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Cold Chain Logistics Practices and Challenges: A Case Study Analysis of FMCG Retail Stores in Bangalore City, India

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***Abstract*— Cold chain logistics is essential for maintaining the safety and quality of temperature-sensitive Fast-Moving Consumer Goods (FMCG) in rapidly urbanizing environments. This study investigates the current cold chain logistics practices and the specific operational and infrastructural challenges faced by FMCG retail stores in Bangalore City, India. While extensive research has focused on macro-level supply chains, a significant gap remains regarding the "last-mile" implementation at the urban retail store level. The study adopts a primary research approach using retail observations from FMCG stores in Bangalore City, and Structural Equation Modelling (SEM) through AMOS was employed to examine relationships between cold chain logistics practices, operational challenges, and retail performance. Results indicate that cold chain logistics practices (CCLP) have a strong positive impact on cold chain performance (β=0.63) and significantly reduce operational challenges (β=−0.41), accounting for 52% of the variance (R^2=0.52) in challenge severity. The model demonstrated high statistical validity with a GFI of 0.930 and a CFI of 0.950. The study contributes to logistics literature by extending cold chain analysis to the retail "last-mile" interface within an emerging economy context, providing practical insights for retailers, managers, and policymakers.**

***Keywords*—Cold Chain Logistics, FMCG Retail, Operational Challenges, Retail Performance, Structural Equation Modelling.**

I. Introduction

Cold chain logistics plays a critical role in maintaining the safety, quality, and shelf life of temperature-sensitive Fast-Moving Consumer Goods (FMCG). In rapidly urbanising economies such as India, increasing consumer demand, expanding organised retail networks, and changing consumption patterns have intensified the need for efficient cold chain systems. Effective cold chain management supports product freshness, reduces spoilage, and strengthens consumer trust. However, infrastructural limitations, inconsistent power supply, and fragmented logistics practices continue to challenge cold chain efficiency within urban retail environments.

In developing economies such as India, cold chain logistics plays a significant role in supporting temperature-sensitive FMCG supply chains.

Rapid urbanization, expanding organized retail networks, and increasing consumer demand have intensified the need for efficient cold chain systems. However, infrastructural limitations, inconsistent power supply, fragmented logistics coordination, and uneven technology adoption continue to affect operational performance and product quality across retail environments. Previous studies by Negi and Anand (2015) and Joshi et al. (2019) highlight that infrastructural limitations, inconsistent logistics coordination, and uneven technology adoption continue to affect the efficiency of cold chain systems in India. These challenges significantly influence the operational performance of FMCG supply chains, particularly in maintaining product quality and reducing spoilage across retail environments.

The organised retail sector for food and beverages in India has grown considerably, driven by rising disposable incomes, urbanisation, and changing lifestyles. Large cities such as Bangalore have emerged as hubs of organised retail, with numerous supermarkets and chain stores. Despite this growth, studies indicate persistent inconsistencies in store-level cold chain operations, including irregular temperature checks, limited workforce expertise, and weak coordination among supply chain stakeholders. Ramanathan et al. (2014) identified similar coordination gaps within Indian retail supply chains.

A. Research Problem

Existing research on cold chain logistics in urban contexts such as Bangalore has primarily examined macro-level supply chain dynamics, focusing on technology adoption and inter-organisational transportation efficiency, while overlooking store-level operations. Consequently, limited understanding exists regarding how FMCG retail stores in cities such as Bangalore manage cold chain integrity to ensure product safety. Given that retail outlets vary considerably in infrastructure, managerial capability, and technology adoption, a uniform solution is unlikely to be effective across all stores.

B. Need for the Study

Rising consumer demand for temperature-sensitive food and beverage products has heightened the need to maintain product quality throughout storage and retail.

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Inadequate cold chain practices can result in spoilage, financial losses, and erosion of consumer trust. This study addresses the need to understand existing gaps in cold chain practices within Bangalore's FMCG retail sector, providing actionable insights for retailers, logistics managers, and policymakers to enhance sustainability and efficiency.

