Supply Chain Network Design in Retail Logistics: A Conceptual Review

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Abstract

Retail supply chains are facing increasing structural complexity due to expanding product assortments, omni-channel fulfillment requirements, disruption risks, and rising sustainability pressures. Although a substantial body of literature addresses facility location and network design problems, existing research remains fragmented across decision areas such as supplier selection, store location planning, warehouse design, and cross-docking. This fragmentation is particularly problematic in retail settings, where heterogeneous assortments, geographically dispersed supplier bases, and dense downstream demand networks create strong interdependencies across sourcing, infrastructure, and flow decisions. This paper develops a conceptual framework for strategic supply chain network design (SCND) in retail logistics and uses it to synthesize the relevant literature from an integrated retail perspective. The framework structures retail SCND along four interrelated layers: retail context and design drivers, strategic design decisions, network configuration and flow architecture, and performance outcomes. In addition, resilience, collaboration, sustainability, and omni-channel retailing are conceptualized as cross-cutting dimensions that reshape network design trade-offs across multiple layers. Based on a semi-systematic literature review, the paper shows that retail network design should be understood as a multi-layered and interdependent strategic problem rather than as a set of isolated planning tasks. By integrating fragmented research streams and highlighting the specific logic of retail distribution systems, the study contributes to a clearer conceptual understanding of retail SCND and provides a foundation for future research on integrated and future-oriented retail logistics network design.

Keywords: *retail, logistics, supply chain design, operations management*

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1. Introduction

Retail supply chains have undergone profound structural change in recent years. Increasing product variety, the expansion of e-commerce, growing exposure to disruptions, and ongoing technological advances have substantially increased the complexity of retail operations and heightened the need for adaptive and robust logistics systems (Liu et al., 2026). In this environment, the design of a retailer's supply chain network has become a critical strategic lever for balancing cost efficiency, service responsiveness, and long-term competitiveness.

Strategic supply chain network design (SCND) in retail comprises long-term decisions about sourcing structures, distribution infrastructure, fulfillment configurations, and the organization of product flows. These decisions arise not only in greenfield settings, but also in response to structural change, such as shifting demand patterns, market expansion, assortment adaptation, new channel configurations, or evolving cost conditions (Holzapfel et al., 2023). Because many of these choices require substantial investment and are only partially reversible, especially with respect to logistics infrastructure, they must be approached as strategic design decisions with long-term performance implications.

A substantial body of literature has examined facility location and network design in supply chains. Foundational reviews by Klose and Drexl (2005), Melo et al. (2009), and ReVelle and Eiselt (2005) provide comprehensive overviews of location-analysis and facility-design models, while more recent work highlights the benefits and methodological challenges of integrating network design with transportation, inventory, and production planning (Jalal et al., 2021). However, much of this literature adopts a generic or manufacturing-oriented perspective and therefore only partially captures the structural logic of retail distribution systems.

Retail supply chains differ in several important respects. Retailers typically manage broad assortments of heterogeneous products, source from geographically dispersed supplier bases, and serve dense downstream networks of stores, fulfillment nodes, or end customers (Kuhn and Sternbeck, 2013). These characteristics increase the need for differentiated distribution concepts, shipment consolidation, segmented infrastructure, and coordination across multiple facility types (Holzapfel et al., 2023; Potoczki et al., 2024). At the same time, the growing integration of online and offline channels changes the role of stores, warehouses, and fulfillment facilities and expands the design space of retail logistics (Tahirov and Glock, 2022).

Despite these specificities, research on retail network design remains fragmented. Core decision problems are often examined in isolation and within different research traditions, which limits understanding of how they interact to shape the structure and performance of retail distribution networks. As a result, the literature still lacks a coherent conceptual perspective that integrates the major design decisions of retail logistics and relates them to broader design requirements such as resilience, sustainability, collaboration, and omni-channel retailing.

This paper addresses that gap by developing a conceptual framework for strategic supply chain network design in retail logistics and by synthesizing the relevant literature from a retail-specific perspective. The paper makes three contributions. First, it develops a structured framework that conceptualizes retail SCND as a layered and interdependent system linking retail context and design drivers, strategic design decisions, network configuration and flow architecture, and performance outcomes. Second, it synthesizes fragmented research streams within this common structure and thereby develops a more integrated understanding of retail network design as a strategic decision problem. Third, it shows how major contemporary developments reshape traditional network design trade-offs by altering sourcing choices, facility requirements, flow structures, and the performance logic of retail distribution networks.

Methodologically, the study follows a semi-systematic literature review approach as outlined by Snyder (2019), combining structured literature identification with a concept-driven synthesis. The conceptual framework developed in this paper provides the basis for positioning, relating, and synthesizing the existing literature.

The remainder of the paper is structured as follows. Section 2 develops the conceptual framework for strategic network design in retail logistics. Sections 3 to 5 review the main structural decision domains of retail SCND, while Section 6 discusses the broader design dimensions that increasingly reshape these decisions. Section 7 concludes with the central insights of the review and outlines directions for future research.

2. Conceptual Framework for Strategic Network Design in Retail Logistics

Strategic retail network design is characterized by strong interdependencies between upstream sourcing, intermediate distribution structures, and downstream demand fulfillment. Warehouses, cross-docks, stores, and e-commerce fulfillment nodes cannot be effectively designed in isolation because their roles, capacities, and economic viability depend on how they interact within the broader network (Kuhn and Sternbeck, 2013; Andrejić, 2023). Yet, as outlined in the introduction, existing research largely treats the relevant decision domains separately, and a comprehensive conceptual structure tailored specifically to retail SCND remains lacking (Hübner et al., 2013; Jalal et al., 2021).

To address this gap, this section develops a conceptual framework that organizes strategic network design in retail logistics as a layered system of interdependent elements. The framework distinguishes between (1) retail context and design drivers, (2) strategic design decisions, (3) network configuration and flow architecture, and (4) performance outcomes.

2.1. Retail Context and Design Drivers

Retail supply chains exhibit structural characteristics that distinguish them from manufacturing oriented supply networks and strongly shape strategic network design decisions. A defining feature of retail logistics is the multi-product environment, in which firms manage broad assortments of heterogeneous products with different demand patterns, value densities, storage requirements, and service expectations (Holzapfel et al., 2018). Closely related is the multi-supplier structure, where retailers source from a large and often geographically dispersed supplier base (Kalchschmidt et al., 2020). On the demand side, retail networks are characterized by multiple sinks, traditionally represented by stores, but increasingly also by end customers in e-commerce and omni-channel settings (Wollenburg et al., 2018). Together, these characteristics increase network complexity and require differentiated planning approaches. In addition, the upstream and downstream parts of the retail network differ structurally: upstream flows are typically convergent and bundling-oriented, whereas downstream flows are divergent and service-oriented, implying different planning logics across network tiers (Potoczki et al., 2024).

At the same time, retailing is not a homogeneous context. Different retail sectors are subject to distinct logistical, regulatory, and service requirements (Onstein et al., 2022). Grocery retail, for example, differs markedly from pharmaceutical or fashion retail with respect to perishability, delivery frequency, assortment dynamics, and product handling requirements (Lagorio and Pinto, 2021; Fani et al., 2025; Luo et al., 2026). In the present framework, such sectoral variation is captured primarily through product characteristics and associated planning requirements, although sector-specific conditions may additionally affect the relevance and feasibility of particular design options. From a supply chain perspective, these structural characteristics can be interpreted as fundamental attributes of network topology and material flow structure that define relevant planning requirements and the feasible design space (Fleischmann and Meyr, 2003). In retail, they are reinforced by strong interdependencies between logistics subsystems, particularly between distribution structures and store operations (Kuhn and Sternbeck, 2013), and by the need to align product characteristics with differentiated distribution concepts (Holzapfel et al., 2023). Beyond these structural features, strategic positioning acts as a central design driver. Retailers typically face persistent trade-offs between cost efficiency and service responsiveness, which directly influence network structure decisions (Esmizadeh and Mellat Parast, 2021). The preferred network design therefore depends not only on technical parameters such as shipment volumes or facility costs, but also on the retailer's competitive positioning and service strategy (Fisher, 1997).

