

Research on the Transformation Challenges and Countermeasures for Small and Medium-sized Cold Chain Logistics Enterprises from a Digital Economy Perspective

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Abstract: Against the backdrop of the digital economy, cold chain logistics—a critical sector ensuring the circulation of fresh produce—has seen digital transformation emerge as a core trend for high-quality industry development. According to the China Cold Chain Logistics Committee, small and medium-sized cold chain logistics enterprises, accounting for over 90% of the sector by scale, play a vital role in regional fresh produce distribution. However, constrained by multiple factors including resources, technology, and management, their digital transformation lags behind industry development, subjecting them to severe survival and competitive pressures. This paper employs a literature review methodology, systematically analysing relevant academic literature, policy documents, and industry reports to dissect the current state and core challenges of digital transformation among SME cold chain logistics enterprises. It constructs a four-dimensional countermeasure framework—"resource integration, technology adaptation, management optimisation, and environmental improvement"—to provide enterprises with low-cost, actionable transformation guidance.

Keywords: Digital Economy; Small and Medium-Sized Cold Chain Logistics Enterprises; Digital Transformation; Transformation Challenges.

1. Introduction

1.1. Research Background and Significance

1.1.1. Research Context

The deep integration of next-generation digital technologies with the real economy is propelling the global economic development momentum from traditional to digital economies. Data has emerged as a new engine driving socio-economic progress, alongside land, capital, and labour [1]. Presently, China's economic restructuring and industrial upgrading face challenges including rising production factor costs, population ageing, and resource-environmental constraints. The digital economy is recognised as an effective means to address these new growth challenges [2]. Cold chain logistics enterprises, serving as vital conduits safeguarding national food safety and medical supplies, find digital transformation particularly crucial amid dual drivers of consumption upgrading and technological innovation. Policy documents such as China's "Overall Plan for Building a Digital China" and the "14th Five-Year Plan for Cold Chain Logistics Development" explicitly advocate deep integration of digital technologies with traditional cold chain logistics, providing clear policy direction for industry digitalisation. The rapid iteration and widespread adoption of digital technologies such as the Internet of Things, SaaS systems, and big data are propelling the cold chain logistics sector towards a shift from traditional, extensive operations towards precision, intelligence, and collaboration. Leading enterprises have achieved significant improvements in operational efficiency and service quality through digital empowerment, gradually widening the digital transformation gap within the industry.

Small and medium-sized cold chain logistics enterprises

constitute the overwhelming majority within the sector, undertaking core functions such as regional fresh produce distribution and cold chain services for small and medium-sized merchants. They serve as vital links connecting production and consumption ends. However, constrained by their resource endowments, the digital transformation of SMEs lags markedly: most still rely on traditional operational models with limited digital adoption, struggling to adapt to industry trends and shifting market demands. Concurrently, market pressure exerted by leading firms leveraging their digital advantages further intensifies survival pressures for SMEs. Against this backdrop, digital transformation has become an imperative for SMEs to overcome developmental bottlenecks and achieve sustainable survival and competitiveness.

1.1.2. Research Significance

(1) Theoretical Significance

Existing research predominantly focuses on the overall empowerment of the logistics sector by the digital economy, the digital transformation models of leading cold chain enterprises, or the generic challenges faced by SMEs in digital transformation. Specialised studies targeting the specific segment of "small and medium-sized cold chain logistics enterprises" remain scarce. The cold chain logistics industry possesses unique characteristics, including stringent temperature control requirements and a strong need for full-chain coordination. When combined with the limited resources typical of SMEs, this creates distinctive scenario-specific challenges for their digital transformation, rendering generic research conclusions difficult to directly apply. This paper, grounded in literature review, systematically integrates theories from the digital economy, cold chain logistics transformation, and SME development to construct a

dedicated research framework for small and medium-sized cold chain logistics enterprises. This not only enriches research at the intersection of the digital economy and SMEs but also fills a theoretical gap in the specific context of small and medium-sized cold chain logistics, providing a reference for subsequent studies.

