Cold Chain Management and E-commerce Logistics Challenges in Palakkad and Coimbatore

OPEN ACCESS

Volume: 13

Special Issue: 1

Month: February

Year: 2026

P-ISSN: 2321-788X

E-ISSN: 2582-0397

Citation:
Ajay, C., et al. "Cold Chain Management and E-Commerce Logistics Challenges in Palakkad and Coimbatore." *Shanlax International Journal of Arts, Science and Humanities*, vol. 13, no. S1, 2026, pp. 145–57.

DOI:
https://doi.org/10.34293/sijash.v13iS1-Feb.10122

C. Ajay
III BBA Logistics
Department of Business Administration (Logistics and Aviation Management)
Nehru Arts and Science College (Autonomous), Coimbatore

R. Nandagopal
III BBA Logistics
Department of Business Administration (Logistics and Aviation Management)
Nehru Arts and Science College (Autonomous), Coimbatore

S. Najumudeen
Assistant Professor
Department of Business Administration (Logistics and Aviation Management)
Nehru Arts and Science College (Autonomous), Coimbatore

Abstract
Cold chain management and e-commerce logistics play a crucial role in ensuring the efficient movement of temperature-sensitive goods and fast-moving consumer products. This study examines cold chain management practices in food and beverage logistics in Palakkad and analyzes the logistics challenges faced in e-commerce distribution in Coimbatore and Palakkad. The research focuses on transportation efficiency, storage facilities, temperature control systems, last-mile delivery issues, infrastructure constraints, and supply chain coordination. Primary data were collected through structured questionnaires from logistics operators, warehouse managers, and delivery personnel, supported by secondary data from industry reports and journals. The study identifies key challenges such as inadequate cold storage infrastructure, high operational costs, traffic congestion, delivery delays, and technological limitations in tracking systems. The findings highlight the need for improved infrastructure, digital integration, and better coordination among supply chain stakeholders. The study concludes that strengthening cold chain systems and addressing e-commerce distribution challenges will enhance operational efficiency, reduce product losses, and improve customer satisfaction in both regions.

Keywords: Cold Chain Management, E-commerce Logistics, Food and Beverage Supply Chain, Last-Mile Delivery, Logistics Challenges.

Introduction

The rapid growth of globalization, urbanization, and digital transformation has significantly reshaped the logistics and supply chain industry. Among the various segments of logistics, cold chain management and e-commerce distribution have emerged as two critical components in ensuring efficient product movement and customer satisfaction. In today's competitive business environment, maintaining product quality and delivering goods on time are essential factors that determine organizational success.

Cold chain management refers to the systematic process of storing, handling, and transporting temperature-sensitive products under controlled conditions to preserve their quality and safety. It plays a crucial role in the food and beverage industry, where perishable items such as dairy products, fruits, vegetables, meat, and frozen foods require continuous temperature monitoring. Any disruption in the cold chain can result in spoilage, financial losses, and health risks. In regions like Palakkad, where agriculture and food processing activities are prominent, effective cold chain logistics becomes essential to reduce wastage and maintain product standards.

At the same time, the rapid expansion of e-commerce has transformed consumer purchasing behavior. Customers expect fast, reliable, and cost-effective delivery services. E-commerce distribution involves complex logistics operations, including warehousing, inventory management, order processing, transportation, and last-mile delivery. However, logistics challenges such as traffic congestion, infrastructure limitations, high fuel costs, delayed deliveries, and technological inefficiencies often affect operational performance. In growing commercial hubs like Coimbatore and Palakkad, these challenges significantly influence supply chain efficiency and customer satisfaction.

While cold chain management primarily focuses on maintaining temperature-controlled logistics for perishable goods, e-commerce logistics emphasizes speed, accuracy, and last-mile delivery efficiency. Both sectors require advanced infrastructure, skilled workforce, real-time tracking systems, and strong coordination among supply chain stakeholders. Despite technological advancements, issues such as inadequate storage facilities, lack of integrated tracking systems, fluctuating demand, and rising operational costs continue to pose major challenges.

This study aims to examine cold chain management practices in food and beverage logistics in Palakkad and analyze the logistics challenges faced in e-commerce distribution in Coimbatore and Palakkad. By integrating these two dimensions, the study provides a comprehensive understanding of supply chain efficiency, operational bottlenecks, and improvement strategies. Strengthening cold chain systems and addressing e-commerce logistics challenges are vital for minimizing product losses, enhancing service quality, and achieving sustainable growth in the logistics sector.

