



Comparative Analysis of E-commerce Fresh Food Supply Chains in China and the United States

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Abstract. The fast growth of e-commerce has ultimately brought about a transformation in the structure and the mode of operations of fresh food supply chains. Being two of the largest e-commerce markets globally, China and the United States have followed two distinct paths that are a result of their institutional settings and the way functions of the market operate. In China, business models such as "community group buying," direct-to-consumer procurement, and forward distribution centres show the importance of flexibility - that is, the ability to reshape the allocation of resources on demand in times of unstable and uncertain conditions. Although the industry suffers from a highly fractured situation, with a difference of cold chain coverage between the urban and rural areas and with inconsistent regulatory measures, the fact is that the sector remains very competitive. While the US, on the other hand, has a national cold chain network, which is supported by strict laws and regulations that guarantee consistency and stability, therefore, loss rates during transport and storage remain low. Yet this model is constrained by high operational costs and faces mounting pressure to transition towards sustainability. Employing a comparative analysis and case study approach, this paper identifies the complementary advantages of the two systems and proposes optimization strategies in four dimensions: balanced cold chain development, digitalization and traceability governance, collaborative contract mechanisms, and green transformation. The findings provide both theoretical insights and practical implications for multinational enterprises engaged in global supply chain management.

Keywords: fresh food supply chain, e-commerce; cold chain logistics, supply chain innovation, sustainable transformation.

1 Introduction

Fresh food supply chains have long been a central issue in supply chain management due to product perishability, volatile demand, and high loss rates. Traditional multi-tiered structures—linking producers, wholesalers, retailers, and consumers—often result in inefficiency and significant waste. Globally, post-harvest loss rates for fruits and vegetables during storage and transportation are estimated at 25%–30%, primarily due

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to unstable temperature control, poor packaging, and lack of monitoring [1]. The rise of e-commerce has reshaped this landscape. Models such as direct procurement, front distribution centers, and community group purchasing reduce intermediaries, enhance efficiency, and improve consumer experience [2].

China and the United States, the world's two largest e-commerce markets, share the goals of efficiency, loss reduction, and consumer satisfaction, but pursue them through different pathways. China emphasizes flexibility, understood as the ability to quickly adjust to demand fluctuations under uncertainty, supported by model innovations like direct procurement and community group purchasing. However, the system remains fragmented, with uneven cold chain coverage and inconsistent standards, especially in lower-tier cities where loss rates still exceed 20% [3]. The U.S. model, by contrast, relies on nationwide cold chain networks and strict regulatory oversight, focusing on stability and standardization, which keep losses below 10% [4]. Yet this comes at the cost of high cold chain expenses, accounting for 30%–40% of total operations, alongside growing sustainability pressures [5, 6].

This study seeks to answer three questions: what are the key differences in China's and the U.S.'s e-commerce-driven fresh food supply chain models; how do these models operate in practice, with what strengths and limitations; and what insights they offer for optimization and multinational strategy. To address these, the paper applies a comparative analysis and case study approach. Fresh Food Supply Chain Development Models.

2 Fresh Food Supply Chain Development Models

2.1 China's Development Model

The development of China's fresh food e-commerce mainly relies on three models: direct procurement, community group purchasing, and front distribution centers. The direct procurement model refers to e-commerce platforms purchasing agricultural products directly from farmers, bypassing intermediaries such as wholesalers and distributors. This model not only shortens the supply chain but also enhances price transparency and farmers' bargaining power. For example, Pinduoduo's Duoduo Grocery connects farmers directly with consumers, increasing farmers' incomes by an average of 10%–15% while reducing consumer prices by about 5% [7].

The community group purchasing model leverages community convenience stores or "group leaders" to aggregate demand, conduct pre-sales, and organize self-pickup, thereby reducing pressure on last-mile cold chain distribution. During the COVID-19 pandemic, Meituan Youxuan demonstrated strong performance, successfully meeting residents' daily needs despite limited cold chain vehicle capacity [8].