(2) Practical Implications

Presently, SME cold chain logistics enterprises commonly grapple with practical dilemmas in digital transformation, including unclear transformation directions, significant resource investment pressures, and suboptimal technology application outcomes, lacking transformation pathways suited to their resource characteristics. This paper systematically reviews academic literature, industry reports, policy documents, and corporate practice materials to identify core challenges in SME cold chain digital transformation. It proposes targeted, low-cost, lightweight, and actionable countermeasures that directly serve as operational guidelines for SME transformation practices, enabling digital empowerment at reasonable cost. Concurrently, the research conclusions may inform government-targeted support policies and industry association service platforms, thereby optimising the external environment for SME cold chain digital transformation and fostering balanced development across the entire cold chain logistics sector.

1.2. Research Methodology and Content

1.2.1. Research Content

This paper addresses the core proposition of digital transformation for SME cold chain logistics enterprises within the digital economy framework. Following a progressive logic of "industry status review – core challenge analysis – tailored solution development", it focuses on resolving practical issues encountered by SMEs during transformation.

First, it systematically reviews the overall trends in digital transformation within the cold chain logistics sector, clarifying the current practices and broader landscape of digital transformation among SMEs.

Secondly, it conducts an in-depth analysis of common challenges faced by SMEs during transformation across four key dimensions: resource constraints, technology application, management operations, and external environment. Drawing on industry case studies, it reveals the underlying causes of these difficulties.

Finally, addressing the core challenges identified, this study constructs a countermeasure system grounded in the distinctive characteristics of SME cold chain logistics enterprises—namely, limited resources and unique operational scenarios. It proposes low-cost, implementable, and highly adaptable transformation pathways alongside specific operational recommendations, providing clear guidance for enterprise transformation practices.

1.2.2. Research Methodology

This study employs a literature review methodology throughout, with conclusions supported by multi-channel, multi-type literature collection and systematic analysis. The specific implementation pathway is as follows: Regarding literature sources, authoritative academic databases such as CNKI, Wanfang, and VIP were utilised to retrieve core keywords including "digital economy," "small and medium-sized cold chain logistics enterprises," "digital transformation," "cold chain digital technologies," and "SME transformation challenges." This yielded theoretical research

outputs such as academic papers and dissertations published within the past 5-10 years, thereby solidifying the theoretical foundation of the study. Industry reports published by professional bodies such as the Cold Chain Logistics Committee of the China Federation of Logistics & Purchasing and iResearch Consulting provided empirical data on digital development trends within the cold chain logistics sector, practical case studies of enterprise transformation, and analyses of industry pain points, ensuring the research aligns with industry realities. Relevant policy documents, including the "14th Five-Year Plan for Cold Chain Logistics Development" and the "Overall Plan for Building a Digital China," were gathered from government websites and policy release platforms to clarify the policy direction and support framework for industry development.

During the research implementation, the collected theoretical literature, industry reports, and policy documents were categorised, analysed, and logically deduced. This process not only provided robust literature support for analysing the current situation and identifying challenges but also offered theoretical foundations and practical references for constructing the countermeasure framework.

1.3. Relevant Theoretical Foundations

1.3.1. Theories Related to the Digital Economy

The digital economy constitutes an economic model built upon next-generation information technologies, where data resources serve as the key production factor, modern information networks act as the primary vehicle, and digital technological innovation functions as the core driving force [3]. Its defining characteristics manifest as technological drive, collaborative sharing, and diminishing marginal costs. Within the logistics sector, the enabling mechanism of the digital economy is primarily realised through the deep integration of digital technologies with operational processes. This manifests as the widespread application of technologies such as the Internet of Things, cloud computing, and blockchain across logistics segments including transportation, warehousing, loading/unloading, handling, and distribution processing. Such integration facilitates the emergence of innovative logistics technologies by adapting to new environments, business models, and operational paradigms [4]. The development of the digital economy facilitates the logistics sector's advancement by matching supply and demand information, coordinating multiple transport modes, optimising operational segments, and implementing energy-saving and efficiency-enhancing measures. This drives the sector's structural upgrading [5]. Through data accumulation and analysis, it propels decision-making from "experience-driven" to "data-driven" approaches, thereby elevating operational efficiency and service quality. This theory provides a core framework for understanding how digital technologies empower the transformation of the cold chain logistics sector and why they represent a key pathway for small and medium-sized cold chain logistics enterprises to overcome developmental bottlenecks.