Finally, external developments increasingly reshape the design space of retail logistics. The rise of e-commerce and omni-channel retailing introduces additional fulfillment structures and more complex flow patterns (Tahirov and Glock, 2022). At the same time, disruption risks and sustainability pressures require retailers to incorporate resilience and environmental objectives into strategic network design. These developments expand the traditional cost-service trade-off and increase the need for more flexible and adaptive network structures (Aldrighetti et al., 2021).

2.2. Strategic Design Decisions

Within this context, strategic network design can be conceptualized as a set of interrelated decision domains that jointly determine the long-term structure of the retail distribution system (Chopra, 2003). In retail, these decisions can be grouped into four main areas: upstream structure decisions, downstream demand-node decisions, intermediate facility decisions, and flow-architecture decisions.

First, upstream structure decisions define the sourcing side of the network. They include supplier selection, sourcing strategies, and the geographical configuration of the supplier base. These choices influence inbound transport structures, supply risk exposure, and the feasibility of shipment consolidation (Kalchschmidt et al., 2020). In particular, supplier-specific shipment volumes, delivery frequencies, and handling requirements affect whether direct shipping, warehousing, or cross-docking is economically and operationally viable (Potoczki et al., 2024).

Second, downstream demand-node decisions concern the structure of the retail demand network. In traditional store-based retailing, this primarily includes store location, store format, and the spatial distribution of outlet demand (Reynolds and Wood, 2010). In omnichannel settings, it also includes the role of stores as potential fulfillment nodes and the position of end customers as decentralized demand points (Wollenburg et al., 2018). The spatial distribution of demand shapes these decisions, which in turn affect service requirements and transportation needs.

Third, intermediate facility decisions address the design of the distribution infrastructure between suppliers and demand nodes. This includes decisions on the number, location, capacity, specialization, and technological configuration of warehouses, fulfillment centers, and cross-docking facilities. Because such facilities require substantial capital investment and have long-term implications for transportation, inventory positioning, and service responsiveness, they represent a central component of strategic SCND (Melo et al., 2009; Holzapfel et al., 2023).

Fourth, flow-architecture decisions determine how products move through the network. These decisions include the choice between alternative distribution concepts, such as direct shipping, warehousing, and cross-docking, as well as decisions on shipment consolidation, allocation of product segments to specific distribution channels, transportation modes, and outsourcing structures (Chopra, 2003; Melo et al., 2009). In contrast to the preceding decision areas, which concern the structural elements of the network, flow-architecture decisions define the logic by which these elements are connected and utilized.

These decision domains are strongly interdependent. Supplier structures affect the feasibility of consolidation concepts; downstream demand patterns influence the attractiveness of centralized versus decentralized facilities; and facility decisions must be coordinated with transportation and inventory considerations to achieve overall system efficiency (Melo et al., 2009; Jalal et al., 2021). This interdependence is also evident in integrated location-routing and direct-shipment models, which show that jointly optimizing structural and flow-related decisions can outperform sequential planning approaches (Azizi and Hu, 2020). Strategic retail network design should therefore be conceptualized as an integrated planning problem rather than as a set of isolated decision tasks.

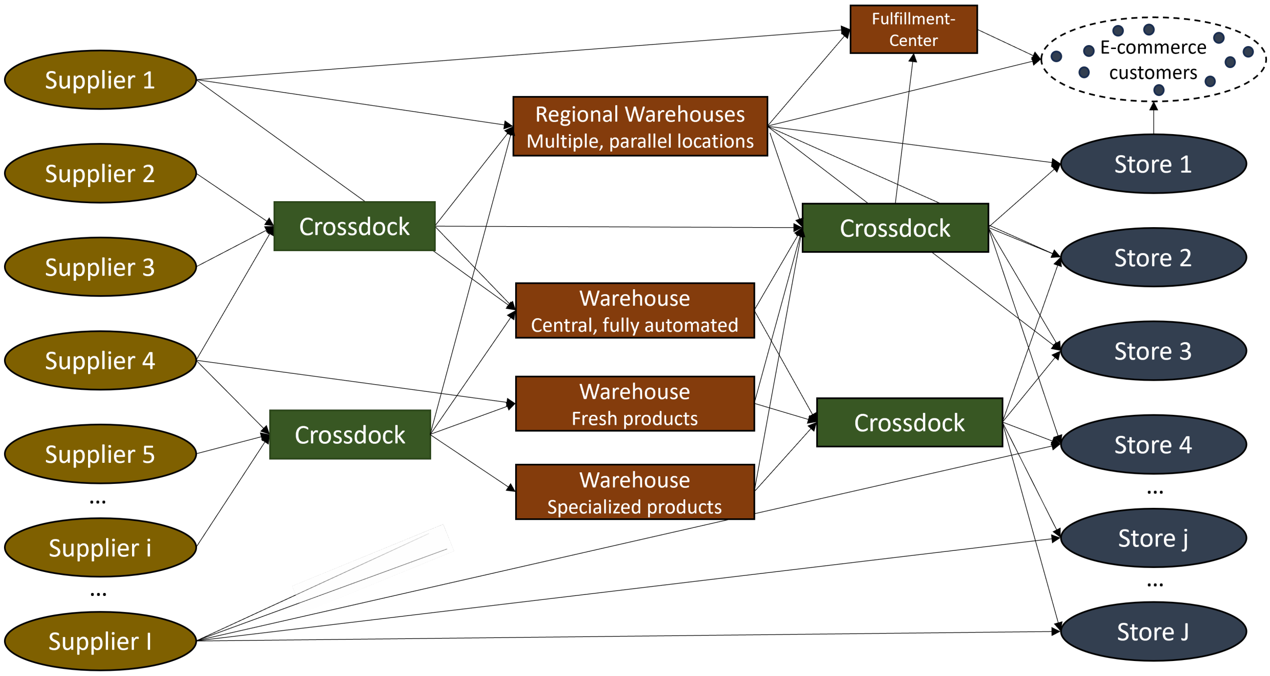

Figure 1: Schematic example of a hybrid retail distribution network

2.3. Network Configuration and Flow Architecture

The combination of strategic design decisions results in a specific network configuration and flow architecture, which together represent the structural manifestation of the retail distribution system. From a topological perspective, retail supply chain networks consist of suppliers, intermediate facilities, and downstream demand nodes. A key design issue concerns the number, type, and arrangement of intermediate facilities within this topology. In retail logistics, three fundamental distribution concepts are commonly distinguished: direct shipping, warehousing, and cross-docking. In practice, however, hybrid and multi-echelon structures are frequent (Kuhn and Sternbeck, 2013). Figure 1 illustrates such a hybrid retail distribution system by showing how suppliers, cross-docks, warehouses, fulfillment centers, stores, and e-commerce customers may be connected within one network.

Network configuration is not only a matter of topology, but also of facility typology and the degree of centralization. Retailers must decide whether to rely on a small number of highly centralized facilities, a more decentralized regional network, or a multi-echelon combination of both. Centralized structures enable inventory pooling and economies of scale, whereas decentralized configurations improve local responsiveness and reduce transport distances to demand points (Fleischmann, 2016; Holzapfel et al., 2023). In many retail settings, this trade-off leads to differentiated multi-echelon systems that combine central and regional facilities with distinct operational roles (Onstein et al., 2022).

