finding is consistent with the hierarchical logic of the R-strategy framework, in which different circular actions pursue different levels of resource-value retention and prevention [8], but extends its application by explicitly connecting each strategy with the logistics processes required for its operational implementation. The many-to-many relationship is particularly evident for Production Logistics, Procurement, Material Handling and Packaging, and Reverse and Circular Logistics, which span preventive, value-retention, and recovery-oriented strategies. Consequently, the R0–R9 framework can be interpreted as defining the intended circular outcome, whereas the nine-process framework identifies the operational pathway through which that outcome is pursued.

A further theoretical implication concerns the position of preventive circularity within logistics research. The reviewed literature contains evidence of R0–R2 across upstream and operational processes, but the overall evidence remains strongly oriented toward reuse, repair, refurbishment, remanufacturing, recycling, and recovery. This pattern is important when considered against the circularity hierarchy proposed by the R0–R9 framework [8], in which Refuse, Rethink, and Reduce are positioned above strategies that retain value through subsequent use, repair, remanufacturing, recycling, or recovery. The finding therefore suggests an asymmetry between the circular strategies emphasized conceptually within CE frameworks and those most frequently operationalized in logistics research. Previous reviews have similarly emphasized the importance of RL and recovery-oriented activities, while providing less systematic attention to preventive logistics decisions [32,36]. The contribution of the present review is to make this asymmetry visible across the full logistics process structure rather than considering it only from a reverse-logistics perspective.

This distinction also refines the interpretation of logistics as an enabler of circularity. The evidence does not support a simple transition from linear to circular logistics through the addition of reverse flows. Instead, circularity requires different logistics capabilities at different points of the product life cycle. It includes anticipating demand and returns, selecting appropriate inputs and suppliers, integrating recovered resources into production, managing circular inventories, maintaining reusable assets, connecting distributed actors, fulfilling circular demand, and orchestrating recovery pathways. This extends earlier conceptualizations of CSCs that emphasize the integration of forward and reverse flows by identifying the individual logistics processes through which such integration can be operationalized.

The findings also clarify the scope of the proposed framework. The nine logistics processes and R0–R9 strategies constitute cross-sectoral analytical dimensions, but their operational relevance varies according to product characteristics, material flows, regulatory requirements, technological conditions, and market structures. This interpretation is consistent with previous reviews that have focused on particular sectors or logistics applications, including construction, packaging, transportation, and logistics service providers [37,39,40,43]. Rather than replacing these sector-specific perspectives, the proposed framework provides a common structure through which their differences can be compared. Its value therefore lies in enabling researchers to identify which logistics processes become critical for particular circular strategies under different industrial conditions, without assuming that the same process–strategy configuration is equally applicable across all sectors.

The answers to RQ1 and RQ2 support the conclusion that logistics enables CE implementation through a network of complementary processes, while the R0–R9 strategies define the intended circular outcome of those processes. This perspective shifts the analytical focus from logistics as a mechanism for closing loops toward logistics as the operational layer through which circularity is anticipated, selected, transformed, buffered, allocated, circulated, connected, distributed, and recovered across the product life cycle.

5.2. Research Trends and Managerial Implications

The findings reveal several research trends that characterize the relationship between logistics processes and CE implementation and, at the same time, indicate important managerial implications. Rather than treating circular logistics as an extension of RL [39,155,181,193], the reviewed literature increasingly connects circularity with digitalization, the integration of forward and reverse flows, circular business models, and sector-specific operational requirements. These trends suggest that managers should approach circularity as a systemic reconfiguration of logistics capabilities rather than as a collection of isolated recovery activities.

A first prominent trend is the increasing use of digital technologies to support circular logistics. The reviewed studies associate IoT, RFID, AI, big data analytics, digital platforms, and information systems with improved traceability, demand and return forecasting, inventory visibility, product identification, routing, and recovery decisions [94,98–100,103,105,111,149,158,165]. From a managerial perspective, the value of these technologies lies not simply in their adoption but in their ability to connect information across logistics processes. Digital visibility can help organizations identify the condition, location, and availability of products, components, packaging, and materials and use this information to determine their most appropriate subsequent use. Managers should therefore evaluate digital investments according to their contribution to circular decision-making and cross-process coordination rather than as stand-alone technology initiatives. At the same time, empirical evidence on the operational performance of these technologies remains comparatively limited, indicating the need for further validation under real logistics conditions.