1.3.2. Enterprise Digital Transformation Theory

Digital transformation is a dynamic process characterised by innovation, disruption, and irreversibility. It involves shaping digital concepts and employing modern digital technologies to alter corporate operational methods, industrial development models, and governmental governance approaches, thereby meeting the new demands of the digital economy. [6] Its core objectives are to achieve cost reduction

and efficiency gains, quality enhancement and upgrading, and value creation. For SMEs, digital transformation typically exhibits characteristics of being "lightweight, scenario-based, and phased", emphasising the alignment of transformation pathways with the enterprise's resource endowments and operational contexts, rather than blindly pursuing full-process, high-investment digital upgrades. This theory clarifies the core logic of digital transformation for small and medium-sized cold chain logistics enterprises: guided by operational pain points, selecting appropriate digital technologies and transformation pathways to progressively achieve digital optimisation of core processes. It provides a theoretical foundation for subsequent analysis of SME transformation challenges and the development of countermeasure systems.

1.3.3. Resource-Based View Theory for Small Enterprises

The Resource-Based View (RBV) stands as a pivotal theory within strategic management, offering a comprehensive explanation for the ultimate sources of competitive advantage and the persistent performance disparities among firms within the same industry—core questions in strategic management. [7][7] Presently, SMEs universally face resource scarcity constraints, particularly the shortage of critical resources such as capital, talent, and technology, which directly impacts their strategic choices and transformation outcomes. Within the digital transformation context, this theory elucidates the core root cause of the transformation predicament faced by small and medium-sized cold chain logistics enterprises: resource constraints make it difficult for them to bear high digital investment costs and attract multi-skilled talent, thereby limiting the depth of technology application and the pace of transformation advancement. Simultaneously, the theory provides direction for countermeasure development, namely that SMEs must compensate for their resource shortcomings through resource integration and external collaboration, rather than replicating the transformation models of large enterprises.

2. Current State of Digital Transformation in Small and Medium-Sized Cold Chain Logistics Enterprises

2.1. Policy Support Landscape

A clear policy guidance framework has been established at the national level. The "14th Five-Year Plan for Cold Chain Logistics Development" designates "digital transformation" as a core task for the industry's high-quality development. It explicitly states that amid the new wave of technological revolution and industrial transformation, the rapid adoption of new technologies such as big data, the Internet of Things, fifth-generation mobile communications (5G), and cloud computing will effectively empower all sectors and stages of cold chain logistics, accelerating the digital transformation and intelligent upgrading of facilities and equipment. [8] Local governments have also rolled out supporting policies, promoting enterprise digital upgrades through special subsidies, tax breaks, and project support. They provide inclusive financial green channels for SMEs that pass digital transformation certification. Concurrently, policy initiatives are accelerating industry standardisation. Documents like the Smart Cold Chain Construction Guidelines clarify technical requirements and data standards for cold chain digitisation, offering policy foundations and directional guidance for

industry transformation.

2.2. Characteristics of Technology Application

Digital technology applications within cold chain logistics have achieved multi-scenario penetration, centring on three core directions: Firstly, the scaled deployment of IoT technologies, where intelligent temperature-controlled tags, sensors and other devices enable real-time monitoring and intelligent management of critical parameters such as temperature and humidity throughout the cold chain logistics process [9]; secondly, the deep integration of big data technology, which ensures unified logistics standards and information sharing, establishes transparent and traceable processes, and drives the development of "smart cold chain" logistics systems [10]; thirdly, the widespread adoption of blockchain and traceability technologies, constructing a trustworthy end-to-end chain from production to consumption, with compliance rates reaching 98% in sectors such as pharmaceutical cold chains and imported fresh produce. Moreover, emerging technological directions such as SaaS-based management systems, digital twins, and green digitalisation are accelerating, propelling the industry's transition from foundational digitalisation towards intelligent collaboration.

2.3. Transformation Gap Manifestations

The industry's digital transformation exhibits pronounced polarisation, with the development gap between leading enterprises and SMEs widening continuously. China's cold chain logistics sector has crystallised into a distinct three-tier competitive structure: National leaders such as SF Express, JD Logistics, and Rongqing Logistics dominate the industry through comprehensive nationwide warehousing and distribution networks, advanced technological equipment, and integrated service capabilities. SF Express, focusing on high-end segments like pharmaceutical cold chain and cross-border cold chain logistics, achieved a 28% year-on-year growth in pharmaceutical cold chain revenue in 2025, establishing this as its core growth driver. Regional representatives such as Hongxing Cold Chain and Da Xiang Logistics have cultivated deep roots in local markets, developing unique strengths in regional cold chain distribution and industrial synergy; while a large number of SMEs primarily concentrate on niche segments, possessing relatively weaker competitive capabilities.