In addition, the resulting network must be interpreted in terms of product flow architecture. A central question is whether all products should follow a standardized distribution logic or whether different product segments should be assigned to different network pathways. Such segmentation is particularly relevant in retail due to heterogeneous assortments and varying service requirements (Holzapfel et al., 2018). Flow design therefore concerns not only which facilities exist, but also which suppliers, products, or shipment types are routed through them. In particular, retail flow design often requires assigning suppliers or product flows to alternative transport concepts, such as direct-to-warehouse delivery versus routing via cross-docks, under heterogeneous shipment-volume and delivery-frequency conditions (Potoczki et al., 2024).

2.4. Performance Outcomes and Strategic Trade-offs

The resulting network configuration affects performance along several dimensions central to strategic retail logistics. At the most fundamental level, network design shapes total logistics cost and service performance (Fisher, 1997). Facility number and location influence fixed infrastructure costs and transportation distances; flow architecture affects shipment consolidation and handling costs; and the degree of centralization affects both inventory pooling and delivery responsiveness (Esmizadeh and Mellat Parast, 2021). However, strategic retail network design should not be evaluated solely in terms of cost and service. Network configuration also influences resilience, sustainability performance, and structural adaptability (Aldrighetti et al., 2021; Govindan et al., 2015; Tai et al., 2023; Holzapfel et al., 2023). For example, redundancy in suppliers or facilities may improve robustness against disruptions but increase fixed costs. Similarly, centralized structures may lower inventory and facility costs while increasing transport-related emissions or reducing responsiveness in certain service environments. The framework therefore conceptualizes performance outcomes as multidimensional and shaped by trade-offs rather than by a single optimization criterion. In retail settings, the central trade-offs typically arise between efficiency and responsiveness, consolidation and flexibility, centralization and proximity, as well as robustness and cost minimization.

2.5. Cross-cutting Design Dimensions

In addition to the core structural and flow-related decisions, several cross-cutting dimensions influence multiple layers of the framework simultaneously. These dimensions do not constitute separate planning areas in the same sense as supplier selection or warehouse design; rather, they modify decision criteria, alter feasible configurations, and reshape performance trade-offs.

Resilience influences network design by increasing the importance of redundancy, diversification, and flexibility. This affects sourcing choices, such as multi-sourcing, as well as infrastructure decisions regarding backup capacity, redundant facilities, and alternative transport structures (Aldrighetti et al., 2021). Resilience therefore modifies both strategic decisions and the evaluation of performance outcomes.

Sustainability affects network design by introducing environmental objectives and constraints into facility placement, transportation planning, and consolidation logic. This includes considerations such as emissions from transport and facility operations, carbon pricing, load factor improvements, and the trade-off between transportation intensity and facility consolidation (Govindan et al., 2015; Colicchia et al., 2015; Tai et al., 2023). Sustainability thus changes both the objective structure of network design and the desirability of particular configurations.

Omni-channel integration changes the structure of the retail network by introducing additional fulfillment pathways, new node types, and new interactions between channels. Stores may serve not only as demand points but also as fulfillment nodes; dedicated e-fulfillment centers may complement traditional distribution centers; and direct-to-customer flows become strategically relevant. Omni-channel retailing therefore affects context conditions, decision domains, network configuration, and the resulting performance trade-offs (Ishfaq et al., 2016; Wollenburg et al., 2018; Tahirov and Glock, 2022).

Collaboration represents an additional cross-cutting dimension because it changes the organizational boundaries within which network design takes place. Shared facilities, pooled transportation resources, and outsourcing arrangements with logistics service providers can expand the feasible design space and alter the economics of centralization, capacity utilization, and spatial coverage (Quintero-Araujo et al., 2017; Ouhader and El Kyal, 2017; Ben Jouida et al., 2021). As a result, collaboration affects the structure of strategic decisions and the set of attainable network configurations.

2.6. Framework Synthesis

The proposed framework conceptualizes strategic retail network design as a layered and interdependent system. Retail-specific context characteristics and external drivers define the environment in which strategic decisions are made. These decisions jointly shape network configuration and flow architecture, which in turn determine multidimensional performance outcomes. Cross-cutting design dimensions modify this logic by influencing both the choice of design options and the criteria by which alternative configurations are evaluated.

Table 1 summarizes the principal strategic planning areas and cross-cutting dimensions captured by the framework and provides orientation for the remainder of the paper. The subsequent sections review the literature along the key strategic decision domains: Section 3 examines supplier selection and store location planning as the design of upstream and downstream network structures; Section 4 addresses strategic warehouse planning as the central intermediate-facility problem; Section 5 analyzes cross-docking as a strategic option at the interface of facility design and flow architecture; and Section 6 discusses cross-cutting dimensions that reshape retail network design beyond traditional cost–service considerations.

Table 1: Strategic planning areas in retail supply chain network design

Planning area	**Key decisions**	**Selected aspects**
Supplier selection	Upstream structure	Geographical sourcing structure, product portfolio fit, delivery reliability, shipment volumes and frequencies, contractual constraints, sustainability and resilience criteria
Store location planning	Downstream demand-node design	Number and location of outlets, store formats, market potential, competitor proximity, service coverage, omni-channel role of stores
Warehouse planning	Intermediate facility design	Number, location, capacity, and specialization of DCs; degree of centralization; automation and warehouse design; differentiated DC types
Cross-dock planning	Intermediate facility and flow integration	Number and location of CDs; consolidation type; process variant; interaction with warehouse structures and inbound shipment patterns
Flow architecture	Distribution concept and transport design	Direct shipping vs. warehousing vs. cross-docking; product-flow segmentation; shipment consolidation; transport mode; outsourcing decisions
Cross-cutting design dimensions		
Resilience	Robustness and flexibility	Multi-sourcing, facility redundancy, safety stock positioning, scenario-robust design, recovery capability
Sustainability	Environmental performance	Emission minimization, green transport modes, facility consolidation trade-offs, carbon pricing integration
Omni-channel	Multi-channel fulfillment integration	E-fulfillment center placement, ship-from-store, click-and-collect, returns integration, inventory pooling
Collaboration	Shared network structures	Shared warehouses and transport, pooled volumes, outsourcing, coalition-based infrastructures, governance and coordination requirements
Performance outcomes	Strategic evaluation criteria	Total logistics cost, service level, lead time, resilience, sustainability performance, adaptability and complexity

3. Supplier Selection and Store Location Planning

Supplier selection and store location planning define the upstream and downstream anchors of retail distribution networks and therefore constitute a foundational part of strategic supply chain network design. While supplier-related decisions shape the geography, reliability, and fragmentation of inbound flows, store location decisions determine the spatial distribution of demand and the service requirements imposed on the network. Together, these decision domains delimit the feasible set of distribution structures, influence the attractiveness of centralization versus decentralization, and condition the design of warehouses, cross-docking systems, and transport concepts.