A second trend concerns the increasing recognition that circular logistics requires coordination between forward and reverse material flows. Several studies examine the integration of collection, return, transportation, inventory, warehousing, distribution, and recovery activities with conventional logistics operations [39,108,135,163,185,190,193]. This integration has direct managerial implications because organizations must coordinate capacity, routing, inventories, facilities, and information across flows that are characterized by different levels of uncertainty, timing, quality, and value. Managers should therefore avoid designing reverse operations as an independent downstream function. Instead, forward and reverse flows should be considered jointly when designing networks, planning transportation and warehouse capacity, allocating inventory, and coordinating customer-facing activities. Such integration can increase the feasibility of higher-value circular pathways while reducing unnecessary movements and resource consumption.

A third trend is the relationship between logistics and circular business models, including PSS, PaaS, leasing, sharing, and other access-based models [9,127,135,140]. These models modify the role of logistics because the provider may retain ownership or responsibility for products throughout extended use cycles. Consequently, logistics decisions are no longer limited to the movement and recovery of products but also become part of the mechanism through which value is maintained over time. For managers, this implies that the design of circular business models should be accompanied by corresponding changes in demand planning, asset tracking, inventory policies, maintenance, transportation, distribution, and return arrangements. The literature therefore points toward a closer integration between business-model design and logistics-system design, particularly when product ownership, customer participation, and responsibility for recovery are redistributed among SC actors.

A fourth trend is the strong contextual dimension of circular logistics. The reviewed studies cover diverse applications, including packaging, transport and logistics services, manufacturing, automotive and batteries, electronics and WEEE, healthcare, food, construc-

tion, energy, textiles, and mining. The importance of individual logistics processes and CE strategies varies according to product characteristics, material composition, life cycle conditions, regulatory requirements, and market structures. This finding is consistent with sector-specific reviews addressing construction, packaging, and transportation [39,40,43]. Managers should consequently use the nine-process and R0–R9 framework as a comparative diagnostic structure rather than as a prescriptive configuration. The relevant managerial priorities should be determined according to the characteristics of the products and flows involved, the feasible circular strategies, and the capabilities of the organization and its SC partners.

These trends imply that managerial implementation of circular logistics requires a shift from isolated process optimization toward cross-functional coordination. Organizations should connect circular objectives with planning, sourcing, production, storage, inventory, handling, transportation, distribution, and recovery decisions; establish information flows that make product and material conditions visible; and align logistics capabilities with the circular business model and sectoral context. The managerial challenge is therefore not simply to improve the efficiency of RL, but to determine how the logistics system as a whole can preserve product and material value while minimizing unnecessary resource consumption and avoidable reverse flows.

5.3. Limitations and Future Research Agenda

This review should be interpreted in light of several methodological limitations. First, the search strategy prioritized thematic specificity by requiring circularity and logistics-related terms within specific bibliographic fields. Although this approach reduced the likelihood of retrieving studies in which logistics was only peripheral, it may have excluded relevant contributions using alternative terminology, such as CSCs, closed-loop systems, resource recovery, or sustainable operations. Therefore, the observed frequency of individual R-strategies should be interpreted as a representation of the identified corpus rather than as definitive evidence of the absence of research in a given area.

Second, the analysis is based on the studies retrieved through the selected databases and eligibility criteria and therefore does not claim to represent the entire body of knowledge on circular logistics. These limitations are particularly relevant when interpreting differences in the frequency of logistics processes and R-strategies. Within these boundaries, the review identifies several directions for future research that respond to RQ4 and extend the study of logistics as an enabler of CE implementation.

The findings of this review reveal several opportunities for advancing research on the preventive role of logistics processes. The reviewed corpus is strongly oriented toward recovery-oriented activities, particularly collection, inspection, reuse, repair, refurbishment, remanufacturing, recycling, and recovery [181,190,193]. In contrast, Demand Management and Forecasting, Procurement, Purchasing and Sourcing, and Inventory Management are less frequently connected with the prevention-oriented strategies R0–R2. Future studies should therefore examine how demand forecasting, purchasing decisions, supplier selection, inventory policies, and production planning can prevent overproduction, excessive inventories, unnecessary resource consumption, and avoidable product returns [127,165,192]. Such research would help clarify how logistics can contribute to circularity before products enter reverse flows rather than primarily managing products after use.