3. Analysis of Transformation Challenges for Small and Medium-Sized Cold Chain Logistics Enterprises from a Digital Economy Perspective

3.1. Resource Constraint Dilemma

The primary bottleneck hindering the digital transformation of small and medium-sized cold chain logistics enterprises lies in their insufficient resource endowment, with their predicament centring on the scarcity of two critical elements: capital and talent.

Regarding funding, digital transformation necessitates sustained investment in hardware and software procurement and maintenance. However, limited revenue streams and tight cash flow make it difficult for these enterprises to bear the substantial costs. Unlike the bespoke development

undertaken by leading firms, their investments are often confined to basic purchases and lack long-term planning. Furthermore, the three-to-five-year return cycle conflicts with the enterprises' demand for quick, low-risk, and high-return profits, exacerbating financial pressures.

Regarding talent, SMEs in cold chain logistics face the triple challenge of "recruitment difficulties, retention struggles, and ineffective utilisation": hybrid professionals proficient in both cold chain operations and digital technology are scarce and tend to gravitate towards leading enterprises; existing staff often possess weak skills and inadequate training, rendering deployed systems ineffective and creating a disconnect between investment and outcomes.

3.2. Technical Application Challenges

The core technical barriers hindering SME cold chain logistics enterprises' transformation effectiveness stem from inadequate alignment between digital technologies and actual business needs, coupled with poor system interoperability.

On one hand, poor technological adaptability is a prominent issue. Market solutions are predominantly tailored for leading enterprises, featuring redundant functionality and high costs, which are severely misaligned with the "regionalised, small-batch" operational scenarios of SMEs. Simultaneously, the application threshold for certain digital technologies is high, requiring specialised technical teams for ongoing maintenance and upgrades. SMEs lack these capabilities, resulting in unresolved issues during technology implementation that hinder transformation progress.

On the other hand, weak system interoperability persists. SMEs' digital transformation often proceeds in a fragmented manner, with warehousing, transportation, and financial systems sourced from different vendors. Incompatible data formats create "data silos." Manual re-entry is required as data cannot synchronise automatically between systems, compromising efficiency and accuracy. Furthermore, systems lack integration with upstream and downstream clients, hindering supply chain coordination and preventing operational optimisation through data analysis.

Furthermore, the depth of technological application remains insufficient. Digitalisation often stagnates at superficial levels such as electronic ledgers and basic data collection, lacking in-depth analysis of data concerning transport routes and inventory turnover. This prevents data-driven decision optimisation, ultimately failing to deliver genuine cost reductions and efficiency gains through transformation.

3.3. Management and Operational Challenges

SME cold chain logistics enterprises face multiple challenges in the management and operational aspects of digital transformation, including ambiguous strategic planning, insufficient integration of business and technology, and difficulties in supply chain coordination.

Strategically, most SMEs lack clear digital transformation roadmaps, with decisions often driven by blind imitation or bandwagon effects. Some enterprises fail to align transformation with their unique business characteristics, resource capabilities, and market demands, instead mechanically replicating leading players' approaches. This results in the adoption of high-cost, complex digital systems that misalign with actual operational needs.

At the operational level, inadequate integration of business and technology remains a core pain point. The essence of

digital transformation lies in leveraging technology to empower business operations, not merely accumulating technological tools. However, some SME cold chain logistics enterprises have failed to clarify the relationship between business and technology, simplistically equating digital transformation with "procuring digital equipment and building digital systems." This overlooks the need for deep integration between technology and business processes, preventing digital transformation from addressing core operational challenges and significantly diminishing its effectiveness.

Concurrently, the complexity of supply chain coordination hampers the transformation process. The core competitiveness of cold chain logistics lies in seamless, efficient coordination across the entire chain. However, SMEs in this sector, constrained by their modest scale and limited bargaining power, struggle to drive digital collaboration among upstream and downstream enterprises.