3.1. Supplier Selection

The supplier base represents a key determinant of the upstream structure of retail supply chains. It shapes inbound transport patterns, affects risk exposure, and constrains the set of feasible distribution concepts. For this reason, supplier selection should not be treated solely as an isolated procurement problem, but as an integral component of strategic network design (Kalchschmidt et al., 2020). From a network-design perspective, the most relevant supplier characteristics are those that affect the spatial and operational structure of inbound flows. These include supplier location, product portfolio characteristics, shipment volumes and delivery frequencies, delivery reliability, lead times, purchase prices, and specific handling or storage requirements. Additional considerations include expansion potential, contractual constraints such as minimum order quantities or delivery frequencies, and exclusivity arrangements (Weber et al., 1991; Wetzstein et al., 2016; Heese, 2025). Such factors influence transport distances, bundling potential, inventory-buffering needs, and the economic viability of alternative distribution concepts. In particular, recent retail-specific research shows that supplier shipment structures can be decisive for the choice between direct deliveries and cross-dock-based inbound consolidation (Potoczki et al., 2024).

The supplier selection problem has been extensively studied in the literature, as reflected in major review contributions by Zimmer et al. (2015), Fahimnia et al. (2015), Wetzstein et al. (2016), and Chai and Ngai (2020). Much of this literature addresses supplier evaluation from a multi-criteria or procurement perspective, often focusing on trade-offs among cost, quality, delivery reliability, flexibility, and sustainability. For retail network design, however, the key issue is not only how suppliers are evaluated individually, but how supplier structures propagate through the logistics system and shape the architecture of the network. Despite these interdependencies, supplier selection and network design are often treated separately in the literature, partly because both problem classes are analytically complex and have evolved in different research streams. Nevertheless, integrated approaches show substantial benefits in terms of overall supply chain performance. Benyoucef et al. (2013) and Kuderinova et al. (2021), for example, demonstrate that jointly considering supplier-related and network-related decisions can improve logistics efficiency relative to sequential planning. Even where decisions are made sequentially, the dynamic evolution of supplier portfolios should be reflected in long-term facility and flow design choices (Emirhüseyinoğlu and Ekici, 2019).

Recent research has also increasingly incorporated resilience and sustainability considerations into supplier selection, although much of this work remains rooted in manufacturing rather than retail settings (Zimmer et al., 2015; Fahimnia et al., 2015). These dimensions are nevertheless highly relevant for retail network design because supplier-related risks and environmental impacts influence the downstream logistics system and affect the value of redundancy, diversification, and consolidation (Dolgui and Ivanov, 2021). From a strategic SCND perspective, supplier selection can therefore be understood as a structural design decision that shapes inbound flow characteristics, affects the need for differentiated facilities, and helps determine the feasible architecture of the retail supply network.

3.2. Store Location Planning

In traditional retail systems, stores constitute the primary demand nodes, and their number, location, format, and market positioning directly affect transport requirements, service expectations, and the design of the distribution infrastructure (Huff, 1963; Brown, 1994; Reynolds and Wood, 2010). Store location planning differs from many other SCND decisions in that it is strongly influenced by market-facing considerations. Store locations determine customer access, local demand capture, and competitive positioning, and are therefore closely tied to revenue generation. From a supply chain perspective, however, these market-oriented objectives must be reconciled with logistics efficiency, resulting in a strategic trade-off between maximizing market coverage and ensuring cost-efficient replenishment and service provision (Brown, 1994). This tension is particularly important in retail, where store networks often evolve incrementally and where expansion, restructuring, and downsizing decisions coexist (Wood and Reynolds, 2011).

The key strategic decisions in this domain concern the number, location, size, and format of stores, as well as their role within the broader retail system. Store formats may differ substantially in terms of assortment breadth, service concept, and logistics requirements, implying that store network design is closely linked to distribution structures and segmentation logics (Arrigo, 2015). More generally, store location planning is often structured along a macro–micro distinction (Brown, 1994): macro-level decisions concern the selection of regions, cities, or districts, whereas micro-level decisions address the exact positioning of individual outlets. Both levels require robust demand assessment and an understanding of local competitive conditions. A broad body of literature examines the determinants of store performance and location attractiveness. Particularly relevant factors include market potential, demographic and socio-economic conditions, accessibility, visibility, real-estate constraints, and the local competitive environment (Reynolds and Wood, 2010; Wood and Reynolds, 2012; Wieland, 2017; Formánek and Sokol, 2022). The competitive effects of store clustering are especially important. While proximity to other retailers may increase demand through agglomeration and shared footfall, empirical evidence suggests that these benefits diminish once competition exceeds a critical threshold (Seong et al., 2022). In addition, retailers must account for internal network effects, especially cannibalization between outlets and the role of stores within a broader spatial portfolio (Reynolds and Wood, 2010).

Methodologically, store location planning has generated a diverse body of work. Traditional approaches include gravity-based and market-area models, most prominently the Huff model (Huff, 1963), as well as analog methods and regression-based site evaluation (Brown, 1994; Reynolds and Wood, 2010; Wood and Reynolds, 2011). More recent work complements these approaches with optimization models, multi-criteria decision-making methods, GIS-based analyses, and machine-learning techniques for location assessment and sales forecasting (Formánek and Sokol, 2022; Lin et al., 2022). Although these methods differ in emphasis, they share the objective of linking expected demand and competitive positioning to a feasible spatial store network. In practice, analytical approaches are often combined with managerial judgment and experience-based decision-making (Reynolds and Wood, 2010).

The growing importance of multi- and omni-channel retailing has further increased the strategic relevance of store location planning. Stores are no longer evaluated solely as customer-facing sales outlets, but also as potential logistics nodes for online demand. Concepts such as ship-from-store and click-and-collect mean that outlet locations can affect not only market access but also local fulfillment capability, delivery responsiveness, and inventory deployment (Wollenburg et al., 2018; Chen et al., 2022; Lin et al., 2022). As a result, stores may simultaneously function as demand nodes and decentralized operational nodes within the retail distribution system.

4. Strategic Warehouse Planning

Warehouses constitute the central intermediate infrastructure of retail distribution networks. They connect upstream sourcing structures with downstream demand nodes and thereby translate strategic network design decisions into logistics performance. In retail, warehouse planning extends beyond storage capacity decisions to the design of an infrastructure that positions inventory, consolidates flows, supports differentiated service requirements, and links heterogeneous product segments to appropriate distribution concepts (Gu et al., 2010; Holzapfel et al., 2023).

Functionally, warehouses decouple supply and demand by providing inventory buffers and enabling the temporal and spatial coordination of material flows (Boysen et al., 2021). This role is particularly important in retail, where demand is fragmented across many stores or end customers and supply originates from multiple suppliers with heterogeneous shipment structures. By holding inventory at intermediate facilities, retailers can stabilize service levels, shorten replenishment lead times, and mitigate upstream uncertainty (Erlebacher and Meller, 2000; Shen and Qi, 2007). Warehouses also facilitate consolidation, sorting, and assortment-building processes essential for efficient downstream distribution (De Koster et al., 2017). Their strategic importance therefore lies in their simultaneous impact on transportation structures, inventory positioning, and service responsiveness.

4.1. Core Strategic Decision Areas

Strategic warehouse planning comprises three interrelated decision areas: network structure, warehouse differentiation, and facility configuration.

First, retailers must determine the overall structure of the warehouse network, including the number of facilities, their roles within the system, and the degree of centralization. These choices shape the balance between inventory pooling, transportation effort, and responsiveness. Highly centralized systems allow economies of scale and lower aggregate inventory levels, but often increase outbound transport distances and reduce local responsiveness (Fleischmann, 2016). More decentralized structures shorten lead times and improve service proximity, but require duplicated inventories and higher fixed infrastructure costs. In practice, many retailers adopt hybrid multi-echelon systems that combine central and regional facilities to balance these competing objectives (Holzapfel et al., 2020, 2023).

