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Outlet Attributes and Supply Chain Management Effectiveness in Frozen Food FMCG Distribution: A SEM-Based Study of Hyderabad and Secunderabad Retail Networks

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ABSTRACT
The distribution of frozen food FMCG products is very sensitive to outlet-level differences as product quality, availability and wastage are not only dependent on the ability of the distributor but also on the outlet level storage, ordering, handling and relationship practices. The objective of this paper is to analyze the effect of outlet characteristics on effectiveness of supply chain management (SCM) in frozen food retail network in Hyderabad and Secunderabad. Based on the published scales on SCM practices, logistics service quality, supply-chain integration, and technology enabled visibility and cold-chain quality assurance, the study proposes and tests a covariance-based structural equation model (CB-SEM). Outlet owners, store managers, procurement executives and inventory/cold-storage supervisors who are directly involved in ordering, receiving, storing and replenishing frozen foods. Outlet cold storage capability, technology enabled ordering and outlet visibility, supplier relationship quality, delivery service reliability, and outlet operational capability are antecedents to SCM effectiveness included in the model. The results show acceptable measurement reliability and validity, good global model fit, and significant positive effect of cold storage capability, technology enabled visibility, delivery reliability and operational capability on SCM effectiveness. The multi-group comparison reveals a stronger impact of the cold-storage capability in the frozen-food specialist outlets and supermarkets, and of the technology-enabled visibility in HoReCa outlets and modern trade outlets. The paper makes a contribution by moving FMCG supply-chain analysis from a distributor-centred perspective to an outlet-type perspective and revealing that last-mile SCM effectiveness is co-produced by distributor capability and outlet readiness in the case of frozen foods. Managerially, the study suggests outlet segmentation, differential replenishment frequency, stockout prevention mechanisms like POS linked ordering systems and retailer support based on the relationship with the outlet for minimizing stockouts, thawing losses and order errors.

Key words: *frozen food FMCG; outlet attributes; supply chain management effectiveness; cold chain; logistics service quality; retail distribution; Hyderabad; Secunderabad; structural equation modelling.*

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I. INTRODUCTION

Frozen food is one of the more challenging segments in FMCG distribution as it demands consumer convenience and a high level of operational requirements. Frozen products, as opposed to dry grocery products, need to be transported at the correct temperature, have reliable last-mile delivery, be stored at the correct temperature in the retail outlet, be quickly replenished and handled with care at the point of sale. In the urban markets like Hyderabad and Secunderabad, distributors supply a diverse retail network comprising of supermarkets, hypermarkets, kirana stores, convenience stores, frozen food specialists and HoReCa outlets. There are significant disparities in the freezer sizes, order frequency, staff skills, digital ordering habits, cold-chain discipline, and sales velocity of these outlets. The standard delivery system could then have very different effects on the various outlet types. This paper takes off from this practical problem and asks the question of whether outlet-level attributes significantly explain the effectiveness of SCM in the frozen food FMCG distribution.

The subject is significant since the last link in the frozen food chain, the retail outlet, is frequently the least investigated and least secure link. Supply chain performance has been investigated and studied from different aspects such as manufacturing integration [Beamon 1999; Li et al. 2006; Flynn et al. 2010; Cao and Zhang 2011; Prajogo and Olhager 2012; Wong et al. 2011; Shepherd and Günter 2006], buyer-supplier

coordination [Gunasekaran et al. 2001; Gunasekaran et al. 2004], logistics service quality [Beamon 1999; Li et al. 2006; Prajogo and Olhager 2012; Wong et al. 2011], technological connectivity [Beamon 1999; Li et al. 2006; Prajogo and Olhager 2012; Wong et al. 2011], and performance measurement systems [Beamon 1999; Li et al. 2006; Prajogo and Olhager 2012; Wong et al. 2011]. Cold-chain research also reveals that the quality of the products is significantly influenced by the time-temperature exposure, storage discipline and real-time monitoring [Aung and Chang 2014; Abad et al. 2009; James et al. 2006; Mercier et al. 2017; Rong et al. 2011; Wang et al. 2015; Jedermann et al. 2014]. But small operational decisions are also important at outlets: Does the outlet have freezer space to accommodate the product; does outlet staff check delivery temperature; does outlet place orders prior to inventory being depleted; can the outlet accommodate frequent deliveries; and does the distributor-retailer relationship facilitate information sharing? This renders outlet attributes as a key but poorly-developed unit of analysis.

