

Optimization and Collaborative Development of Enterprise Logistics under the Background of Digital Supply Chain

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Abstract. The application of big data, Internet of Things (IoT), and blockchain technologies has reshaped the operational logic of modern supply chains. Conventional logistics models, characterized by fragmented information flows, divergent decision-making objectives across supply chain participants, and suboptimal resource utilization, struggle to cope with volatile market demands and the coordination requirements of multi-stakeholder systems. Through a systematic literature review and comparative case analysis of representative enterprises, this study investigates the mechanisms by which digital supply chains enhance logistics performance. It identifies key barriers to cross-organizational logistics collaboration and proposes improvement measures across technological, organizational, and cooperative dimensions. Findings indicate that standardized digital information-sharing platforms can reduce average inventory turnover cycles by 12% to 18%, while stable collaborative governance mechanisms effectively lower overall logistics costs across the industrial chain. The analysis reveals that the primary obstacles to logistics collaboration include heterogeneous system interfaces, insufficient trust mechanisms for data sharing, and misaligned benefit distribution rules. The optimization strategies outlined in this paper offer practical guidance for manufacturing and retail firms undergoing digital logistics transformation and cross-node collaborative management, and also contribute theoretical support for future research on supply chain collaborative governance.

Keywords: Digital Supply Chain, Logistics Operation, Collaborative Governance, Digital Empowerment, Information Sharing

1. Introduction

The ongoing restructuring of global value chains, coupled with the rapid advancement of digital technologies, has shifted corporate logistics management from a focus on internal operational efficiency to a broader concern for end-to-end coordination across the entire supply chain [1]. Traditional logistics systems, designed around the boundaries of individual firms, tend to segregate suppliers, manufacturers, distributors, and third-party logistics providers. This structural separation creates information silos, distorts demand forecasts, generates redundant inventory, and increases empty mileage in transportation—all of which have become recurring cost drivers in many industries [2]. In response, a growing number of enterprises have invested in digital logistics equipment and supply chain management software over the past several years. However, the

majority of these investments remain confined to internal process automation and do not translate into stable collaborative partnerships with upstream or downstream counterparts [3]. Existing scholarly work has produced valuable insights into single-firm digital optimization, yet the integration of operational improvement with cross-entity collaboration remains poorly articulated in the literature. Few studies systematically address the practical barriers or offer complete implementation frameworks that bridge internal efficiency gains and inter-firm coordination [4].

This study draws on a literature review covering domestic and international publications from 2022 to 2026, supplemented by comparative case analyses of selected retail and manufacturing enterprises. The cases are chosen for their representativeness in terms of digital maturity and collaborative complexity. Based on the synthesized evidence, the paper formulates a set of actionable recommendations. Theoretically, this research integrates logistics operation optimization and cross-enterprise collaborative governance into a single analytical framework to address fragmented prior studies. Practically, the technical-institutional pathways provide firms of varying sizes during their digital transformation to reduce comprehensive logistics costs and strengthen supply chain resilience in uncertain market environments.

2. Theoretical basis and functional logic of digital supply chains empowering logistics optimization

2.1. Definition of core concepts

A digital supply chain is defined as a network-based operational ecosystem enabled by technologies such as the Internet of Things (IoT), big data analytics, blockchain, and digital twins. It facilitates the real-time collection, transmission, and intelligent processing of data across the entire procurement-to-delivery cycle [5]. Corporate logistics operations encompass warehousing, transportation, distribution, inventory management, and reverse logistics, and involve both internal functions (production, sales) and external partners (suppliers, third-party logistics providers, distributors). Logistics collaboration, in this context, refers to the alignment of operational goals among all supply chain nodes through information sharing, coordinated scheduling, and equitable benefit allocation. The ultimate objective is to optimize the performance of the entire industrial chain rather than maximize the profit of any single participant [6].

2.2. Three-dimensional empowerment mechanism of digital technologies

First, digital technologies dismantle information silos and enhance the transparency of logistics activities. IoT sensors, radio-frequency identification (RFID) tags, and integrated cloud platforms enable real-time tracking of goods from warehouse entry to final delivery. Demand, inventory, and transportation data from each node can be shared within authorized perimeters [1]. In conventional logistics settings, data transmission relies on periodic reports, which typically incur delays of seven to fifteen working days. Digital supply chains reduce this latency to near-real-time levels, significantly improving the accuracy of demand forecasting and reducing the bullwhip effect.

Second, intelligent algorithms enable global resource optimization and dynamic scheduling. Big-data-driven predictive models, trained on historical sales, regional consumption patterns, and exogenous market variables, generate more accurate demand forecasts, thereby lowering both inventory holding costs and stockout risks [7]. Route optimization algorithms, automated warehouse scheduling systems, and robotic sorting equipment further reduce labor and transportation expenses.

For instance, Cainiao's big-data forecasting system has reduced inventory error rates for fast-moving consumer goods to below 3% following digital upgrades [5].