Second, warehouse planning involves differentiation across facility types. Retail assortments are typically heterogeneous with respect to demand characteristics, value density, handling requirements, perishability, and service expectations, making a single standardized warehouse concept inefficient for the entire product portfolio (Holzapfel et al., 2018). Recent retail-specific research therefore emphasizes that strategic warehouse planning concerns not only the depth of the network, that is, the number of facilities, but also its breadth, meaning the number of different warehouse types assigned to different product segments (Holzapfel et al., 2023). Differentiated structures may include specialized facilities for temperature-sensitive products, high-throughput facilities for fast-moving items, or channel-specific facilities for e-commerce demand (Boysen et al., 2019, 2021; Schorung et al., 2024). Warehouse planning is thus closely linked to product segmentation and the broader flow architecture of the network.

Third, facility configuration concerns warehouse design, process structure, and automation. These decisions define the technological and organizational setup of individual facilities and shape their long-term role within the network. Strategic warehouse design has long been recognized as a multi-dimensional planning problem involving systems, resources, equipment, and internal process flows (Rouwenhorst et al., 2000; Baker and Halim, 2007). More recent research highlights that automation is not merely a tactical process issue but a strategic configuration choice because it interacts with network centralization, throughput structure, product segmentation, and channel strategy (Dubey and Veeramani, 2017; Boysen et al., 2019, 2021; Zhen and Li, 2022; Fatima et al., 2022; Kembro and Norrman, 2025). Highly automated facilities may be particularly attractive in centralized and high-volume settings, whereas more flexible and labor-intensive solutions may be preferable in differentiated or uncertain environments.

4.2. Warehouse Location Planning

Within this broader infrastructure-design problem, warehouse location planning captures the spatial dimension of strategic warehouse design. It addresses where warehouses should be placed, how many should be operated, and which demand nodes and product flows should be assigned to them. Because these decisions require substantial long-term investment and affect transportation costs, service levels, and inventory deployment, they have long been central to SCND research (Klose and Drexl, 2005; Melo et al., 2009).

The analytical literature on warehouse location planning builds on classical facility location models. At the most fundamental level, the problem can be represented by continuous formulations such as multi-source Weber-type models or by discrete formulations such as the p-median problem introduced by Hakimi (1964). A central distinction concerns capacitated versus uncapacitated facility location problems, depending on whether warehouse capacities are modeled explicitly (Melo et al., 2009). Many contributions also extend the problem from single-echelon to multi-echelon structures to reflect the hierarchical architecture of distribution systems (Tcha and Lee, 1984; Şahin and Süral, 2007).

Subsequent research has incorporated a broader set of practically relevant considerations. Dynamic and stochastic formulations account for temporal change and uncertainty in demand or supply conditions (Ballou, 1968; Mirchandani et al., 1985; Canel et al., 2001). Multi-commodity formulations explicitly consider multiple products with heterogeneous characteristics, building on early contributions such as Warszawski and Peer (1973) and Geoffrion and Graves (1974) and later extensions including Pirkul and Jayaraman (1998), Jayaraman and Ross (2003), Keskin and Üster (2007), and Camm et al. (1997). These developments are especially relevant in retail, where broad assortments and product-specific constraints may strongly affect feasible facility structures. A distinctive feature of retail warehouse location planning is that facilities often differ not only in location and capacity, but also in functional role and technological design. Retailers may operate different distribution center types for different product groups, service requirements, or channels. In such settings, location planning must be linked to decisions about facility typology and product allocation (Holzapfel et al., 2023). This perspective is particularly useful in retail because it captures the fact that warehouse location decisions are inseparable from assortment structure, channel differentiation, and distribution logic.

From an objective-function perspective, warehouse location models traditionally emphasize the trade-off between fixed facility costs and transportation costs (Klose and Drexl, 2005; Melo et al., 2009). For retail networks, however, this view is often too narrow. The number and location of warehouses also affect inventory consolidation, replenishment frequency, and service responsiveness, implying that inventory-related and service-related considerations should be incorporated into strategic design. Important extensions therefore integrate inventory costs and replenishment decisions, for example through the square-root law logic in Erlebacher and Meller (2000) building on Maister (1976), or through joint location–inventory models such as Teo and Shu (2004). Further work incorporates transport discounts and routing-related effects into strategic facility decisions (Tsao and Lu, 2012; Shen and Qi, 2007). Collectively, these extensions reflect a broader shift from isolated facility-location analysis toward integrated network design.

5. Strategic Cross-dock Planning

Cross-docking constitutes a major design option in retail distribution networks and complements traditional warehousing and direct-shipping concepts. From a strategic perspective, it affects both the physical network configuration and the flow architecture of the supply chain by enabling the consolidation, sorting, and redirection of shipments without long-term storage. In retail settings, cross-docking is particularly relevant where inbound shipment structures are fragmented, supplier deliveries are frequent but small, and downstream distribution requires efficient consolidation and synchronization of flows. Recent retail-specific work therefore suggests that cross-docking should be understood not as a stand-alone facility concept, but as an integrated element of retail supply chain network design that interacts closely with sourcing structures, warehouse configurations, and transport decisions (Apte and Viswanathan, 2000; Belle et al., 2012; Kuhn and Sternbeck, 2013; Potoczki et al., 2024).

5.1. Role of Cross-docking in Retail Distribution Networks

The strategic rationale for cross-docking lies in its ability to improve transport utilization and to reduce inefficiencies associated with fragmented material flows. In retail supply chains, especially in grocery and other high-frequency replenishment environments, suppliers often generate less-than-truckload inbound shipments destined for a limited number of downstream warehouses or retail locations. Cross-docking enables such fragmented flows to be consolidated into more efficient line-haul transports and redistributed without the need for long-term storage (Apte and Viswanathan, 2000; Potoczki et al., 2024).

Two fundamental consolidation logics can be distinguished. First, inter-supplier consolidation bundles shipments from multiple suppliers at an upstream cross-docking facility in order to create high-utilization transports to downstream facilities. Second, intra-supplier consolidation allows a supplier serving multiple destinations to deliver in larger loads to a cross-dock, where the shipment is subsequently split and redirected to individual destinations

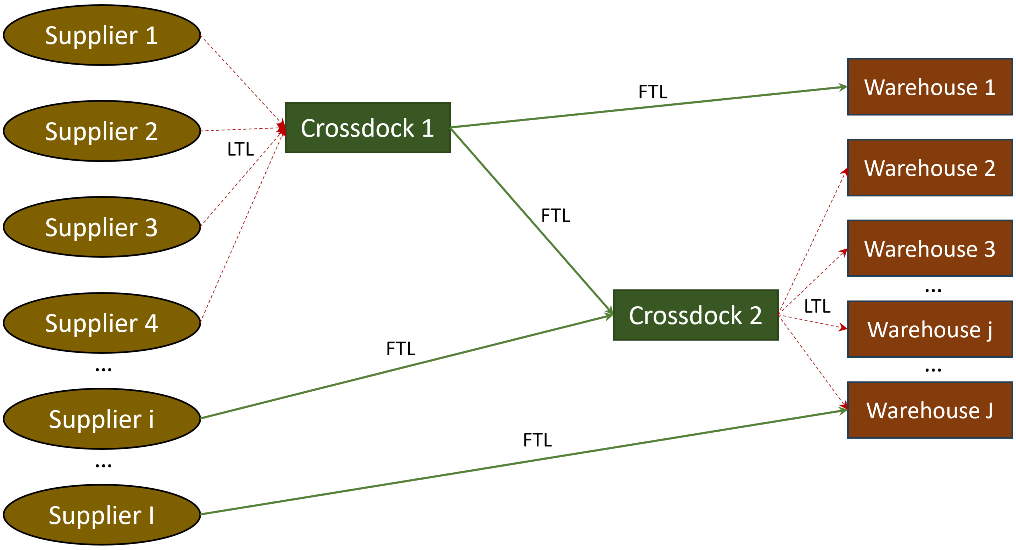

Figure 2: Schematic illustration of two cross-docking consolidation mechanisms: LTL-to-FTL consolidation at an upstream cross-dock and break-bulk from FTL to LTL at a downstream cross-dock