3.4. External Environmental Challenges

The digital transformation of SME cold chain logistics enterprises faces not only internal challenges but also multiple constraints from the external environment, primarily manifested in three aspects: insufficient policy support, lack of industry standards, and intensified market competition.

Regarding policy support, although national and local governments have introduced a series of policies to promote the digital transformation of cold chain logistics, targeted support measures for SMEs remain inadequate, limiting the effectiveness of policy implementation. Certain policies impose high subsidy thresholds, requiring enterprises to meet annual revenue targets or exceed specific digital investment thresholds, conditions beyond the reach of most SMEs. Others remain at the macro-guidance level, lacking concrete implementation rules and supporting services such as complimentary technical training or expert consultation, leaving SMEs uncertain how to apply for support or advance their transformation.

At the industry standards level, the standardisation framework for cold chain digitalisation remains incomplete, creating significant obstacles for SME transformation. Currently, China's cold chain logistics sector lacks unified digital technology standards, data standards, and security protocols. Differences in IoT device transmission protocols, data recording formats, and traceability information fields across enterprises result in incompatible systems and data silos, severely hampering supply chain collaboration efficiency. This absence of industry standards leaves SMEs without clear directional guidance for digital transformation, forcing them to navigate the process independently and thereby increasing the trial-and-error costs and risks associated with transformation.

At the market competition level, the digital advantages of leading enterprises exert intense market pressure, progressively narrowing the transformation window for SMEs. Leading cold chain logistics enterprises, leveraging substantial capital and technological resources, have enhanced operational efficiency and service quality through digital transformation, thereby capturing greater market share in premium segments. Faced with competitive pressure from these leaders, SMEs risk losing their current market position or even facing elimination if they fail to accelerate digital transformation. However, they encounter multiple obstacles—including resource constraints, technological gaps,

and management challenges—creating a dilemma.

4. Recommendations for Digital Transformation of Small and Medium-Sized Cold Chain Logistics Enterprises

4.1. Addressing Resource Constraints: Integrating Resources Through Multiple Channels to Lower Transformation Barriers

Addressing the core challenges of capital shortages and talent scarcity, SMEs must move beyond isolated efforts. By integrating resources and fostering external collaboration, they can compensate for their shortcomings and achieve low-cost transformation.

For funding security, establish a three-dimensional procurement system combining policy, market, and internal resources: Firstly, precisely align with policy incentives by appointing dedicated personnel to liaise with government departments. Thoroughly study policy documents such as the "14th Five-Year Plan for Cold Chain Logistics Development," focusing on support measures for SMEs including digitalisation subsidies, tax relief, and inclusive finance. Prepare application materials according to requirements to lower subsidy application thresholds. Secondly, innovate market financing models by adopting pay-per-module SaaS systems, exploring co-construction and shared use of digital infrastructure with upstream/downstream clients, or securing funding through supply chain finance platforms to ensure liquidity for transformation. Thirdly, optimise internal resource allocation by phasing investments, prioritising core scenarios like temperature monitoring and order management, and gradually expanding scope only after achieving initial results while reducing non-essential expenditure.

Regarding talent safeguards, establish a three-pronged talent system encompassing recruitment, cultivation, and borrowing. Lower recruitment thresholds by establishing targeted training partnerships with local vocational colleges specialising in logistics management and information technology. Reduce recruitment costs for high-end talent by offering internship positions and attracting graduates to join the workforce. Secondly, strengthen internal development by offering free digital skills training to existing staff through industry associations and online learning platforms, prioritising practical competencies like system operation and foundational data analysis. Finally, leverage external resources by signing long-term service agreements with digital service providers, requiring complimentary technical training and regular on-site maintenance to compensate for internal technical limitations. Engage industry experts as digital transformation consultants to provide professional guidance on strategic planning and technology selection, thereby reducing trial-and-error costs.

4.2. Overcoming Technical Application Challenges: Lightweight Adaptation and Enhanced Integration

To address issues of poor technology compatibility, system fragmentation, and insufficient application depth, SME cold chain logistics enterprises should adhere to the principles of "demand orientation, lightweight selection, and phased

integration" to enhance the effectiveness of technology application.