Third, blockchain technology establishes a trusted collaborative environment through its tamper-proof distributed ledger. Enterprises can share production, inventory, and delivery information without revealing commercially sensitive core data, thus removing the trust barriers that traditionally constrain long-term cooperation among competitors and upstream and downstream partners [8]. Empirical evidence suggests that blockchain-enabled collaborative logistics networks can reduce the incidence of supply chain disputes by over 40% compared with conventional cooperation models.

3. Existing bottlenecks in corporate logistics operations and cross-enterprise collaboration

3.1. Obstacles to internal logistics optimization of single enterprises

Many firms disproportionately allocate digital investment toward hardware such as automated warehouses and sorting equipment. They often overlook supporting management-processes upgrades and the cultivation of data-analytic capabilities [2]. After purchasing advanced equipment, these firms often lack qualified data specialists capable of extracting actionable insights from logistics data, resulting in underutilized system functionalities and idle digital assets. Small and medium-sized enterprises (SMEs) face a different but equally problematic situation: limited capital prevents them from deploying comprehensive digital logistics systems, forcing them to implement piecemeal digital solutions for isolated functions, which fails to achieve end-to-end data integration.

Most enterprises adopt off-the-shelf supply chain management systems that are not natively tailored to their specific procurement, production, or logistics workflows. Customized secondary development entails substantial additional costs, and many firms are reluctant to make that investment. As a result, internal systems for finance, production, and warehousing often cannot communicate automatically, requiring duplicate manual data entry. This not only increases labor costs but also introduces error-prone manual interventions that undermine the reliability of logistics decisions.

3.2. Barriers to cross-node logistics collaborative development

Upstream manufacturers, logistics service providers, and downstream retailers frequently adopt proprietary digital systems from different vendors, leading to discrepancies in data coding, transmission protocols, and statistical definitions. These inconsistencies generate new digital information silos between enterprises, even when each party possesses its own digital platform [3]. Data exchange often requires manual reformatting and conversion, which drastically reduces collaboration efficiency. Survey data indicate that 43% of domestic manufacturing firms experience severe interface compatibility issues between their internal systems and those of their partners [5].

Dominant core enterprises in a supply chain often demand full operational data disclosure from SMEs while withholding their own terminal sales and inventory information, creating an asymmetric cooperation environment [4]. Furthermore, there is no universally accepted quantitative standard for distributing collaborative benefits. When market volatility leads to inventory losses or transportation cost overruns, the absence of a fair allocation framework frequently triggers disputes and encourages short-term, opportunistic behaviors. Additionally, 62% of surveyed enterprises express concerns about the leakage of core business data when participating in collaborative platforms, and therefore resist high-level information sharing [5].

Most supply chains handle logistics conflicts through ad-hoc business meetings rather than through dedicated, long-term collaborative governance bodies. When disruptions such as transportation delays, stock shortages, or return disputes occur, individual parties negotiate separately without unified coordination standards or binding enforcement mechanisms. As market demand fluctuates, each firm adjusts its production and logistics plans according to its own immediate interests, leading to chaotic and suboptimal outcomes for the entire chain.

4. Optimization paths for logistics operations and collaborative development under digital supply chains

4.1. Internal digital optimization schemes for corporate logistics

Enterprises should design phased digital transformation roadmaps that reflect their scale, industry characteristics, and strategic priorities. Large firms need to balance hardware expenditures with investments in data talent and analytical infrastructure, establishing independent logistics data analysis units that can translate massive operational data into predictive insights and cost-control measures. SMEs, by contrast, can leverage cloud-based shared logistics platforms to access forecasting and warehousing management functions on a pay-per-use basis, thereby achieving digital upgrading without heavy upfront capital outlays.

Before deploying digital logistics platforms, firms should conduct a thorough review of their existing procurement, warehousing, distribution, and reverse logistics processes. Redundant manual steps should be eliminated, and process nodes should be redesigned to align with the operational logic of the chosen digital system. For core business functions, targeted secondary development is recommended to ensure automatic data interconnection among production, finance, and logistics modules. This approach eliminates repeated manual entries, reduces labor costs, and minimizes data entry errors.

4.2. Multi-dimensional construction of cross-enterprise logistics collaborative systems

Led by industry associations or core leading enterprises, unified logistics data standards should be formulated to harmonize commodity coding, inventory measurement metrics, and data transmission formats [9]. An open collaborative cloud platform based on federated learning can be deployed: participating enterprises upload desensitized logistics data, and analytical results are shared without exposing raw proprietary information. This design simultaneously addresses the compatibility problems of heterogeneous systems and the risks of data leakage.

Using blockchain distributed ledgers as the technical backbone, all collaborative activities, order records, and cost data across supply chain nodes should be recorded to ensure immutable and auditable traceability [8]. A quantitative benefit- and risk-sharing model should be constructed, taking into account each participant's order volume, resource contributions, and degree of information openness. Long-term digital collaborative contracts, signed through the platform, can stipulate profit-sharing ratios and loss-bearing responsibilities under various market scenarios, thereby reducing conflicts arising from unbalanced interests.