(Potoczki et al., 2024). Figure 2 illustrates these mechanisms schematically. It shows how fragmented inbound shipments can be consolidated into high-utilization line-haul transports at an upstream cross-dock and later disaggregated into destination-specific outbound flows at a downstream cross-dock. The same concept can be (inversely) applied for the distribution of products from warehouses to demand points. In this case, shipments from different warehouses can be bundled in cross-docks to achieve inter-warehouse consolidation effects; likewise, intra-warehouse consolidation effects can be achieved when shipments from one warehouse with multiple destinations are jointly transported on the main leg and broken up at a cross-dock that is situated close to major demand points. Beyond transportation consolidation, cross-docking also affects inventory positioning and the role of intermediate facilities in the network. By enabling more frequent replenishment in smaller lot sizes, it may reduce average inventory levels at downstream warehouses and thereby lower holding costs. At the same time, the use of cross-docks introduces additional handling operations and may increase lead times if detours or synchronization requirements become substantial (Gümüş and Bookbinder, 2004; Benrqya et al., 2020). Recent retail-specific analysis further shows that inbound cross-docking may reduce warehouse ramp contacts and associated receiving effort, thereby creating operational benefits beyond pure transportation savings (Potoczki et al., 2024).

A defining characteristic of cross-docking is the absence of long-term storage. Goods typically remain in the facility for less than 24 hours and are dispatched on the same day (Belle et al., 2012). Importantly, this functionality does not necessarily require dedicated facilities; cross-docking processes may also be embedded within conventional warehouses, resulting in mixed warehouse concepts (Apte and Viswanathan, 2000). This underlines the close relationship between warehouse planning and cross-dock planning in retail network design.

The suitability of cross-docking depends strongly on product and demand characteristics. It is particularly attractive for products with stable demand, predictable replenishment cycles, and substantial bundling potential, as often found in grocery retailing (Apte and Viswanathan, 2000; Vogt, 2010). Conversely, highly irregular or low-volume flows may limit its effectiveness. This product selectivity also links cross-dock planning to warehouse planning, since smaller and more frequent replenishment may reduce storage requirements, while the magnitude of this effect depends on the underlying storage policy. Cross-docking should therefore be conceptualized as a selective and context-dependent design option rather than as a universally superior alternative to warehousing (Potoczki et al., 2024).

5.2. Success Factors and Operational Preconditions

The effectiveness of cross-docking depends on several structural and operational prerequisites. A central requirement is sufficient bundling potential, which is determined by shipment volumes, supplier structure, delivery frequencies, and the degree of demand aggregation. Without adequate shipment density and synchronization, the transport benefits of cross-docking may not compensate for the additional handling effort introduced at the facility (Apte and Viswanathan, 2000; Belle et al., 2012; Vogt, 2010). A second prerequisite is the operational feasibility of delivery patterns. Cross-docking performance depends not only on aggregate flow volumes but also on the temporal structure of inbound and outbound shipments. In this context, Potoczki et al. (2024) show that models relying on overly aggregated or linearized transport assumptions may substantially overestimate bundling effects and therefore the economic value of cross-docking. This observation is highly relevant for strategic planning, as it indicates that cross-dock design must remain grounded in operationally feasible transport patterns. A third success factor is information transparency and coordination across supply chain actors. Because cross-docking requires tight synchronization of inbound and outbound flows, delays, forecast errors, or poor information exchange may propagate rapidly through the system and undermine consolidation benefits (Apte and Viswanathan, 2000; Belle et al., 2012; Benrqya et al., 2020). Consequently, cross-docking is closely linked to planning capabilities and information-system support.

The economic attractiveness of cross-docking also depends on how transportation responsibilities are allocated between retailers and suppliers. If inbound transportation is supplier-managed, part of the consolidation benefit may accrue upstream and therefore require contractual coordination; under EXW-type arrangements, by contrast, transportation savings directly benefit the retailer (Potoczki et al., 2024). At the same time, the benefits of cross-docking must be weighed against its drawbacks. Additional transshipment operations increase handling complexity and cost, while detours via cross-docks may lengthen transport paths and increase pipeline inventory (Gümüş and Bookbinder, 2004; Benrqya et al., 2020). These trade-offs imply that cross-docking is not a purely cost-saving mechanism; rather, its strategic attractiveness depends on whether transport consolidation, inventory effects, and operational implications jointly support the overall network design.

5.3. Process Variants and Cross-dock System Design

Cross-docking is not a homogeneous concept but encompasses several operational variants that differ in the allocation of sorting and consolidation tasks. The literature commonly distinguishes between alternative process configurations that vary in complexity, supplier involvement, and facility requirements (Napolitano, 2000; Yan and Tang, 2009; Vogt, 2010; Benrqya et al., 2020).

In pre-allocated supplier consolidation, suppliers pre-sort shipments according to their final destinations before delivery to the cross-dock. This allows pallets or shipments to be transferred quickly from inbound to outbound vehicles with limited handling effort at the facility. Such a design reduces processing complexity at the cross-dock but requires strong upstream coordination and supplier process capabilities (Napolitano, 2000; Vogt, 2010).

In contrast, CD operator consolidation shifts sorting and consolidation activities to the cross-docking facility. Suppliers deliver undifferentiated shipments, which are then sorted, broken down, and reassembled by the operator according to downstream destinations. This variant offers greater flexibility but requires more handling effort, more sophisticated process design, and higher operational coordination (Yan and Tang, 2009; Benrqya et al., 2020). Depending on whether pallets remain intact or are reconfigured at the facility, additional differences in labor intensity, equipment needs, and process complexity arise. In retail settings, pre-allocated supplier consolidation may be a particularly plausible starting configuration when cross-docking is introduced for the first time, because suppliers often already prepare shipments for specific warehouse destinations in direct-shipping systems.

These process variants have direct strategic implications. They affect facility design, labor requirements, information-system needs, and the division of tasks between suppliers and the retailer or logistics service provider. As a result, the choice of cross-docking variant should be treated as part of strategic network design rather than as a purely operational issue. It determines how cross-docks can be embedded into the wider distribution system and which upstream and downstream structures are compatible with their effective use.

5.4. Cross-dock Location Planning

From a strategic perspective, the placement of cross-docking facilities represents a location problem that is tightly linked to transportation and flow design. The relevant literature distinguishes between strategic decisions on the number and location of facilities, tactical decisions on flow allocation, and operational decisions on scheduling and dock assignment (Belle et al., 2012). In retail contexts, these levels are strongly interdependent because the economic value of cross-docking depends on both spatial consolidation opportunities and temporally feasible transshipment processes.

Conceptual contributions emphasize that cross-dock locations should be aligned with shipment structures and bundling potential. Upstream cross-docks are typically located close to supplier clusters in order to facilitate early consolidation, whereas downstream cross-docks may be positioned nearer to demand points or downstream facilities in order to support efficient regional distribution (Apte and Viswanathan, 2000; Vogt, 2010). In contrast to traditional warehouse location planning, however, cross-dock location decisions must explicitly account for synchronization requirements and transshipment logic. Their attractiveness is therefore shaped not only by distances and volumes, but also by timing constraints and the direction of consolidation flows.