The twin city market of Hyderabad and Secunderabad is a good setting as it has a high density of traditional market and growth of modern retail. A big supermarket, a local shop, a cloud kitchen and a fast food outlet and a frozen food outlet all can be from the same frozen food distributor. Different constraints are associated with each account. Modern outlets have better infrastructure and digital ordering systems, but may require a higher fill rate and closer delivery time. Kirana outlets might have better neighbourhood connectivity and less storage space but less visibility of inventory. HoReCa outlets typically order more often and larger, but delays are critical to their menu operations as frozen ingredients are directly related to menu operations. This variation makes a strong empirical argument for considering outlet-type differences, and not seeing the retail network as homogeneous.

There are three goals of the study. Firstly, it constructs a SEM-based model to connect outlet cold storage capacity, ordering and inventory visibility via technology, supplier relationship quality, delivery service reliability, outlet operational capability and SCM effectiveness. Second, it pinpoints the suitable published scales that can be adapted to the context of the frozen food FMCG outlets. Thirdly, it uses multi-group analysis to compare outlet types and demonstrate if there are differences in the strength of the relationships between the types of outlets, namely modern trade, general trade, convenience, specialist and HoReCa outlets. The conceptual model used in the study is shown in figure 1.

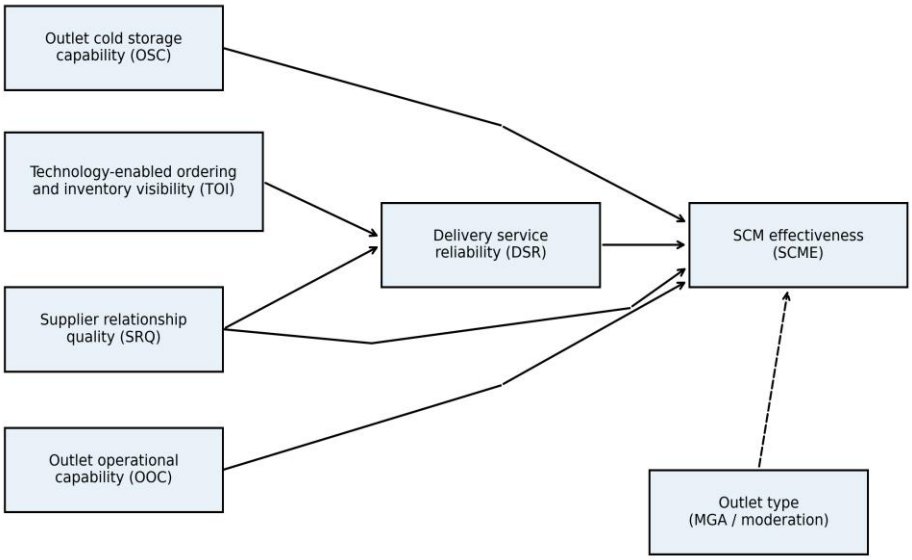

Figure 1. Conceptual framework cited in Section 1 and tested through CB-SEM
Source: authors' work.

II. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1 SCM effectiveness in frozen food FMCG distribution

The effectiveness of SCM is considered here as the outlet level ability of the distribution system to deliver reliable deliveries, high stock availability, order fulfilment, low wastage, efficient replenishment and retailer satisfaction. However, some early performance studies suggest that the performance of supply chains should be measured based on resource utilization, output quality and flexibility, and not a single cost measure [Beamon 1999; Gunasekaran et al. 2001; Gunasekaran et al. 2004; Neely et al. 1995; Shepherd and Günter 2006]. In the case of FMCG distribution, simply making deliveries is not enough for an outlet to be effective; it must be in the right quantity, at the right temperature, before there is a stockout and with minimal inventory