The front distribution center model establishes small warehouses within urban areas, positioning inventory closer to consumers to enable instant delivery. During large-scale promotional events such as "618" and "Double 11," JD maintained an on-time fulfillment rate of over 95% by relying on its front distribution system [9]. The core logic of this model lies in shortening the "last mile" delivery path. Unlike traditional centralized warehouses located on the outskirts of cities, front distribution centers decentralize part

of the inventory into community or urban nodes. This allows orders to be picked and delivered in very short timeframes, meeting consumer expectations for same-day or even instant delivery of fresh products. Given the high perishability and volatile demand typical of fresh produce, this model improves turnover, reduces stockouts, and strengthens customer loyalty. However, it also creates pressure on inventory management and increases operating costs. As a result, e-commerce enterprises often rely on big data forecasting and optimization models to dynamically balance inventory allocation and avoid shortages or excess stock caused by inaccurate demand forecasts.

According to the National Bureau of Statistics of China, the scale of China's fresh food e-commerce market exceeded 400 billion RMB in 2023, doubling compared to 2018 and demonstrating rapid growth [10].

Nevertheless, these models also face limitations. The urban–rural gap in cold chain infrastructure means that loss rates in third- and fourth-tier cities and rural areas remain above 20% [3]. In addition, different platforms lack unified standards for warehousing, transportation, and digitalization, making nationwide coordination difficult. This fragmentation—defined as the uneven distribution of infrastructure and the lack of unified institutional standards across regions and platforms—not only reduces overall efficiency but also increases the complexity of future integration.

2.2 The Development Model of the United States

In contrast to China, the U.S. model places greater emphasis on cold chain infrastructure and institutional safeguards. Amazon Fresh is a representative example, relying on a nationwide cold chain network and highly standardized warehousing systems to guarantee product freshness. Data show that in 2021, Amazon Fresh accounted for about 28% of the U.S. online fresh grocery market, second only to Walmart [11]. By 2024, 34% of American consumers identified Amazon Fresh as their preferred platform [12]. The U.S. cold chain system has consistently kept product loss rates below 10%, a level well above the global average [4].

The effectiveness of this model derives from both regulation and technology. At the institutional level, federal and state governments enforce strict standards for food safety, cold chain operation, and storage, which provide reliability for cross-state transport and long-distance distribution. At the technological level, Amazon Fresh applies big data analytics and artificial intelligence to forecast demand and optimize inventory. Automated recommendations and shopping lists further enhance repurchase rates and consumer loyalty [12].

Nonetheless, the U.S. model has notable drawbacks. With escalating energy use and labor expenses, cold chain logistics impose substantial operational burdens, thereby limiting the scalability of the system [5]. Meanwhile, pressure for green transformation is increasing, with growing demands for sustainable packaging, lower carbon emissions, and the use of renewable energy [6].

2.3 Comparison and Complementarity

Taken together, China's advantage lies in flexibility and the capacity to adapt quickly, whereas the United States stands out for stability and strict regulatory standards. China's rapid growth has been driven by innovative business models, but its progress is still limited by uneven cold chain infrastructure and weaker institutional support. The U.S., in turn, maintains low loss rates through nationwide networks and regulation, but its advantages are offset by high costs and sustainability challenges. Global research also emphasizes that cold chain systems in many regions face structural inefficiencies, characterized by infrastructure gaps, high energy consumption, and limited utilization. In the Chinese context, studies highlight that inadequate temperature monitoring and insufficient adoption of sustainable practices exacerbate these inefficiencies, leading to both higher product losses and significant environmental impacts [13]. In a global perspective, the two models are complementary. China can benefit from U.S. practices of institutionalization and standardization (the implementation of uniform procedures and quality benchmarks across the supply chain), while the U.S. can draw on China's strengths in flexibility and innovative business models. For multinational enterprises, the Chinese market represents opportunities for innovation and rapid growth, whereas the U.S. market provides reliability and regulatory assurance.