Review of Literature

Cold chain management and e-commerce logistics have gained significant attention in supply chain research due to their growing importance in ensuring product quality and timely delivery. According to Christopher (2016), supply chain efficiency depends on effective coordination, temperature control systems, and real-time monitoring, particularly for perishable goods. Shashi, Centobelli, and Cerchione (2018) emphasized that cold chain management reduces food wastage and enhances food safety by maintaining consistent temperature throughout storage and transportation. Similarly, Aung and Chang (2014) highlighted that inadequate cold storage infrastructure and poor transportation facilities are major contributors to post-harvest losses in developing regions. Bogataj, Bogataj, and Vodopivec (2005) pointed out that temperature deviations in cold chain logistics significantly impact product shelf life and financial performance.

In the context of food and beverage logistics, Kuo and Chen (2010) observed that the integration of information technology, such as RFID and GPS tracking systems, improves transparency and efficiency in cold chain operations. Joshi, Banwet, and Shankar (2013) found that infrastructure limitations and high operational costs remain major challenges in maintaining effective cold chain networks in emerging markets. Research by Akkerman, Farahani, and Grunow (2010) indicated that successful cold chain management requires proper coordination among producers, transporters, warehouse operators, and retailers.

Parallel to cold chain research, studies on e-commerce logistics have focused on last-mile delivery challenges and operational efficiency. Hübner, Kuhn, and Wollenburg (2016) stated that

e-commerce growth has significantly increased pressure on distribution networks, especially in urban and semi-urban areas. Gevaers, Van de Voorde, and Vanelslander (2011) emphasized that last-mile delivery accounts for a major portion of logistics costs and is often affected by traffic congestion, infrastructure constraints, and delivery scheduling issues. Boyer, Prud'homme, and Chung (2009) found that customer satisfaction in e-commerce largely depends on delivery speed, order accuracy, and real-time tracking systems.

In the Indian context, Singh and Pandey (2015) reported that inadequate warehousing facilities and fragmented transportation systems create significant challenges for both cold chain and e-commerce logistics. Kalia and Paul (2021) observed that digital transformation and automation have improved distribution efficiency, but rural and semi-urban regions still face infrastructural gaps. Raj, Sinha, and Kumar (2022) highlighted that coordination issues between warehouses and last-mile delivery agents often lead to delays and increased operational costs.

Overall, the literature suggests that cold chain management ensures product quality and reduces wastage in food and beverage logistics, while efficient e-commerce logistics enhances customer satisfaction and market competitiveness. However, many studies examine these areas separately, and limited research integrates cold chain practices with e-commerce distribution challenges in regional contexts such as Palakkad and Coimbatore. Therefore, the present study attempts to bridge this gap by analyzing both cold chain management and e-commerce logistics challenges to provide a comprehensive understanding of supply chain efficiency and improvement strategies.

Objectives of the Study

1. To examine the existing cold chain management practices in food and beverage logistics in Palakkad.
2. To identify and analyze the major logistics challenges faced in e-commerce distribution in Coimbatore and Palakkad.
3. To evaluate the impact of infrastructure, transportation, and technological factors on supply chain efficiency and customer satisfaction.

Research Methodology

Research methodology refers to the systematic procedure adopted to collect, analyze, and interpret data in order to achieve the objectives of the study. The present study examines cold chain management practices in food and beverage logistics in Palakkad and analyzes the logistics challenges in e-commerce distribution in Coimbatore and Palakkad.

Research Design

The study adopts a descriptive research design, as it aims to describe existing cold chain practices and identify operational challenges in e-commerce logistics. This design helps in understanding the current logistics system and identifying areas for improvement.

Nature of the Study

The study is analytical in nature, as it evaluates the impact of infrastructure, transportation, and technological factors on supply chain efficiency and logistics performance.

Sources of Data

The study is based on both primary and secondary data.

Primary Data

Primary data were collected through a structured questionnaire from:

- Cold storage operators
- Warehouse managers
- Logistics service providers
- E-commerce delivery personnel

The questionnaire included questions related to storage facilities, temperature monitoring systems, transportation efficiency, last-mile delivery issues, infrastructure constraints, and technological support.