A second research direction involves examining logistics as an integrated circular system rather than as a collection of independent operational processes. Although previous studies recognize the importance of connecting forward and RL [39], the evidence remains distributed across individual processes and operational problems. Future research should examine how information, material, financial, and decision flows are coordinated across

procurement, production, warehousing, inventory, transportation, distribution, and RL. Research could investigate integrated planning models in which decisions concerning demand, capacity, inventory, routing, recovery, and reintegration are jointly considered. This systems perspective would contribute to explaining how circular logistics capabilities emerge from the interaction of processes rather than from the optimization of individual functions.

The third research avenue relates to circular business models and service-oriented logistics. PSS, PaaS models, leasing, sharing, and other access-based configurations modify product ownership, customer relationships, demand patterns, and responsibilities for maintenance and recovery [9,37,127,135]. However, the reviewed literature provides comparatively less evidence on how these business models reshape the full set of logistics decisions beyond reverse flows. Future studies should examine their implications for demand planning, asset utilization, inventory ownership, maintenance, transportation, distribution, returns, and interorganizational coordination. Particular attention should be given to the governance mechanisms required when circular value creation depends on several organizations sharing information, assets, responsibilities, and risks throughout extended product life cycles.

A fourth priority concerns the operational impact of digital technologies. Digital technologies are frequently identified as enablers of traceability, visibility, prediction, routing, inventory management, and recovery decisions [103,132,165]. Nevertheless, the literature provides less empirical evidence on their actual operational and economic effects. Future studies should evaluate whether and under which conditions IoT, AI, big data analytics, digital product information, and collaborative platforms improve logistics performance and circular outcomes. Relevant performance dimensions include recovery yield, asset utilization, inventory levels, transportation efficiency, lead times, resource consumption, costs, and the proportion of products directed toward higher-value circular strategies.

Fifth, more research should address operational-level circular logistics problems. Existing research has provided important contributions concerning RL network design and recovery systems [190,193], but additional attention is needed at the operational level. Examples include collection scheduling, product identification, condition assessment, quality inspection, sorting, reusable packaging management, inventory allocation, routing, and decisions regarding the most appropriate circular pathway for returned products and materials. Empirical and optimization-based research on these problems could strengthen the connection between strategic circularity objectives and day-to-day logistics decisions.

Finally, future research should deepen cross-sectoral comparison while preserving industry-specific differences. The sectoral analysis indicates that circular logistics research is distributed across diverse contexts, but the concentration of studies varies substantially among industries. Future research could therefore compare the same logistics process or R-strategy across sectors to identify which relationships are transferable and which depend on specific product, material, technological, regulatory, or market conditions. Comparative studies between sectors such as packaging, automotive and batteries, electronics, healthcare, food, construction, and transport could help establish the boundaries of applicability of the proposed framework. This would strengthen the understanding of the framework as a common analytical structure while avoiding the assumption that the same logistics configuration is equally appropriate across industries.

Consequently, this review suggests that future research should progressively shift from a predominantly recovery-oriented understanding of circular logistics toward a more comprehensive view encompassing prevention, value retention, reintegration, and recovery across the product life cycle. This direction is consistent with the hierarchy represented by the R0–R9 framework, in which prevention and higher-value strategies precede recovery-oriented options. The central research challenge is therefore not only to understand how

logistics systems recover products and materials after use, but also how they can anticipate demand, select appropriate resources and suppliers, coordinate circular operations, preserve value during use, and prevent avoidable waste from being generated in the first place.

6. Conclusions

This systematic literature review demonstrates that logistics processes constitute a fundamental operational enabler of the CE by connecting material, product, information, and value flows throughout the supply chain. Based on the analysis of peer-reviewed studies, this study provides a comprehensive understanding of how the different logistics processes contribute to implementing the R-strategies and, in doing so, extends current knowledge beyond the traditional focus on RL. The findings show that the nine logistics processes considered in this review are associated with multiple R0–R9 strategies, revealing a many-to-many relationship rather than a one-to-one correspondence between logistics processes and circular strategies. The proposed synthesis therefore provides a conceptual foundation for understanding logistics as a system-wide capability for circular value creation.