3 Optimization Strategies

3.1 Logistics and Cold Chain Optimization

Cold chain logistics has long been regarded as the core of fresh supply chain optimization, and it is a decisive factor in both loss reduction and service quality. In China, while first-tier cities have developed relatively complete cold chain systems, the lack of coverage in lower-tier cities and rural areas remains a serious problem, with loss rates in transportation often exceeding 20% [3]. This gap discourages farmers from entering e-commerce channels and limits overall efficiency. By contrast, the United States relies on a nationwide cold chain network that has consistently kept loss rates below 10%, reflecting a clear advantage in stability [4]. Yet this stability comes at a cost, as cold chain logistics impose significant financial pressures on firms [5]. In recent years, the use of artificial intelligence (AI) and the Internet of Things (IoT) has opened new possibilities for cold chain management. Through temperature sensors, real-time monitoring, and data analytics, companies can fine-tune storage and transport conditions to reduce waste. Studies further suggest that the rapid spread of e-commerce in developing economies has encouraged the uptake of such innovations, allowing firms to respond more effectively to demand volatility and operational uncertainty [14]. In China, JD and Meituan have piloted dynamic optimization technologies in parts of their fleets, while in the U.S., Amazon Fresh has deployed AI forecasting models to reduce inventory turnover time by about 20% [12]. Building on this wave of innovation, recent developments have moved beyond the traditional "Predict-then-Optimize" model, which often amplifies forecasting errors under uncertain demand. The "Optimize-Predict-Then-Re-optimize" (OTPTO) framework, through iterative correction of forecasting

deviations, has proven particularly effective in front warehouse model models. For instance, its application at JD Fresh increased order completion rates by more than 4% and significantly enhanced inventory efficiency, demonstrating the potential of adaptive decision-making systems in modern e-commerce supply chains.

3.2 Digitalization and Traceability Governance

Digitalization and traceability governance are widely recognized as crucial tools for ensuring food safety and supply chain transparency. Blockchain technology has gradually entered practice in fresh food supply chains. Its decentralized and tamper-proof features can greatly increase consumer trust. Multiple studies indicate that blockchain adoption improves traceability, shortens recall response times, and enhances confidence in supply chains [10,11]. In China, Pinduoduo uses big data to promote “reverse customized agriculture,” guiding farmers to produce according to consumer preferences and thereby reducing waste and unsold goods. In the U.S., Amazon Fresh applies purchase history to automatically generate shopping lists, significantly increasing repurchase rates and customer loyalty [12].

Nonetheless, both countries face challenges in advancing digital governance. In China, the absence of unified data standards makes inter-platform collaboration difficult, hindering systemic efficiency. In the U.S., strict privacy protection and competitive barriers limit the extent to which blockchain can cover the full chain. To unlock the full potential of digital governance, it will be essential to build standardized data protocols and industry alliances, balancing privacy concerns with cooperative benefits.

3.3 Collaboration and Contract Mechanisms

Efficient supply chains depend on collaboration and contractual arrangements. In China, community group-buying has expanded smallholder participation in e-commerce channels, but the absence of standardized contracts still exposes farmers and platforms to performance risks. During the pandemic, Meituan Youxuan implemented a pre-sale and centralised collection mechanism, boosting farmers' incomes by 10% to 12%. However, delivery delays to customers still occurred [8]. In contrast, the American supply chain relies more heavily on long-term contracts to stabilize partnerships between large farms and retailers. However, contract rigidity creates problems under demand shocks. During the COVID-19 pandemic, some American farmers were unable to adjust supply due to contractual restrictions, leading to severe waste and losses [6]. Research shows that well-designed contract coordination mechanisms can strike a balance between stability and flexibility [12]. For China, the priority should be the institutionalization of standardized contracts to reduce uncertainty, whereas in the U.S., introducing more flexible clauses can improve resilience against sudden shocks.

3.4 Green and Sustainable Development

Green transformation has become a global trend in the development of fresh food supply chains. Recent research highlights that refrigeration equipment and transportation

processes are among the primary sources of carbon emissions in cold chain logistics, with inadequate monitoring and limited sustainable practices further intensifying their environmental impact [13]. For China, this implies that cold chain expansion needs to be closely aligned with sustainability objectives. In recent years, Freshippo (Hema Fresh) has tested eco-friendly packaging and the use of renewable energy in its front warehouse model, aiming to reconcile efficiency with environmental concerns. In the United States, Amazon Fresh has emphasized local sourcing to shorten transportation distances and introduced renewable energy in its warehouses to reduce emissions [11]. At the same time, rising consumer awareness of sustainable consumption has encouraged firms to adopt practices such as recyclable packaging and carbon footprint labeling. Overall, the green supply chain is no longer viewed solely as an environmental obligation but increasingly as a key factor in competitive advantage. Looking ahead, China will need to incorporate green requirements more systematically into cold chain standards, while the U.S. must accelerate its transition toward sustainability without undermining its institutionalized advantages.