Regarding technology selection: Firstly, precisely identify requirements by first mapping core operational pain points, then selecting targeted digital solutions to avoid redundant functionality. For warehousing enterprises, prioritise procurement of inventory alert and temperature zone management modules, omitting non-essential transport dispatch capabilities. Secondly, prioritise mature, lightweight technologies. Opt for market-proven digital solutions with low operational barriers and maintenance costs, such as simplified IoT temperature-monitoring terminals, cloud-based SaaS management platforms, and standardised data interfaces. Avoid blind pursuit of "cutting-edge" technologies like big data forecasting or AI-driven scheduling. Make rational choices based on existing data infrastructure and operational scale, upgrading incrementally once foundational digitalisation is established.

Regarding system integration, address the issue of "data silos". Firstly, promote lightweight integration of internal systems by selecting digital products supporting standardised interfaces. Prioritise connecting core operational systems such as warehousing, transportation, and order management to achieve foundational data interoperability and shared access, thereby eliminating manual double-entry. Where existing system interfaces are incompatible, employ simple data hubs or third-party data conversion tools for data integration, avoiding extensive system restructuring. Secondly, facilitate collaborative integration with external systems by proactively connecting to regional cold chain logistics coordination platforms. Adopt the platform's unified data standards and technical protocols to enable data sharing with upstream and downstream enterprises. For key clients, negotiate standardised order formats and temperature-controlled data recording protocols, directly interfacing with client systems via APIs to reduce data conversion costs. Collaborate with other SMEs within the region to promote localised industry standardisation, such as unified temperature-controlled data transmission protocols and traceability information fields, thereby enhancing collaborative efficiency.

Regarding application depth: Firstly, unlock the value of foundational data by transitioning from basic collection and storage to analytical applications. Leverage the fundamental analytical capabilities of SaaS systems to statistically analyse inventory turnover data, transport route data, and customer demand data. This enables optimisation of replenishment frequencies, adjustment of delivery routes, and precise alignment with customer requirements. Secondly, focus resources on achieving digital breakthroughs in core scenarios characterised by high wastage and low efficiency. For instance, in temperature monitoring scenarios, implement real-time temperature/humidity alerts and anomaly data traceability; in inventory management, enable automatic stock alerts and intelligent warehouse allocation; in delivery operations, achieve simplified route optimisation and real-time order tracking. This "small-scale implementation" approach delivers "significant improvements", avoiding the resource wastage and suboptimal outcomes associated with blanket deployment.

4.3. Resolving Management and Operational Challenges: Strategic Leadership and Enhanced Integration

To address issues of strategic ambiguity, disconnect between business and technology, and collaboration difficulties, SME cold chain logistics enterprises must enhance management empowerment. Guided by a clear strategy, they should drive deep integration between business and technology to improve collaborative efficiency.

Strategic planning should involve formulating differentiated transformation strategies. Firstly, define the transformation positioning by developing a "differentiated + phased" plan tailored to the company's scale, business characteristics, and market positioning, avoiding blind imitation of leading enterprises. For instance: Specialised route operators should concentrate on "digitalisation of transport operations," optimising route planning and temperature monitoring; while warehousing-focused SMEs should prioritise "digitalisation of warehouse management," improving inventory turnover and temperature zone control efficiency. Secondly, define transformation objectives and priorities, breaking down goals into quantifiable phased metrics. Advance according to the principle of "easier before harder, core before secondary" to ensure clear direction and measurable outcomes. Thirdly, enhance management awareness by organising specialised digital transformation training and industry exchange activities for executives. This elevates understanding and prioritisation of the digital economy, clarifies management's role in coordinating transformation efforts, and secures necessary resource allocation and organisational support.

Regarding operational optimisation, drive deep integration between business and technology. Firstly, reconstruct business processes by leveraging digital technology applications to refine traditional workflows. Following the establishment of an online order platform, concurrently optimise order verification, delivery scheduling, and after-sales service procedures to ensure technological implementation genuinely resolves operational pain points. Secondly, establish a "business + technology" collaboration mechanism by forming dedicated transformation teams comprising key business personnel and technical staff. These teams shall manage requirement alignment, technology implementation, and effectiveness evaluation, ensuring technology selection meets business needs and processes adapt to technological applications. Regular transformation effectiveness review meetings shall be convened to adjust technical solutions based on operational feedback, creating a closed-loop "requirements-application-evaluation-optimisation" process.