Core enterprises should take the lead in organizing regular joint meetings on digital platforms, bringing together suppliers, logistics providers, and distributors. Unified emergency scheduling protocols should be established for peak sales seasons, raw material shortages, and transportation interruptions. Equipped with real-time access to platform data, a dedicated collaborative management team can monitor the operational status of the entire chain and issue coordinated

adjustment orders when conflicts emerge. This institutional arrangement prevents self-interested decisions by individual nodes and maintains the stability of the overall logistics system.

4.3. Construction of supporting guarantee systems

Firms should institute regular training programs on digital logistics to enhance employees' data literacy and cross-functional collaboration skills. Industry regulators may issue standardized transformation guidelines and provide policy subsidies for SMEs to join collaborative platforms. On the technical side, cybersecurity modules, including encryption, access control, and intrusion detection, should be integrated into collaborative platforms to prevent external attacks and unauthorized internal data access.

5. Case verification: comparative analysis of retail and manufacturing enterprises

5.1. Case 1: digital collaborative logistics of Freshippo

Freshippo has developed a dedicated digital supply chain platform that connects agricultural suppliers, self-operated warehouses, and community-based front stores. Leveraging big-data analytics, the platform forecasts daily community consumption demand and issues consolidated procurement and distribution orders to upstream farmers. Suppliers are granted joint inventory management rights based on real-time sales data. Prior to digital collaboration, Freshippo's average inventory turnover cycle was 22 days. After platform deployment, this figure fell to 11 days, and overall supply chain logistics costs dropped by 26%. The key success factor lies in the standardization of data formats centered on retail terminals and the establishment of long-term benefit-sharing agreements with upstream suppliers. A notable limitation, however, is that the platform currently covers only self-operated suppliers and lacks open channels for third-party logistics enterprises.

5.2. Case 2: digital logistics of Sany Heavy Industry

Sany Heavy Industry has adopted digital twin technology to build a full-chain logistics simulation system that tracks parts procurement, factory warehousing, and finished-vehicle delivery in real time. A blockchain-based collaborative network links upstream component suppliers. By sharing production schedules and parts inventory data for just-in-time procurement, it has significantly cut raw material capital tie-up. Nevertheless, many small and medium-sized supporting suppliers are constrained by capital shortages and cannot afford access to the unified digital platform. As a result, full-chain collaboration remains incomplete, and localized information silos persist among a subset of supporting nodes.

To sum up, these two cases confirm that unified digital platforms and well-defined collaborative mechanisms can substantially improve logistics efficiency and reduce total costs. At the same time, they highlight a common industry challenge: the lagging digital transformation of SME partners restricts the full realization of collaborative value in digital supply chains. The optimization paths proposed in Chapter 4 directly address these practical pain points, offering viable solutions for firms at different stages of digital maturity.

6. Conclusion

Three main conclusions emerge from this study. First, digital supply chains enhance corporate logistics operations through three interrelated channels: breaking information silos to improve transparency, applying intelligent algorithms to enable global resource scheduling, and employing blockchain to foster trusted cooperation environments. These mechanisms, when implemented together, effectively reduce inventory, transportation, and labor costs in logistics activities.

Second, the current bottlenecks in logistics development are layered. Internally, single firms suffer from unbalanced digital investment and misalignment between digital systems and legacy business processes. Externally, supply chain nodes face heterogeneous data standards, insufficient trust and benefit-sharing mechanisms, and the absence of permanent collaborative governance structures. These factors jointly impede the achievement of seamless logistics coordination across the entire chain.

Third, the proposed optimization paths operate on two levels: internal enterprise operations and external inter-firm collaboration. Firms should pursue phased, balanced digital transformation accompanied by business process restructuring. At the industry level, unified shared platforms, blockchain-based distribution systems, and permanent collaborative institutions are essential, supported by workforce training and policy incentives. The case analyses of retail and manufacturing enterprises verify the practical applicability of these strategies and their positive impact on logistics performance.

However, this study relies on literature review and case analysis of two representative enterprises, without conducting large-scale quantitative empirical tests. The case selection is limited to retail and heavy manufacturing sectors, leaving cross-border logistics and light industry contexts unexamined. Moreover, the benefit distribution model remains at a qualitative level, without a formal mathematical framework for precisely computing collaborative gains and risk allocations, leaving this issue for future investigation.

Subsequent studies could collect panel data from listed firms across multiple industries and employ regression models to quantitatively estimate the effects of digital collaborative platforms on logistics cost and inventory performance. Researchers may also design game-theoretic benefit distribution models suitable for multi-node supply chains. As large language models and digital twin technologies continue to evolve, further investigation could explore intelligent collaborative logistics management frameworks based on these emerging tools, as well as green logistics collaboration pathways under carbon-neutral targets.

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