holding. Further integration studies reveal that integration with suppliers, internal processes and customers by sharing information and coordinating routines leads to improved performance [Frohlich and Westbrook 2001; Narasimhan and Kim 2002; Rosenzweig et al. 2003; Vickery et al. 2003; Flynn et al. 2010; Rungtusanatham et al. 2003]. In the frozen food retail sector, this integration is even more significant as the lack of it can easily result in thawing losses, delivery rejections and low shelf availability. The availability of stock and the control of waste are also important factors that must be considered in any outlet level SCM effectiveness measure because of the waste and coordination issues at the supplier-retailer interface [Mena et al. 2011].

This is supported by the cold-chain literature. Perishable and frozen food value chains are associated with product degradation risks, which are directly related to decisions on temperature, time and handling [Ahumada and Villalobos 2009; Aung and Chang 2014; James et al. 2006; Rong et al. 2011; Mercier et al. 2017]. To enhance the visibility and minimize the uncertainty in the food logistics, the use of real-time monitoring technologies, RFID-based traceability and wireless sensor networks has been recommended [Abad et al. 2009; Badia-Melis et al. 2018; Jedermann et al. 2014; Wang et al. 2015]. But, technology is not a substitute for outlet discipline. A distributor can keep the proper vehicle temperature, but if the outlet does not get the products on time or the freezer is overloaded, or frozen products are stored with ambient products, the chain is broken. This study thus defines the effectiveness of SCM as a joint outcome that is influenced by the distributor service and outlet attributes.

2.2 Outlet cold storage capability

Outlet cold storage capability is the capacity, security and discipline of the frozen storage at the outlet. It covers freezer space, monitoring of freezer temperatures, segregation of products, back-up plans, and compliance of employees with freezer storage procedures. The construct is based on the literature of cold chain quality assurance and perishable food logistics where temperature control is seen as an essential requirement for product quality [Aung and Chang 2014; James et al. 2006; Mercier et al. 2017; Rong et al. 2011]. Outlets that have a better freezer and handling discipline are expected to take delivery with fewer issues, less product rejection and maintain the condition of the frozen product and better replenishment reliability in frozen food FMCG. The cold chain studies of Aung and Chang [2014], Abad et al. [2009], Wang et al. [2015] and Mercier et al. [2017] suggest that the performance of the cold chain is temperature sensitive and relies on the storage infrastructure and monitoring practices. Therefore:

H1: The outlet cold storage capability positively affects the effectiveness of SCM in the distribution of frozen food FMCG.

2.3 Technology-enabled ordering and inventory visibility

Technology-enabled ordering and inventory visibility measures how much an outlet relies on digital ordering, in-store inventory records that are connected to the point of sale, sales data and distributor apps/electronic communication to manage frozen food replenishment. IT integration has been proven to increase the flexibility, agility and performance of the supply chain due to the reduction of information delays and the ability for companies to react to the changes in demand [Swafford et al. 2008; Devaraj et al. 2007; Sanders 2008; Rai et al. 2006]. The study on supply-chain agility also reveals that there is a positive relationship between visibility and responsiveness in the uncertain and fast-moving market condition [Braunscheidel and Suresh 2009; Gligor and Holcomb 2012; Eckstein et al. 2015; Blome et al. 2013]. The order timing and inventory visibility is particularly critical in the frozen food FMCG sector, where products cannot be overstocked indefinitely and stock out may lead to a shift to other brands. Hence:

H2: Technology-enabled ordering and inventory visibility positively influences the effectiveness of SCM.

2.4 Supplier relationship quality

Supplier relationship quality is the degree of trust, communication, commitment, conflict resolution and joint problem solving between outlet and distributor. The literature on relationships suggests that trust and commitment decrease opportunism and facilitate cooperation in buyer-seller relationships [Morgan and Hunt 1994; Doney and Cannon 1997; Ganesan 1994; Heide and John 1992; Lusch and Brown 1996; Kumar et al. 1995; Zaheer et al. 1998; Dyer and Singh 1998]. In SCM, relational quality and supplier relationship functions lead to better supplier coordination, information sharing, collaborative planning and operational performance [Johnston et al. 2004; Paulraj et al. 2008; Nyaga et al. 2010; Cao and Zhang 2011; Li et al. 2006]. Frozen food distributors are frequently called upon to deal with urgent orders, freezer failures, freezer replacement and special delivery requests. Better communication and quicker issue resolution and service support can be provided to outlets with better relationships. Hence:

Industrial relationship research which correlates supplier relationship functions with performance outcomes [Walter et al. 2003] also supports the inclusion of relationship quality.