One of the main contributions of this review is the identification of a clear imbalance within the existing literature. Research has predominantly concentrated on Reverse and Circular Logistics and on value-retention and recovery-oriented strategies such as Reuse (R3) and Recycle (R8), while the preventive strategy Reduce (R2) is also frequently addressed. In contrast, preventive strategies such as Refuse (R0) and Rethink (R1) are comparatively less represented in the reviewed corpus despite their higher priority within the CE hierarchy. These findings suggest that the current body of knowledge is more developed in managing products after use than in preventing waste generation through upstream logistics decisions. Consequently, the transition toward CSCs requires expanding the role of logistics beyond recovery activities to include preventive decisions in demand management, procurement, production, inventory management, warehousing, packaging, transportation, and distribution.

The review also highlights several research trends, particularly the increasing role of digital technologies and Industry 4.0 tools, the integration of forward and reverse flows, the emergence of circular business models and service-oriented logistics, and the context-dependent implementation of circular logistics across industries. However, technology alone is insufficient to achieve circularity. Its effectiveness depends on complementary organizational capabilities, governance mechanisms, interorganizational collaboration, and business models capable of sustaining circular material flows over time.

This review also establishes a research agenda that encourages a shift from recovery-oriented logistics toward preventive and system-oriented approaches. Future studies should investigate how logistics processes jointly support higher-priority circular strategies, how circular business models reshape logistics decisions, how digital technologies perform under real-world conditions, and how operational challenges and sector-specific requirements influence circular logistics implementation. Further cross-sectoral research is also needed to identify which logistics–CE relationships are transferable across contexts and which depend on specific product, material, technological, regulatory, and market conditions.

The findings should be interpreted in light of the restricted search strategy adopted in this review. Although the strategy was designed to prioritize thematic specificity, it may have excluded relevant studies using alternative terminology for logistics and circularity. Therefore, the frequencies of logistics processes and R-strategies should be understood as characteristics of the identified corpus rather than as definitive evidence of the absence or prevalence of particular topics in the broader literature.

Finally, this study positions logistics as an operational implementation layer of the CE, where logistics enables circular economy implementation through a network of com-

plementary processes, while the R0–R9 strategies define the intended circular outcome of those processes. This perspective moves beyond the conventional CE-to-reverse-logistics relationship and provides researchers with a foundation for further investigation while offering managers a comprehensive perspective for designing logistics systems capable of preventing waste, preserving resource value, and supporting circular value creation throughout product life cycles.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/logistics10100236/s1>, Table S1: PRISMA 2020 Checklist.

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Abbreviations

The following abbreviations are used in this manuscript:

AI	Artificial Intelligence
CAoS	Circular Assessment of Suppliers
CE	Circular Economy
CLSC	Closed-Loop Supply Chain
CSC	Circular Supply Chain
EoL	End-of-Life
FL	Forward Logistics
HDPE	High-Density Polyethylene
IoT	Internet of Things
LSP	Logistics Service Providers
OM	Operations Management
PaaS	Product as a Service
PI	Physical Internet

PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PSS	Product-Service Systems
RTI	Returnable Transport Item
RL	Reverse Logistics
SC	Supply Chain
SCM	Supply Chain Management
SLR	Systematic Literature Review
TRID	Transportation Research International Documentation
WEEE	Waste Electrical and Electronic Equipment
WoS	Web of Science

Appendix A

Table A1 provides the complete reference mapping underlying the cross-mapping presented in Table 5. It identifies the studies associated with each combination of the nine logistics processes and the R0–R9 circular economy strategies. This supplementary evidence preserves the traceability of the qualitative coding and allows the detailed references supporting each process–strategy relationship to be consulted without overloading the main text.

Table A1. Detailed reference mapping of logistics processes and R-strategies.