Regarding collaborative development, a multi-faceted synergy system is being constructed. Firstly, supply chain coordination is being strengthened by proactively integrating with regional cold chain logistics public service platforms. Leveraging these platforms enables information sharing and order coordination with upstream and downstream enterprises. For core partners, data sharing agreements are being signed, adopting unified data standards to achieve real-time synchronisation of critical data such as orders, inventory, and temperature control, thereby enhancing supply chain responsiveness. Secondly, promote collective development among SMEs by establishing a digital transformation alliance with regional peers. This involves joint procurement of digital

systems, shared technical services, and collaborative platform development to reduce individual enterprises' transformation costs.

4.4. Overcoming External Environmental Challenges: Leveraging Policies, Promoting Joint Standard-Setting, and Addressing Competition

To address insufficient policy support, absent industry standards, and intensifying market competition, small and medium-sized cold chain logistics enterprises must proactively advocate for their interests and unite to weather challenges. Concurrently, they should enhance core competitiveness through digital transformation to withstand external pressures.

Regarding policy utilisation: Firstly, cold chain logistics enterprises should proactively align with policy directives, strengthen digital technology application capabilities, deeply engage in industry big data centre and information platform development, and continuously optimise data circulation and processing mechanisms to achieve efficient resource allocation and comprehensive operational efficiency improvements.[11] Secondly, actively participate in policy pilot schemes by applying to become local government digital transformation pilot enterprises. This secures policy preferences, financial support, and technical guidance, leveraging pilot demonstration effects to accumulate experience for subsequent transformations.

Regarding industry standards, proactively engage in collaborative standard-setting and sharing. Firstly, participate in industry association standard development, actively attend local or sector-level cold chain digitalisation standard workshops, and propose standard recommendations based on practical experience. Drive the formulation of lightweight data standards and technical interface standards suitable for SMEs. Prioritise adoption of published industry recommended standards to ensure compatibility with mainstream industry standards and enhance collaborative adaptability. Secondly, co-develop regional localised standards by collaborating with upstream/downstream enterprises and peers within the region to negotiate unified local standards such as order formats, temperature control data recording specifications, and traceability information fields, resolving data incompatibility issues among regional enterprises. Promote these local standards through industry associations to gradually expand their applicability and reduce collaboration costs.

Regarding market competition, leverage digitalisation to forge differentiated advantages. Firstly, focus on niche markets, avoiding direct competition with leading enterprises in high-end full-chain service domains. Deepen engagement in specialised segments such as county-level agricultural product cold chains, local fresh produce delivery, and bespoke services for small-to-medium merchants. Enhance service quality and efficiency within these niches through digital transformation to establish differentiated competitiveness. Secondly, enhance customer service experiences by providing value-added services through digital tools, such as real-time temperature control data, order tracking information, and inventory alert notifications, thereby boosting customer satisfaction and loyalty. For small and medium-sized merchant clients, introduce digital customised services. Thirdly, strengthen brand building by improving operational efficiency and service quality through digital transformation,

gradually accumulating brand reputation. Utilise channels such as social media and industry exhibitions to promote the achievements of digital transformation, enhance brand influence, and break free from the predicament of pure price competition.

5. Conclusion

Against the backdrop of digital economic development, this paper focuses on the core challenges of digital transformation for small and medium-sized cold chain logistics enterprises. Employing literature review methodology, it examines industry dynamics, analyses transformation obstacles, and constructs a strategic framework. Research indicates that these enterprises, as the industry's backbone, fulfil critical regional fresh produce distribution functions. Digital transformation represents an imperative for overcoming resource constraints and navigating market competition. However, their current transformation pace lags behind industry trends, underscoring both urgency and necessity. These enterprises face multidimensional core challenges encompassing resources, technology, management, and external environments. In response, this paper proposes a four-dimensional countermeasure system: "Resource Integration – Technology Adaptation – Management Optimisation – Environmental Improvement". This involves low-cost, implementable measures such as multi-channel funding acquisition, lightweight technology selection, differentiated strategy formulation, and policy support alignment, tailored to each enterprise's resource endowment and operational context.

Moving forward, the digital transformation of SME cold chain logistics enterprises will evolve towards lightweight intelligentisation and green digitalisation. By leveraging regional cold chain public service platforms to build collaborative ecosystems, resource sharing and efficient development will be achieved, injecting momentum into the industry's high-quality growth.

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