C. Objectives of the Study

- To examine the existing cold chain logistics practices followed by FMCG retail stores in Bangalore City.
- To identify the key operational and infrastructural challenges faced by FMCG retailers in managing cold chain systems.
- To understand how cold chain practices influence product quality and overall retail performance.

D. Scope of the Study

The study is confined to selected FMCG retail stores operating within Bangalore City. It focuses on cold chain activities related to storage, transportation, temperature control, and in-store handling of perishable goods. The study does not include manufacturing-level cold chain operations or export-oriented supply chains.

II. Review Of Literature

This section reviews existing literature relating to cold chain logistics, with particular emphasis on the FMCG retail sector. The review examines global perspectives, developing economy challenges, and retail-level logistics practices to establish the theoretical foundation of the study, identifying research gaps relating to cold chain implementation within urban retail environments.

A. Global Perspective on Cold Chain Logistics

Cold chain logistics is critical for transporting temperature-sensitive goods such as food, pharmaceuticals, and dairy products without spoilage. Aung and Chang (2014) demonstrated that failure to maintain consistent temperature control throughout delivery leads to significant product waste, emphasising the need for integrated technological systems and stakeholder coordination. Accorsi et al. (2017) examined cold chain distribution systems and found that poor coordination among logistics stakeholders substantially undermines operational performance. Zhang et al. (2020) noted that digital technologies such as the Internet of Things (IoT) and real-time tracking are increasingly important for enhancing transparency and efficiency in cold chain systems, though their focus remained on logistics networks rather than retail-level operations.

B. Cold Chain Logistics in Developing Economies

Cold chain systems in developing economies face persistent challenges, including inadequate storage infrastructure, unreliable power supply, and high operating costs. Negi and Anand (2015) found that despite substantial investment, India's cold chain system remains inconsistent due to uneven transportation infrastructure across regions. Joshi and Banwet (2019) identified poor coordination among suppliers, transporters, and retailers, alongside limited adoption of standardised procedures and tracking technologies, as key barriers to effective cold chain management in India.

C. Cold Chain Practices in FMCG and Retail Sector

The FMCG sector faces challenges related to limited shelf life and unpredictable demand patterns. Sood and Singh (2020) found that Indian retail stores often lack adequate temperature control and storage practices, contributing to product spoilage, though their study did not closely examine urban retail-level operations. Raut et al. (2019) found that limited financial resources and a shortage of skilled personnel constrain retailers' ability to maintain consistent cold chain operations.

D. Research Gap

- Existing studies predominantly examine macro-level or whole-supply-chain dynamics rather than day-to-day operations at the retail store level.
- Limited research exists on cold chain logistics within FMCG retail stores in large Indian cities.
- There is insufficient focus on practical challenges such as infrastructure limitations, workforce capability, and real-time operational constraints.

E. Summary and Research Direction

Based on the review of existing literature, it is evident that although cold chain logistics has been extensively studied, a significant gap remains in understanding its practical implementation at the FMCG retail store level in urban India. This study aims to bridge this gap by examining cold chain logistics practices and challenges in FMCG retail stores in Bangalore City.

III. Research Methodology

A. Research Design

The study adopts a descriptive research design to examine cold chain logistics practices and operational challenges within FMCG retail stores in Bangalore City. The selected approach enables a structured assessment of retail-level logistics activities, including storage, temperature control, handling procedures, and operational performance.

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B. Case Selection

The study focuses on FMCG retail stores in Bangalore City, a major commercial and retail hub in India, selected due to the high presence of organized retail chains, availability of cold storage–dependent product categories, and diverse consumer demand.

C. Sources of Data

Primary data was collected from selected FMCG retail stores operating in Bangalore City, focusing on cold chain logistics practices, operational challenges, temperature monitoring, storage practices, and retail performance indicators. Supporting literature from journals, reports, and academic publications provided theoretical background.