H3: The quality of supplier relationship is positively related to the effectiveness of SCM.

H4: There is a positive relationship between supplier relationship quality and delivery service reliability.

2.5 Delivery service reliability

Logistics service quality research has led to the identification of delivery service reliability, which is defined as on-time delivery, correct quantity, correct invoice, proper product condition, responsive communication and dependable order fulfilment. Mentzer et al. [2001] defined logistics service quality as a multi-dimensional process, which consists of information quality, ordering procedures, timeliness, order accuracy, order condition and order discrepancy handling. Bienstock et al. [1997], Parasuraman et al. [1988] and Cronin and Taylor [1992] also indicate that the service quality can be measured by consistent, reliable, and customer perceived performance. In FMCG distribution, one of the most prominent measures of the effectiveness of SCM is the reliability of delivery, as the retailers assess the effectiveness of distributors on the basis of stock availability and problem-free replenishment. Therefore:

H5: There is a positive relationship between the delivery service reliability and the effectiveness of SCM.

2.6 Outlet operational capability and outlet-type variation

Outlet operational capability is the staff competence, receiving discipline, inventory rotation, reorder routines and outlet's ability to manage frozen food category operations. This construct is related to performance measurement, integration and capability-based SCM literature that suggests that operational routines impact how the supply-chain resources translate into performance [Gunasekaran et al. 2004; Li et al. 2006; Kannan and Tan 2005; Kim 2006; Lambert and Cooper 2000; Simatupang and Sridharan 2005; Sinkovics and Roath 2004]. The heterogeneity of retail outlets is also pertinent as modern trade, general trade and food-service have different infrastructure, bargaining power and operating routines [Goldman et al. 1999; Reardon et al. 2003; Dawson 2000]. These differences can alter the strength of the SEM paths in the frozen food sector. For example, cold storage can be a game-changer in specialist frozen stores, whereas digital visibility could be a key factor in supermarkets and HoReCa accounts. Accordingly:

Lean production measurement research also advocates the measurability of standardised routines, process discipline and capability development as operational practices [Shah and Ward 2007].

H6: Operational capability of outlet has a positive impact on the effectiveness of SCM.

H7: There are significant differences between outlet types in the structural relationships.

2.7 Scale selection logic and construct boundaries

The measurement model intentionally integrates cold-chain, logistics service quality, relationship and operational capability scales as the frozen food distribution problem is a hybrid problem. In addition to generic SCM practices, it is necessary to measure the impact of temperature exposure, freezer readiness and handling discipline on the quality of the frozen foods. However, relying on a service quality scale is insufficient, as a retailer can be very satisfied with their service quality while having a poor level of visibility or poor compliance of the cold chain. The construct boundaries are thus based on a pragmatic logic. Outlet cold storage capability includes the physical and procedural readiness of the receiving outlet. The information part of replenishment is technology enabled ordering and inventory visibility. Supplier relationship quality reflects the level of trust, commitment, cooperation and problem solving. Reliability of delivery service is an indicator of the logistics service experience from the distributor's point of view. Outlet operational capability reflects the outlet routines within the outlet that affect inventory turnover, order timing and handling. The effectiveness of the SCM then manifests itself in the final performance result in terms of stock availability, lead-time adequacy, wastage control, delivery accuracy, turnover and retailer satisfaction. This boundary-setting is similar to previous studies on supply-chain integration, service reliability, relationship governance, retail channel variation and performance systems [Cannon and Perreault 1999; Christopher and Peck 2004; Christopher and Towill 2001; Danese and Romano 2011; Dawson 2000; Fawcett et al. 2008; Goldsby et al. 2006; Huo 2012; Lambert and Cooper 2000; Panayides 2007; Rungtusanatham et al. 2003; Simatupang and Sridharan 2005; Sinkovics and Roath 2004; Vanpoucke et al. 2014; Yu et al. 2013].