Recent retail-specific work extends this perspective by jointly considering cross-dock location, supplier-specific flow assignment, and delivery-frequency decisions in an existing warehouse network. Potoczki et al. (2024) show that cross-dock location in retail cannot be separated from shipment structure and transport organization, since the profitability of a cross-dock depends critically on which suppliers use it, at what frequency, and under which shipment-size conditions. This further reinforces the view that cross-dock location planning is part of a broader network and flow design problem. In addition, the viability of a cross-dock location depends not only on spatial consolidation opportunities but also on whether sufficient throughput can be sustained: very small facilities may be difficult to justify organizationally, whereas existing sites may also impose effective upper bounds due to limited space and handling capacity (Potoczki et al., 2024).

5.5. *Integrated Cross-dock Location and Network Design Models*

A substantial body of analytical research integrates cross-docking decisions into broader supply chain network design models. These studies typically extend classical facility-location formulations by introducing cross-docks as additional intermediate nodes and jointly optimizing facility decisions, transport allocation, and shipment routing.

Early contributions include Sung and Song (2003), who develop a model that simultaneously determines the number and location of cross-docks, shipment allocations, and transportation modes while minimizing fixed and transport-related costs. Sung and Yang (2008) build on this line of work by proposing a branch-and-price solution approach. Other contributions embed cross-docking into multi-echelon distribution systems and jointly optimize warehouses and cross-docks. For example, Jayaraman and Ross (2003) analyze a two-level distribution network in which both warehouses and cross-docking facilities are located strategically under capacity and transportation constraints. Related integrated approaches are developed by Bachlaus et al. (2008) and Mousavi et al. (2013), who incorporate stochastic and multi-objective elements into the design problem.

Another important research stream explicitly links cross-dock design with transport-flow decisions. Gümüş and Bookbinder (2004) propose a model that jointly determines whether flows should be routed directly or via cross-docks, thereby capturing trade-offs among facility costs, transportation costs, and inventory-related effects. This line of work is particularly relevant for retail settings because it recognizes that cross-docking changes not only facility structures but also the logic of product flow through the network. The cross-docking literature also spans broader review and classification work. Belle et al. (2012) provide an overview of decision problems across strategic, tactical, and operational planning levels. Benrqya et al. (2020) review cross-docking system design and highlight the interplay between facility location, process design, and scheduling decisions. Together with earlier conceptual contributions such as Apte and Viswanathan (2000) and Vogt (2010), this literature establishes cross-docking as a multi-level planning problem with strong interactions between operational feasibility and strategic design.

6. Cross-cutting Topics

The preceding sections have examined the core structural decision domains of retail supply chain network design, namely the design of upstream and downstream network structures, intermediate distribution infrastructure, and cross-docking-based flow architectures. However, contemporary retail network design can no longer be understood solely in terms of classical trade-offs between facility costs, transportation efficiency, and service levels. Several cross-cutting dimensions reshape these trade-offs by altering both the objectives of network design and the set of configurations that are strategically attractive.

In the retail context, four such dimensions are particularly salient: resilience, collaboration, sustainability, and online and omni-channel retailing. These do not constitute independent planning areas in the same sense as warehouse or store network design. Rather, they act as modifying forces that affect multiple layers of the conceptual framework developed in Section 2. They influence sourcing structures, facility decisions, flow architectures, and performance outcomes simultaneously. As a result, they expand the traditional design space of retail logistics and strengthen the need for integrated network design approaches.

6.1. Resilient Network Design

Resilience has become a central concern in supply chain network design due to increasing exposure to disruptions such as technological failures, pandemics, geopolitical conflicts, and natural disasters (Fahimnia et al., 2015; Ribeiro and Barbosa-Povoa, 2018; Hosseini et al., 2019; Aldrighetti et al., 2021). In retail logistics, where distribution systems are often asset-intensive and only partially adaptable in the short term, disruptions can have severe implications for transportation, replenishment, and service continuity. Resilience therefore introduces an additional strategic objective into network design that goes beyond cost efficiency and service responsiveness. From a structural perspective, resilience affects both network configuration and sourcing decisions. A network optimized under stable conditions may become highly vulnerable if suppliers, facilities, or transport links fail. Ignoring such risks may result in substantial recovery costs, increased transportation effort, and lost sales due to unmet demand (Aldrighetti et al., 2021). Consequently, resilience must be incorporated into strategic design either as an explicit objective or through constraints reflecting disruption scenarios and recovery requirements.

The literature identifies several structural mitigation strategies. These include facility fortification and physical protection (Aldrighetti et al., 2021; Hosseini and Barker, 2016), increased capacity redundancy and safety stock (Schmitt et al., 2015), parallel or redundant network structures (Maharjan and Kato, 2022; Obermair et al., 2022; Holzapfel et al., 2023), and sourcing strategies such as dual or multi-sourcing (Yildiz et al., 2015). Other approaches aim to reduce network complexity or to increase the geographical diversification of suppliers in order to avoid correlated risks (Adenso-Diaz et al., 2012; Hosseini and Barker, 2016). Taken together, these measures typically improve robustness but may reduce efficiency by increasing fixed cost, inventory, or structural complexity.

Methodologically, resilience is commonly incorporated into SCND models through stochastic programming, dynamic optimization, robust optimization, or simulation-based scenario analysis (Sadghiani et al., 2015; Alikhani et al., 2021; Mohamed et al., 2020; Maharjan and Kato, 2022). These approaches allow researchers to assess how alternative network structures perform under disruption risk and to evaluate the trade-off between expected efficiency and robustness. In retail settings, where supply and demand structures are often highly interconnected, this trade-off is particularly relevant because resilience measures frequently affect multiple parts of the network at once.

Overall, resilience modifies strategic retail network design by making redundancy, diversification, and recovery capability more valuable. It therefore shifts the design logic away from purely lean configurations toward structures that can maintain or restore service under adverse conditions.

6.2. Collaboration

Collaboration alters network design by changing the organizational boundaries within which logistics structures are configured. In particular, horizontal collaboration between firms at the same supply chain tier enables the joint use of logistics resources such as warehouses, transportation capacity, and consolidation facilities. In retail and distribution systems, such collaboration can fundamentally change the economics of network design by pooling demand, increasing asset utilization, and reducing duplication of infrastructure.

A central mechanism through which collaboration affects network design is volume pooling. By combining shipment volumes or demand across firms, collaborative arrangements can improve transport utilization and create stronger economies of scale in warehousing and consolidation. This may reduce the number of facilities required or make more centralized structures economically feasible (Quintero-Araujo et al., 2017; Sanchez Rodrigues et al., 2015). Analytical research further shows that joint optimization of location and allocation decisions can reduce total logistics cost compared to independently designed networks (Alikhani et al., 2023; Ouhader and El Kyal, 2017). Another relevant mechanism is capacity sharing. Rather than investing in dedicated new facilities, firms may use existing warehouses or transport resources of partner organizations. Such coalition-based structures can improve spatial coverage and reduce transportation distances, but they also introduce capacity constraints and dependencies between the participating actors (Ben Jouida et al., 2021). As a result, collaboration expands the feasible design space of network planning while simultaneously increasing coordination complexity.

The literature also highlights important organizational challenges. Stable collaboration requires governance structures, information sharing, and benefit-allocation mechanisms that are perceived as fair by all partners. If gains are distributed unequally or coordination costs become excessive, collaborative structures may not be sustainable in the long run (Ben Jouida et al., 2021; Ouhader and El Kyal, 2017). This distinguishes collaboration from purely technical network optimization and underlines that inter-organizational feasibility is itself a design constraint.