D. Method of Data Collection

Data was collected through structured retail observations and survey-based assessment across selected FMCG retail stores in Bangalore City. Information relating to SOP adherence, temperature monitoring, storage practices, staff training, equipment maintenance, and operational challenges was gathered for analysis.

E. Variables of the Study

Independent Variables: Cold chain logistics practices; cold storage, transportation, and temperature monitoring practices.

Dependent Variables: Product quality; cold chain efficiency; operational performance of FMCG retail stores.

F. Hypotheses of the Study

H01: There is no significant relationship between cold chain logistics practices and product quality in FMCG retail stores.

H11: There is a significant relationship between cold chain logistics practices and product quality in FMCG retail stores.

H02: Cold chain logistics challenges do not significantly affect operational efficiency in FMCG retail stores.

H12: Cold chain logistics challenges significantly affect operational efficiency in FMCG retail stores.

G. Method of Analysis

The collected data was analysed using descriptive statistics and Structural Equation Modelling (SEM) through AMOS software to test the relationships between logistics practices, operational challenges, and retail performance indicators.

H. Limitations of the Study

The study was limited to selected FMCG retail stores operating within Bangalore City.

The sample size and geographical scope may limit the generalisation of findings to other regions or unorganised retail sectors, and the study did not include manufacturing or export-oriented supply chain operations.

IV. Results And Discussion

A. Overview of Data Analysis

This section presents the empirical findings derived from a sample of 100 retail observations in Bangalore City. The analysis was conducted in two stages: descriptive statistics to understand the current state of cold chain logistics practices (CCLP) and challenges, followed by Structural Equation Modelling (SEM) using AMOS to test the structural relationships between logistics practices, operational challenges, and retail performance.

B. Descriptive Statistics of Cold Chain Practices

The descriptive analysis provides a snapshot of the operational realities within Bangalore's FMCG retail stores, with respondents rating various practices and challenges on a 5-point Likert scale.

TABLE I
Descriptive Statistics of Cold Chain Practices

Indicator	Mean	Std. Dev.
Documented SOPs followed	3.170	1.407
Planned equipment maintenance	3.120	1.335
Staff training available	3.080	1.447
Regular temperature monitoring	3.050	1.500
Quick transfer to cold storage	2.990	1.453
FIFO/FEFO adherence	2.910	1.386
Perceived challenge severity	3.050	1.388

Interpretation: The mean scores for all logistics practices hover around 3.0, indicating a highly neutral and inconsistent application of cold chain standards across the city. The relatively high standard deviations suggest significant variance between organized retail chains and smaller independent outlets in Bangalore.

C. Measurement Model Assessment

To ensure the validity of the research framework, the measurement model was evaluated using factor loadings and model fit indices via AMOS.

- *Factor Loadings:* All indicators for the primary construct, Cold Chain Logistics Practices (CCLP), showed strong factor loadings, with Quick Transfer to Storage (0.82) and FIFO/FEFO adherence (0.80) being the most significant contributors.

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- *Outcome Validity:* Product Quality (0.84) and Service Efficiency (0.81) emerged as the strongest indicators of performance, while Power/Energy Issues (0.77) was the primary indicator for operational challenges.

D. Structural Model and Hypothesis Testing

The structural model was used to test the paths defined in the research hypotheses.

TABLE II
HYPOTHESIS TESTING RESULTS

Hyp.	Structural Path	β	Result
H11	CCLP → Cold Chain Performance	0.63	Supported
H12	CCLP → Operational Challenges	-0.41	Supported

- *Impact on Performance:* The analysis revealed a strong positive relationship (0.63) between logistics practices and performance, confirming that stores in Bangalore that strictly follow SOPs and temperature monitoring achieve significantly higher product quality and efficiency.
- *Reduction of Challenges:* The path coefficient of -0.41 indicates that better logistics practices are highly effective in mitigating operational challenges such as spoilage and supplier coordination issues.
- *Explanatory Power:* The model explains 52% of the variance ($R^2 = 0.52$) in operational challenges and 40% of the variance ($R^2 = 0.40$) in retail performance.