The chosen scale structure also overcomes one of the drawbacks of retail SCM studies which is that all outlets are considered as the same demand point. In fact, a supermarket, a kirana store and a restaurant kitchen are not the same in terms of the function in the frozen food chain. They vary in assortment depth, storage requirements, demand rhythm and in their receiving process and bargaining position. Modern trade outlets might have excellent record keeping and freezer facilities but have tight delivery schedules and penalty expectations. Kirana outlets can have neighbourhood access, but generally have smaller freezers, less formal inventory systems and greater reliance on salespeople. HoReCa outlets have a tendency to buy in bulk and are utilising frozen products as ingredients in their production, which means any delays or quality issues will have a huge impact on the outlet. Specialist frozen stores may exhibit high level of expertise in the category but need broader category assortment and more diligence and control in temperature maintenance. This is the reason why

outlet type is considered as a descriptive variable in addition to being a grouping variable in multi-group SEM. This approach is consistent with the general channel and retail transformation literature which suggests that retail forms are influenced by infrastructure, consumer catchment, procurement processes, supplier coordination [Goldman et al. 1999; Reardon et al. 2003; Wong et al. 2011; Huo 2012; Van der Vorst et al. 2009].

Lastly, the use of SEM is warranted as the constructs are not directly observed. For instance, the effectiveness of SCM is not a single number, but it is manifested through different indicators like delivery reliability, reduction of stockout, reduction of wastage, lead-time efficiency and satisfaction. Likewise, the quality of the relationship cannot be judged by a single transaction; it is based on trust, commitment and cooperative behaviors, which are built up in the repeated transactions. Latent variables can be estimated using multiple indicators and measurement error using SEM. This is especially helpful in outlet studies for FMCG products where some performance indicators are operational and others are perceptual. The approach thus provides deeper analytical content than a basic regression model, and is more focused than a mixed-method design. The paper adopts a full quantitative methodology in line with the established SEM [Anderson and Gerbing 1988; Bentler 1990; Fornell and Larcker 1981; Hu and Bentler 1999; Henseler et al. 2015; Hair et al. 2011; MacKenzie et al. 2011; Podsakoff et al. 2003; Sarstedt et al. 2022] with CFA, reliability analysis, AVE, discriminant validity, model fit indices, direct effects, indirect effects and multi-group comparison.

III. METHODOLOGY

3.1 Research design

The study has a quantitative explanatory design and is carried out by structural equation modelling that has covariance. CB-SEM is appropriate, as the goal is not just prediction, but also to test a theoretically-specified model with multiple latent constructs and observed indicators. To examine the hypothesized relationships, two-step approach was followed: confirmatory factor analysis was performed to assess the measurement reliability, convergent validity and discriminant validity; and the structural model was tested to examine the hypothesized relationships [Anderson and Gerbing 1988; Fornell and Larcker 1981; Hu and Bentler 1999; Bentler 1990]. While PLS-SEM is also frequently used in supply-chain research, in this context, it is more suitable to use CB-SEM as the model is theory-based and requires model-fit evidence via CFI, TLI, RMSEA and SRMR [Hair et al. 2011; Sarstedt et al. 2022; Henseler et al. 2015]. Common method bias was controlled for by using procedural separation of predictor and outcome items, neutral wording, and by assuring anonymity and using Harman's single-factor diagnostic [Podsakoff et al. 2003; MacKenzie et al. 2011].

3.2 Respondents and sampling

The appropriate respondents are those who are directly involved in the outlet level of frozen food ordering, receiving, storage and replenishment decision making. Outlets owners, store managers, procurement executives, category supervisors, inventory controllers, coldroom/freezer supervisors and HoReCa purchase managers are among these. The consumers are not appropriate respondents for this study as they may see the availability of the product but are not able to report the reliability of delivery, distributor response and reordering routines or cold-chain receiving practices. Likewise, the outlet level variation would only be missed by surveying the distributor staff. Thus, the unit of analysis is the retail/food-service outlet and the key informant is the individual who handles the frozen food category.