Secondary Data

- Secondary data were collected from:
- Research journals
- Books and academic publications
- Government and industry reports
- Online sources related to cold chain management and e-commerce logistics

Sampling Design

- Sampling Method: Convenience sampling method was adopted.
- Sample Size: The study is based on 124 respondents.
- Sampling Area: Palakkad and Coimbatore.
- Target Population: Cold chain operators, warehouse managers, logistics companies, and e-commerce delivery personnel.

Tools for Data Collection

A structured questionnaire was used as the main data collection instrument. The questionnaire consisted of:

- Demographic details of respondents
- Questions related to cold chain infrastructure and temperature control
- Questions related to e-commerce logistics challenges
- Statements measured using a 5-point Likert scale

Statistical Tools Used for Data Analysis

The collected data from 124 respondents were analyzed using:

Percentage Analysis: To identify major operational challenges and analyze demographic data.

Chi-Square Analysis: To determine whether there is a significant association between infrastructure availability, transportation efficiency, technological support, and logistics performance.

Period of the Study

The study was conducted during the academic year 2025–2026.

Limitations of the Study

- The study is limited to 124 respondents in Palakkad and Coimbatore.
- Convenience sampling may not fully represent the entire logistics sector.
- Time constraints limited broader data collection.
- Responses are based on personal experiences and operational perceptions.

Data Analysis and Interpretation

This chapter presents the analysis and interpretation of data collected from 124 respondents, including cold storage operators, warehouse managers, logistics providers, and e-commerce delivery personnel in Palakkad and Coimbatore. The statistical tools used for analysis are Percentage Analysis and Chi-Square Analysis. The data are presented in tabular form followed by interpretation.

Percentage Analysis

Area of Operation

Area	Number of Respondents	Percentage (%)
Palakkad	68	55%
Coimbatore	56	45%
Total	124	100%

Interpretation

The majority of respondents (55%) operate in Palakkad, while 45% operate in Coimbatore. This shows balanced participation from both regions, with slightly higher representation from Palakkad.

Type of Logistics Activity

Activity	Number of Respondents	Percentage (%)
Cold Chain (Food & Beverage)	50	40%
E-commerce Distribution	54	44%
Both	20	16%
Total	124	100%

Interpretation

44% of respondents are engaged in e-commerce distribution, while 40% are involved in cold chain logistics. This indicates that both sectors are significantly active in the study area.

Availability of Adequate Cold Storage Facilities

Response	Number	Percentage (%)
Yes	52	42%
No	72	58%
Total	124	100%
Total	124	100%

Interpretation

A majority of respondents (58%) reported inadequate cold storage facilities. This suggests infrastructure gaps in maintaining temperature-controlled storage systems.

Major Challenges in E-commerce Logistics

Challenge	Number	Percentage (%)
Traffic Congestion	36	29%
High Transportation Cost	32	26%
Delivery Delays	30	24%
Lack of Technology	26	21%
Total	124	100%

Interpretation

Traffic congestion (29%) is identified as the major challenge, followed by high transportation costs (26%). This indicates that urban infrastructure and rising operational costs significantly affect distribution efficiency.

Impact of Technology on Logistics Efficiency

Opinion	Number	Percentage (%)
Highly Positive	40	32%
Positive	48	39%
Neutral	20	16%
Negative	16	13%
Total	124	100%

Interpretation

71% of respondents believe that technology positively impacts logistics efficiency. This highlights the importance of digital tracking systems, automation, and real-time monitoring.

Chi-Square Analysis

Chi-square test is used to determine whether there is a significant association between selected variables.

Relationship Between Infrastructure Availability and Logistics Efficiency

Hypothesis

- H1: There is no significant relationship between infrastructure availability and logistics efficiency.
- H2: There is a significant relationship between infrastructure availability and logistics efficiency.

Result

- Calculated Chi-square value = 11.24
- Table value (5% level of significance) = 9.49

Since the calculated value is greater than the table value, the null hypothesis is rejected.

Interpretation

There is a significant relationship between infrastructure availability and logistics efficiency. Adequate cold storage and transportation facilities directly improve supply chain performance.

Relationship Between Technology Usage and Delivery Performance

Hypothesis

- H1: There is no significant relationship between technology usage and delivery performance.
- H2: There is a significant relationship between technology usage and delivery performance.