Beyond horizontal collaboration, outsourcing to logistics service providers represents another important form of structural reconfiguration. Shared logistics infrastructures operated by third-party providers may allow firms to access economies of scale and established transport networks without owning the corresponding assets (De Vos and Raa, 2016; Hsiao et al., 2010). In addition, neutral intermediaries such as fourth-party logistics providers may facilitate collaboration by coordinating information exchange and reducing organizational frictions between participating firms (Guha et al., 2025; Hingley et al., 2011).

From a strategic network design perspective, collaboration therefore acts as a cross-cutting dimension because it changes who designs, owns, and operates the network. It modifies sourcing and facility decisions, affects the viability of centralized versus decentralized structures, and introduces governance considerations into the evaluation of alternative network configurations.

6.3. Green and Sustainable Network Design

Sustainability increasingly shapes strategic supply chain network design by extending the evaluation of logistics systems beyond traditional economic criteria. Sustainable supply chain management encompasses environmental, economic, and social dimensions and therefore affects all stages of the distribution system (Govindan et al., 2015; Rajeev et al., 2017; Joshi, 2022). While the economic dimension has always been central to network design, environmental and social considerations have become much more prominent in recent years.

In quantitative SCND research, sustainability is most often operationalized through environmental metrics, such as CO_2 emissions or other transport- and facility-related pollutants (Tai et al., 2023). These arise from transportation activity, facility operations, energy consumption, and infrastructure development (Joshi, 2022; Figueiredo et al., 2025). As a result, the environmental implications of network design depend not only on distances and transport modes, but also on the number, type, and utilization of facilities. A key insight from the literature is that economic and environmental objectives are not necessarily aligned. In some cases, cost-efficient network configurations also reduce emissions by lowering transport effort or improving load factors. In other cases, however, environmentally preferable designs may imply higher logistics cost. For example, a lower number of distribution centers may increase transport distances while reducing emissions from facility operations due to stronger scale effects (Colicchia et al., 2015). The environmental performance of a network therefore depends on how transport, consolidation, and facility-related effects interact.

These trade-offs are commonly modeled using multi-objective optimization approaches, either by weighting economic and environmental objectives or by identifying Pareto-efficient solutions (Govindan et al., 2015; Colicchia et al., 2015; Kumar and Kumar, 2024; Tai et al., 2023). Alternatively, environmental constraints can be integrated into cost-based models through emission caps, carbon taxes, or carbon pricing mechanisms. Such approaches reflect the fact that sustainability does not simply add another evaluation metric; it can fundamentally alter the preferred structure of the network.

In addition to environmental concerns, the literature increasingly discusses social sustainability dimensions such as employment effects, regional development, and working conditions, although these remain less frequently embedded in formal network design models (Joshi, 2022; Figueiredo et al., 2025). This suggests that the sustainability perspective in SCND is still evolving from a predominantly environmental focus toward a broader multi-dimensional understanding.

In retail logistics, sustainability modifies network design by changing how centralization, transport intensity, and facility specialization are evaluated. It thus acts as a cross-cutting dimension that broadens the objective function of retail SCND and reinforces the need for trade-off-oriented rather than purely cost-driven network design.

6.4. Online and Omni-channel Retailing

The rise of e-commerce and omni-channel retailing has fundamentally transformed the structure and requirements of retail distribution systems. Unlike traditional store-based supply chains, omni-channel networks must simultaneously support store replenishment and direct-to-customer fulfillment, thereby increasing both the heterogeneity of demand and the complexity of fulfillment structures (Titiyal et al., 2019; Lim and Srai, 2018; Liu et al., 2022; Risberg, 2022). In this sense, omni-channel retailing changes not only the scale of retail logistics, but also the functional role of nodes and flows within the network. A major implication is the emergence of multiple fulfillment node types. In addition to conventional distribution centers, retailers may operate dedicated e-commerce fulfillment centers, micro-fulfillment centers, store-based picking operations, or supplier-based drop-shipping arrangements (Titiyal et al., 2019; Ievgenii Pavlovich, 2025; Risberg, 2022). Each of these options implies different trade-offs between inventory pooling, transport cost, picking efficiency, and service responsiveness. Centralized e-fulfillment systems benefit from scale and inventory consolidation, whereas decentralized store-based or urban fulfillment concepts allow shorter delivery times and closer proximity to customers (Malik and Vidyarthi, 2022; Snoeck et al., 2023; Bilir, 2023).

At the same time, the role of physical stores is changing. Stores increasingly serve not only as sales outlets but also as operational nodes within the logistics system, for example through ship-from-store or click-and-collect concepts (Baron et al., 2024; Lin et al., 2022; Yang and Zhang, 2025; Tahirov et al., 2024). More broadly, the growth of direct channels has blurred the traditional separation between upstream manufacturers, downstream retailers, and final customers, increasing the need to coordinate direct and indirect channels within a single fulfillment system (Tahirov and Glock, 2022). This creates additional complexity because stores may simultaneously act as demand nodes, inventory locations, and fulfillment points. The literature further emphasizes that omni-channel retailing intensifies the need for integrated inventory and network decisions. When online and offline demand draw on shared inventories and facilities, capacity constraints and stock allocation rules become more important (Wollenburg et al., 2018; Yang and Zhang, 2025). Moreover, omni-channel systems require closer coordination between forward and reverse flows, as returns and cross-channel inventory movements become a central feature of the network (de Borba et al., 2020; Nel and Badenhorst, 2020). From a strategic network design perspective, omni-channel retailing therefore acts as a powerful cross-cutting dimension because it changes the definition of demand nodes, introduces additional facility types, and modifies the logic of flow architecture. It increases the value of flexibility and network adaptability, while also reinforcing the need to jointly consider facility location, inventory deployment, and fulfillment strategy.

Taken together, resilience, collaboration, sustainability, and omni-channel retailing show that strategic retail network design must be evaluated in a broader and more dynamic decision space than suggested by traditional cost-minimization models. These dimensions do not replace the core structural decisions discussed in the preceding sections, but they systematically reshape them by modifying objectives, feasible configurations, and performance trade-offs. This perspective also frames the concluding section of the paper, which synthesizes the main insights and outlines implications for future research on retail supply chain network design.

7. Conclusion

This paper develops a conceptual framework for strategic supply chain network design in retail logistics and uses it to synthesize a fragmented literature. The central argument is that retail SCND should not be understood as a set of isolated problems such as supplier selection, store location, warehouse planning, or cross-docking design. Rather, it constitutes an integrated strategic decision system in which sourcing structures, demand-node configurations, intermediate facilities, and flow architectures jointly shape network performance.

The review further shows that a retail perspective adds important insights beyond generic or manufacturing-oriented SCND models. Retail networks are characterized by broad assortments, heterogeneous product requirements, geographically dispersed suppliers, multiple demand sinks, and increasing channel complexity. These characteristics make the interaction of structural decisions particularly important and help explain why resilience, sustainability, collaboration, and omni-channel retailing are not peripheral considerations, but cross-cutting design dimensions that reshape the underlying trade-offs of network design.

The framework contributes by organizing these interdependencies into a coherent structure and by linking fragmented research streams within a common retail-specific perspective. This also points to several directions for future research. In particular, more work is needed on integrated retail SCND models that jointly capture sourcing, facility, inventory, and transport-flow decisions; on empirical research examining how retailers configure hybrid networks across products, channels, and market environments; and on models that incorporate resilience, sustainability, and omni-channel requirements as endogenous design dimensions rather than as ex-post extensions.

Overall, the paper positions retail SCND as a multidimensional and strategically central OM problem. By shifting attention from isolated design choices to the interdependence of structural decisions, it provides a stronger foundation for future research on retail logistics network design.

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