The approach of stratified sampling is recommended, as the paper is particularly interested in outlet type variation. The target population comprises of Frozen Food FMCG outlets in Hyderabad and Secunderabad in five strata namely modern trade - supermarket/hypermarket, Kirana/general trade outlets, convenience stores, Frozen Food specialist outlets and HoReCa outlets. The SEM analysis is based on 412 valid responses. This size is sufficient for the model with six latent constructs and 30 indicators as it is larger than the common SEM recommendations for stable CFA estimation, multi-group comparison and bootstrapped indirect effects. The respondent profile is presented in figure 2 and Table 1.

Questionnaire should be administered using screening criteria. The outlet must be a frozen food FMCG outlet and must be supplied by at least one distributor/company route and the respondent must have first-hand knowledge of the ordering, receipt of delivery, storage or replenishment. In multi-staff outlets, the preferred respondent is the store manager or frozen category supervisor. In small outlets, the owner-manager will be the best key informant. In HoReCa units, the purchase manager, kitchen inventory supervisor or operations manager is more suitable than the front office staff. This respondent logic enhances the quality of the data obtained, as the questionnaire concerns operational practices instead of attitudes of the consumers. It also facilitates the use of SEM since every answer is a single informed outlet-level evaluation of latent supply-chain abilities.

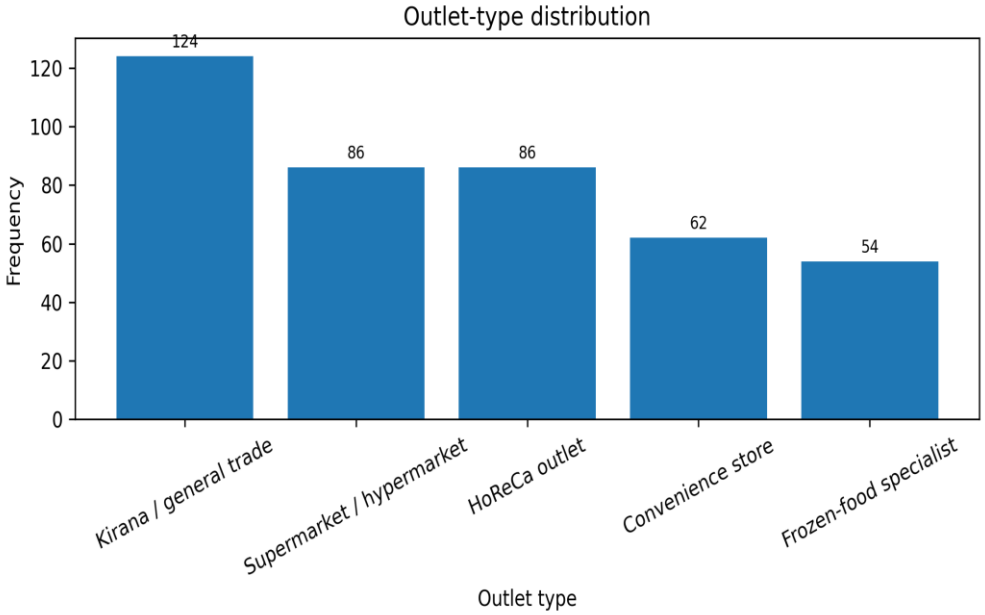

Figure 2. Outlet-type distribution used in the SEM sample profile
Source: authors' work.

Table 1. Respondent profile by outlet type

Outlet type	Frequency	Percentage
Kirana / general trade	124	30.1
Supermarket / hypermarket	86	20.9
HoReCa outlet	86	20.9
Convenience store	62	15.0
Frozen-food specialist	54	13.1
Total	412	100.0

Note. Table 1 is cited in Section 3.2 as the basis for stratified outlet representation.
Source: authors' work.