Result

- Calculated Chi-square value = 13.67
- Table value = 9.49

Since the calculated value is greater than the table value, the null hypothesis is rejected.

Interpretation

There is a significant relationship between technology usage and delivery performance. The adoption of digital tools improves tracking accuracy, reduces delays, and enhances overall logistics efficiency.

Overall Analysis

The percentage analysis indicates that inadequate infrastructure, traffic congestion, and high operational costs are the major challenges affecting both cold chain and e-commerce logistics. The findings also reveal that technology plays a crucial role in improving efficiency and reducing operational inefficiencies.

Chi-square analysis confirms that infrastructure and technology significantly influence logistics performance. Therefore, improving storage facilities, transportation networks, and digital integration will enhance supply chain efficiency in Palakkad and Coimbatore.

Findings of The Study

This chapter presents the major findings derived from the analysis of data collected from 124 respondents involved in Cold Chain Management (Food & Beverage Logistics) and E-commerce Distribution in Palakkad and Coimbatore. The findings are based on percentage analysis and chi-square statistical testing.

Regional Distribution of Logistics Operations

The study reveals that 55% of respondents operate in Palakkad, while 45% operate in Coimbatore. This indicates that both regions have active logistics networks, but Palakkad shows slightly higher representation in cold chain and food-based logistics activities.

Palakkad, being strategically located near the Tamil Nadu–Kerala border, serves as a transit and storage hub for agricultural and food products. Coimbatore, on the other hand, is a commercial and industrial city with strong e-commerce penetration.

Nature of Logistics Activities

The data indicates:

- 44% are engaged in e-commerce logistics.
- 40% operate in cold chain logistics.
- 16% are involved in both sectors.

This shows that e-commerce logistics has slightly overtaken traditional cold chain operations due to increasing online shopping behavior and rapid growth in last-mile delivery services.

However, cold chain logistics remains crucial, especially for perishable food items, dairy products, frozen goods, and beverages.

Infrastructure Challenges in Cold Chain Management

A major finding of the study is that 58% of respondents reported inadequate cold storage facilities. Only 42% confirmed availability of sufficient infrastructure.

This indicates:

- Insufficient refrigerated warehouses.
- Limited availability of temperature-controlled vehicles.
- Power supply interruptions affecting storage conditions.
- High investment cost for cold storage setup.

Inadequate infrastructure leads to:

- Food spoilage.
- Quality deterioration.
- Increased wastage.
- Financial losses for businesses.

Major Challenges in E-commerce Distribution

Respondents identified several operational challenges:

a) Traffic Congestion (29%)

- Urban traffic in Coimbatore and inter-district transport congestion significantly delays deliveries. Peak-hour traffic increases fuel consumption and reduces delivery efficiency.

b) High Transportation Cost (26%)

- Rising fuel prices, vehicle maintenance expenses, and toll charges increase overall logistics costs. This directly affects profitability.

c) Delivery Delays (24%)

- Delivery delays are caused by traffic, improper route planning, and last-mile connectivity issues in semi-urban and rural areas.

d) Lack of Advanced Technology (21%)

- Some logistics operators still rely on manual tracking systems, limiting efficiency and transparency.

Impact of Technology on Logistics Performance

- 71% of respondents agreed that technology positively impacts logistics efficiency.

Technology includes:

- GPS tracking systems.
- Warehouse Management Systems (WMS).
- Inventory management software.
- Barcode and RFID systems.
- Route optimization software.

Technology Benefits include:

- Real-time shipment tracking.
- Reduced delivery errors.

- Improved inventory accuracy.
- Better customer satisfaction.
- Lower operational inefficiencies.

However, smaller logistics operators face financial constraints in adopting advanced digital systems.

Relationship Between Infrastructure and Logistics Efficiency

- Chi-square analysis confirmed a significant relationship between infrastructure availability and logistics efficiency.

This Statistically Proves that:

- Companies with proper cold storage and transport facilities perform better.
- Infrastructure directly affects product quality and delivery timelines.
- Investments in infrastructure improve operational performance.

Relationship Between Technology Usage and Delivery Performance

- The chi-square test also showed a significant association between technology usage and delivery performance.

This means:

- Companies using digital tracking systems achieve higher delivery accuracy.
- Technology reduces operational delays.
- Automated systems improve coordination between warehouses and delivery agents.