E. Assessment of Model Fit

To validate the reliability of these findings, the following model fit indices were achieved, all of which fall within the recommended academic thresholds:

TABLE III
MODEL FIT INDICES

Index	Value	Threshold
Chi-square / df	1.84	< 3.0 (Good)
GFI (Goodness of Fit)	0.930	> 0.90 (Acceptable)
CFI (Comparative Fit Index)	0.950	> 0.90 (Excellent)
RMSEA	0.058	< 0.08 (Good)

F. Discussion of Findings

The findings bridge the "last-mile" research gap by highlighting that retail-level practices are the primary drivers of cold chain integrity in urban India. The strong path coefficient of 0.63 towards performance aligns with global perspectives that technology and coordination are key to reducing waste.

However, the neutral mean scores (3.0) for practices like FIFO/FEFO and temperature monitoring confirm the concerns raised by previous researchers regarding the lack of workforce capability and infrastructure in developing economies like India. The high R^2 of 0.52 for operational challenges indicates that the majority of store-level failures in Bangalore can be addressed through managerial commitment and standardised logistics practices rather than purely external infrastructure improvements.

V. CONCLUSION AND RECOMMENDATIONS

A. Summary of Findings

- *Objective 1* – Existing Logistics Practices: Descriptive analysis revealed that Bangalore's FMCG retailers operate with a neutral level of consistency, with mean scores for practices like Documented SOPs (3.17) and Staff Training (3.08) hovering around the mid-point of a 5-point scale.
- *Objective 2* – Key Operational Challenges: The study identified Power/Energy Issues (0.77 factor loading) and Spoilage/Wastage (0.74 factor loading) as the primary infrastructural and operational hurdles faced by retailers.
- *Objective 3* – Influence on Performance: The structural model confirmed a strong positive relationship (β = 0.63) between logistics practices and retail performance, with robust practices explaining 52% of the variance in the reduction of operational challenges.

B. Managerial Implications

The findings provide practical implications for FMCG retailers and logistics managers. Stronger SOP adherence, workforce capability development, temperature monitoring, and improved cold storage handling can significantly improve retail-level cold chain performance. Policymakers may support these improvements through infrastructure strengthening and logistics capability initiatives in urban retail environments.

C. Conclusion

The study successfully demonstrates that the "last-mile" of the cold chain is the most critical stage for maintaining product integrity in urban environments like Bangalore. The statistical validation through AMOS supports both H11 and H12. Specifically, the high factor loadings for Quick Transfer to Storage (0.82) and FIFO/FEFO adherence (0.80) demonstrate that disciplined handling practices are critical for maintaining effective cold chain performance.

The model fit indices (GFI = 0.930, CFI = 0.950) further indicate that the proposed framework provides a reliable basis for analysing retail cold chain logistics practices within developing economy contexts.

D. Practical Recommendations

- *Prioritise "Quick Transfer" Protocols:* Given its high loading (0.82), stores must implement strict "zero-wait" times for moving temperature-sensitive goods from delivery trucks to in-store cold storage.
- *Invest in Workforce Capability:* Staff training showed a significant loading (0.72) but a low mean score (3.08). Retailers should move beyond simple hiring to specialised training in temperature monitoring and cold chain SOPs.
- *Digital Integration:* To address the 52% variance in challenges, stores should adopt IoT-based real-time tracking to move away from inconsistent manual temperature checks.
- *Infrastructural Support:* Policymakers should focus on stable power grids or subsidised energy-efficient cooling technology to mitigate the high impact of energy issues (0.77) on store operations.

E. Limitations and Future Research

The study was limited to selected FMCG retail stores within Bangalore City. The sample size and geographical scope may limit the generalisation of findings to other regions and unorganised retail sectors. Future research may extend the study to include small independent retailers ("Kirana" stores) or conduct comparative analysis across multiple Indian metropolitan cities.

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