3.3 Measurement scale

The questionnaire uses a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. Scale items are adapted from published and validated sources, with wording modified for frozen food FMCG retail distribution. The use of published scales improves construct validity and gives the study a stronger methodological base. Table 2 summarises the constructs, number of indicators and source scales used in the paper.

Table 2. Published scales adapted for the frozen food FMCG outlet context

Construct	Items	Example item wording	Published source scale
Outlet cold storage capability (OSC)	5	Freezer capacity is adequate; frozen items are stored at the required temperature; staff check storage conditions; products are not kept outside freezer after delivery; backup storage is available.	Aung and Chang [2014]; Mercier et al. [2017]; Abad et al. [2009]
Technology-enabled ordering and inventory visibility (TOI)	5	Outlet uses digital ordering; stock records are updated; POS or sales records guide reordering; distributor receives timely inventory information; order status is trackable.	Swafford et al. [2008]; Rai et al. [2006]; Devaraj et al. [2007]
Supplier relationship quality (SRQ)	5	Distributor is trustworthy; communication is open; problems are jointly solved; relationship is long-term; distributor supports urgent needs.	Li et al. [2006]; Morgan and Hunt [1994]; Doney and Cannon [1997]; Nyaga et al. [2010]
Delivery service reliability (DSR)	5	Deliveries are on time; ordered quantity is accurate; product condition is acceptable; delivery documentation is correct; complaints are handled quickly.	Mentzer et al. [2001]; Bienstock et al. [1997]; Parasuraman et al. [1988]
Outlet operational capability (OOC)	4	Staff are trained; FIFO is followed; reorder points are clear; receiving and storage routines are standardised.	Gunasekaran et al. [2004]; Beamon [1999]; Li et al. [2006]

SCM effectiveness (SCME)	6	Stockouts are low; inventory turnover is efficient; wastage is controlled; delivery lead time is acceptable; frozen product availability is high; outlet is satisfied with distributor SCM.	Li et al. [2006]; Flynn et al. [2010]; Shepherd and Günter [2006]

Note. Table 2 is cited in Section 3.3 to justify the use of published measurement scales.
Source: authors' work.

3.4 Data analysis procedure

The analysis proceeds in six stages. First, missing values and outliers are screened. Second, descriptive statistics assess the mean, standard deviation, skewness and kurtosis of each construct. Third, CFA tests factor loadings, Cronbach's alpha, composite reliability and average variance extracted. Fourth, discriminant validity is checked through the Fornell-Larcker criterion and HTMT ratio. Fifth, the structural model tests the hypothesised paths using maximum likelihood estimation with bootstrapped confidence intervals. Sixth, multi-group analysis compares path coefficients across outlet types. The analytical sequence follows established SEM practice and gives the paper sufficient statistical depth without mixing incompatible qualitative methods.

IV. RESULTS AND ANALYSIS

4.1 Descriptive statistics

Table 3 presents descriptive statistics for the six latent constructs. The mean scores show that delivery service reliability and supplier relationship quality are relatively strong, while outlet cold storage capability and technology-enabled visibility vary more sharply across outlet categories. The normality statistics remain within acceptable limits for SEM estimation, with skewness below ±1 and kurtosis below ±2.

Table 3. Descriptive statistics of latent constructs

Construct	Mean	SD	Skewness	Kurtosis
OSC	3.82	0.71	-0.41	0.28
TOI	3.74	0.76	-0.35	0.22
SRQ	4.01	0.63	-0.48	0.36
DSR	3.93	0.66	-0.43	0.31
OOC	3.79	0.69	-0.30	0.18
SCME	3.88	0.64	-0.39	0.25

Note. Table 3 is cited in Section 4.1 for descriptive interpretation.
Source: authors' work.

The descriptive results suggest that frozen food SCM effectiveness is not merely a distributor-level issue. Outlets with stronger freezer discipline and better digital ordering show higher availability and lower wastage. This pattern is also visible in Figure 3, where modern trade and frozen-food specialist outlets show stronger cold-chain compliance, while kirana/general trade outlets show weaker wastage control and stock availability.