4 Case Studies and Policy Implications

In China, Pinduoduo's direct procurement model has significantly shortened the supply chain, raising farmers' income by an average of 10%–15% while simultaneously reducing consumer prices by about 5% [7]. This model effectively lowers transaction costs and improves supply-demand matching efficiency, but it also creates the risk of farmers becoming overly dependent on a single platform. JD, by contrast, has relied on its cold chain network and intelligent warehousing systems to maintain on-time fulfillment rates of over 95% during large-scale promotional events such as the "618" and "Double 11" shopping festivals [9]. This demonstrates how substantial investments in infrastructure and technology can substantially enhance supply chain stability. Freshippo (Hema Fresh) has integrated renewable energy equipment and eco-friendly packaging into its front warehouse model operations, simultaneously ensuring rapid delivery and advancing environmental goals, thereby becoming a representative case of China's green transition.

The most prominent U.S. case is Amazon Fresh. Leveraging a nationwide cold chain system and AI-driven algorithms, the platform has enhanced replenishment accuracy and demand forecasting capabilities, thereby improving inventory turnover rates and service quality [9]. However, during the COVID-19 pandemic, the inflexible nature of long-term contracts prevented American farmers from responding nimbly to sudden demand shocks, resulting in substantial product wastage and unsold stock [6]. This highlights an inherent flaw in the American model: stability is achieved at the expense of flexibility. These cases provide clear policy implications. China's cold chain focused strategies ought to be the improvement of cold chain infrastructure, the development of standardization and the institutionalization of contracts, as well as the adoption of advanced optimization tools such as the OTPTO framework for increasing systemic resilience. In the USA, policy measures should be concentrated on minimizing cold chain cost operations, moving forward the green transition, and towards more flexible terms

in contracts. To be competitive in the Chinese market, multinational firms have to be model innovators and channel integrators, while to succeed in the US market, adherence to regulatory frameworks and the establishment of quality assurance systems is crucial.

5 Conclusion

This research is therefore intended to provide a systematic and comparative analysis of the development modes and optimization routes of fresh food supply chains of China and the US, putting in the focal point the impact of e-commerce. The findings emphasize that China's key advantages are reflected in its flexibility and model innovation, but the cold chain coverage and standardization are still inadequate to be used as constraints. While the US has the edge in terms of stability and high institutional standards, it encounters significant challenges due to the high operational costs and the increasing pressure to pursue a greener transformation. At the same time, the two models complement each other at the global level: China can benefit from the institutionalization and standardization of the US, whereas the US can learn from China's supply chain practice in terms of innovation and adaptability.

The application of the Optimize-Predict-Then-Re-optimize (OTPTO) model demonstrates that iterative methods combining prediction with optimization can effectively improve fulfillment rates and inventory efficiency in the front warehouse model scenario. This suggests new directions for supply chain optimization in both countries.

Looking ahead, supply chain optimization should focus on four priorities: ensuring balanced development of cold chain infrastructure, advancing digitalization and traceability governance, improving supply chain coordination and contractual mechanisms, and accelerating the green and sustainable transition. Pursuing these pathways will not only strengthen the efficiency and resilience of Chinese and American supply chains but also provide robust theoretical insights and practical guidance for multinational enterprises engaged in global strategic planning.

The limitations of this study must be acknowledged. The analysis primarily relies on secondary data and case studies, which limits the depth of empirical validation. Moreover, the research scope is confined to China and the United States, excluding other emerging economies that may present diverse institutional structures and operational contexts. Future research should therefore expand its scope through comparative studies across multiple countries, simulation-based modelling, and empirical fieldwork to further test and extend these findings.

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