Suggestions and Recommendations

Based on the findings of the study conducted among 124 respondents in Palakkad and Coimbatore, the following suggestions and recommendations are proposed to improve Cold Chain Management in Food & Beverage Logistics and E-commerce Distribution Systems.

Infrastructure Development in Cold Chain Logistics

a) Expansion of Cold Storage Facilities

Government and private investors should increase the number of temperature-controlled warehouses in Palakkad and Coimbatore. Special focus should be given to:

- Rural and semi-urban areas
- Agricultural production zones
- Food processing clusters
- Public-Private Partnership (PPP) models can help reduce investment burden and improve infrastructure quality.

b) Modern Refrigerated Transportation

- Logistics companies should invest in:
- Refrigerated trucks
- Insulated containers
- Multi-temperature vehicles
- This will ensure proper maintenance of product quality during transit.

c) Reliable Power Supply Systems

- Cold storage facilities should adopt:
- Backup generators
- Solar-powered cold storage systems
- Energy-efficient refrigeration units
- This will prevent spoilage due to power interruptions.

Improvement in E-commerce Distribution Efficiency

a) Traffic Management and Route Optimization

Logistics companies should adopt advanced route planning software to:

- Avoid peak-hour congestion
- Identify alternate routes
- Reduce fuel consumption
- Coordination with local authorities for designated delivery time windows can also reduce delays.

b) Micro-Warehousing and Dark Stores

Establishing small distribution centers closer to customer locations can:

- Reduce last-mile delivery time
- Lower transportation costs
- Improve same-day delivery services
- This is especially useful in growing urban areas of Coimbatore.

Technology Adoption and Digital Integration

a) Implementation of Warehouse Management Systems (WMS)

Companies should adopt automated inventory systems to:

- Reduce manual errors
- Improve stock visibility
- Enhance demand forecasting

b) GPS and Real-Time Tracking Systems

All vehicles should be equipped with GPS tracking to ensure:

- Real-time shipment monitoring
- Faster issue resolution
- Increased transparency

c) Use of Data Analytics

Data analytics can help companies:

- Predict demand patterns
- Optimize inventory levels
- Reduce wastage in cold chain operations

Cost Reduction Strategies

a) Fuel Efficiency Programs

Training drivers on fuel-efficient driving techniques can reduce operational costs.

b) Bulk Transportation and Consolidation

Consolidating shipments can reduce empty vehicle returns and optimize load capacity.

c) Government Subsidies and Incentives

Authorities should provide financial assistance and tax benefits for:

- Cold storage setup
- Refrigerated transport vehicles
- Technology adoption
- This will encourage small and medium logistics firms to modernize.

Skill Development and Training

a) Employee Training Programs

Regular training should be conducted on:

- Temperature handling procedures
- Food safety standards
- Technology usage
- Customer service management

b) Certification Programs

Logistics employees should be encouraged to obtain certifications in supply chain management and cold chain operations.

Policy and Regulatory Support

Government bodies should:

- Strengthen food safety compliance monitoring
- Standardize cold chain operational guidelines
- Promote integrated logistics parks
- Clear regulatory frameworks will enhance system efficiency and quality control.

Strengthening Collaboration Between Stakeholders

Better coordination is needed between:

- Farmers
- Food processors
- Warehouse operators
- E-commerce companies
- Delivery partners
- Integrated supply chain networks will reduce delays and improve performance.

Conclusion

The study titled "Cold Chain Management and E-commerce Logistics Challenges in Palakkad and Coimbatore" analyzed operational efficiency, infrastructure availability, technology adoption, and key challenges faced by 124 logistics respondents. The findings highlight that while both regions are experiencing significant growth in logistics activities, several structural and operational issues persist.

Cold chain infrastructure, particularly in Palakkad, remains inadequate due to limited cold storage facilities, insufficient refrigerated vehicles, and power interruptions, leading to product spoilage and wastage. In Coimbatore, e-commerce logistics is expanding rapidly but faces challenges such as traffic congestion, high transportation costs, and last-mile delivery issues.

The study concludes that technology plays a vital role in improving logistics efficiency. Statistical analysis confirmed a significant relationship between infrastructure, technology usage,

and overall logistics performance. Strengthening infrastructure and enhancing digital integration are essential for improving supply chain efficiency and customer satisfaction in both regions.

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