Logistics Process	R-Strategy	Documents	References
Demand Management and Forecasting	R0	2	[131,150]
	R1	9	[39,109,131,137,140,147,150,158,187]
	R2	6	[101,129,150,158,170,176]
	R3	3	[122,176,188]
	R4	2	[178,192]
	R5	1	[192]
	R6	1	[178]
	R7	0	-
	R8	1	[122]
	R9	0	-
Procurement, Purchasing and Sourcing	R0	1	[39]
	R1	6	[95,115,127,135,139,154]
	R2	12	[39,102,109,118,130,131,138,142,148,175,178,186]
	R3	5	[9,118,139,186,199]
	R4	1	[186]
	R5	1	[125]
	R6	1	[186]
	R7	2	[129,140]
	R8	13	[9,41,94,97,118,122,127,139,167,181,186,194,199]
	R9	4	[127,140,172,186]
Production Logistics Processes	R0	2	[140,152]
	R1	7	[104,123,129,133,135,147,190]
	R2	23	[35,39,41,93,95,96,99,102,104,118,119,125,135,140,152,155,156,166,167,175,176,189,192]
	R3	6	[102,109,121,176,190,192]
	R4	5	[155,159,174,187,199]
	R5	5	[102,121,130,155,194]
	R6	21	[35,39,98,100–102,104,109,134,136,150,155,169–172,174,181,187,194,199]
	R7	1	[150]
	R8	14	[40,97,98,106,115,131,137,155,171,180,182,194,195,198]
	R9	4	[97,118,142,194]
Warehousing	R0	0	-
	R1	1	[107]
	R2	5	[94,103,110,151,196]
	R3	8	[39,114,119,121,126,150,164,170]
	R4	3	[39,150,187]
	R5	2	[121,150]
	R6	1	[150]
	R7	1	[150]
	R8	3	[120,122,126]
	R9	1	[164]

Table A1. Cont.

Logistics Process	R-Strategy	Documents	References
Inventory Management	R0	1	[196]
	R1	2	[179,199]
	R2	11	[39,103,107,136,144,159,171,172,174,189,192]
	R3	11	[114,126,131,150,164,166,168,179,181,188,191]
	R4	3	[32,40,150]
	R5	3	[32,123,150]
	R6	1	[121]
	R7	1	[196]
	R8	0	-
	R9	2	[154,164]
Material handling and packaging	R0	1	[41]
	R1	10	[40,41,93,105,107,124,133,151,155,189]
	R2	18	[40,41,94,95,113,117,123,145,146,151,157,161,171,175,182,188,191,195]
	R3	21	[95,99,103,113,135,138,140,145,151–153,157,161,168,171,174,182,188,190,191,198]
	R4	0	-
	R5	0	-
	R6	3	[169,176,179]
	R7	1	[169]
	R8	15	[35,95,97,101,117,118,123,137,150,152,153,161,169,176,179]
	R9	1	[39]
Transportation	R0	1	[150]
	R1	5	[140,144,150,152,164]
	R2	26	[35,94,103,106–109,117,124,133,135,141,144,146,150,155,157,161–164,175,185,189,191,198]
	R3	7	[108,114,126,135,140,163,168]
	R4	1	[152]
	R5	1	[152]
	R6	2	[163,169]
	R7	1	[169]
	R8	9	[32,39,108,109,122,143,150,163,169]
	R9	5	[110,122,150,153,179]
Distribution and Order Fulfillment	R0	1	[41]
	R1	5	[41,99,140,157,182]
	R2	8	[39,133,137,141,147,164,190,196]
	R3	19	[41,100,104,113,114,119,123,140,146,151,155,166,167,179–181,185,194,197]
	R4	4	[167,178,187,191]
	R5	3	[159,167,179]
	R6	3	[97,167,178]
	R7	1	[169]
	R8	5	[32,97,108,156,170]
	R9	0	-
Reverse and Circular Logistics	R0	1	[193]
	R1	9	[39,112,138,141,155,167,182,193,198]
	R2	9	[108,109,112,119,135,163,185,190,193]
	R3	55	[9,31,32,35,40,41,93,94,96–102,104,106,108,110–112,114,117,118,126,127,130,135,136,143–147,150,155–158,161,163,167–169,171,175,179,182,187–189,193,195,197,199]
	R4	25	[9,31,40,93,96,98,103,106,112,119,140,143,144,147,148,150,155,156,158,167,168,178,191,197,199]
	R5	20	[9,93,102,103,119,125,139,140,147,150,151,155,158,166,167,179,193,194,196,197]
	R6	32	[31,32,35,41,93,96,98,102,111,119,120,125,131,139,140,143,147,155,156,158,163,166,167,174,176,178,179,191,193,196,197,199]
	R7	5	[32,97,108,156,170]
	R8	71	[9,31,35,39,41,93,96–104,106,108–110,112,114,117–124,129,134,135,137,138,140,142,145,147,148,151,153,154,156–159,161–163,166,170–172,174–176,179,180,182,185,187,189–193,195–199]
	R9	36	[31,35,40,41,95,97,102,104,106,109,114–116,119–123,125,135,140,146,148,150,151,156,161,162,171,180,182,187,190,193,195]

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