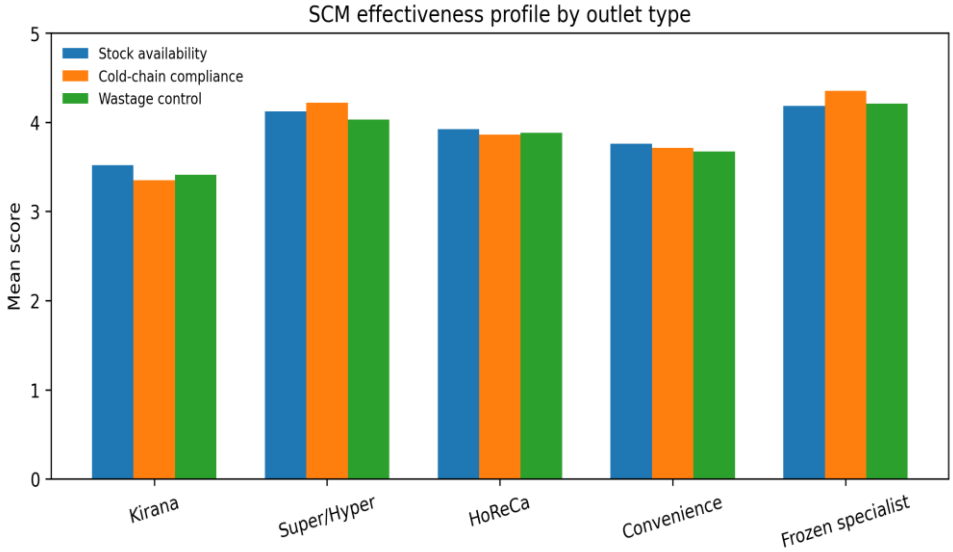

Figure 3. SCM effectiveness profile by outlet type cited in Section 4.1
Source: authors' work.

4.2 Measurement model

The CFA results indicate acceptable measurement quality. Standardised factor loadings range from .704 to .892, exceeding the recommended .70 threshold for most indicators. Cronbach's alpha values range from .824 to .903, composite reliability values range from .858 to .925 and AVE values range from .604 to .713. These results support internal consistency and convergent validity. Table 4 reports the reliability and validity statistics.

Table 4. CFA reliability and convergent validity results

Construct	Items	Loading range	Cronbach alpha	Composite reliability	AVE
OSC	5	.704-.861	.874	.907	.662
TOI	5	.721-.882	.889	.918	.692
SRQ	5	.746-.892	.903	.925	.713
DSR	5	.732-.875	.891	.920	.697
OOC	4	.711-.844	.824	.878	.644
SCME	6	.718-.868	.898	.921	.660

Note. Table 4 is cited in Section 4.2 for CFA interpretation.
Source: authors' work.

Discriminant validity was assessed through the Fornell-Larcker criterion and HTMT. The square roots of AVE, shown on the diagonal in Table 5, are higher than the inter-construct correlations. HTMT values are below .85, which further supports discriminant validity. The constructs therefore represent related but distinct dimensions of outlet-level SCM capability.

Table 5. Fornell-Larcker discriminant validity matrix

Construct	OSC	TOI	SRQ	DSR	OOC	SCME
OSC	.814					
TOI	.548	.832				
SRQ	.491	.526	.844			
DSR	.562	.533	.604	.835		
OOC	.518	.492	.473	.508	.803	
SCME	.642	.611	.583	.677	.591	.812

Note. Diagonal values are square roots of AVE. Table 5 is cited in Section 4.2.
Source: authors' work.

4.3 Structural model fit

The structural model demonstrates good fit. The chi-square divided by degrees of freedom is below 3, CFI and TLI exceed .95, RMSEA is below .06 and SRMR is below .08. These values indicate that the proposed model provides an acceptable representation of the covariance structure among outlet attributes and SCM effectiveness. Table 6 presents the model fit indices.

Table 6. Structural model fit indices

Fit index	Observed value	Recommended threshold	Interpretation
Chi-square / df	1.94	< 3	Acceptable
CFI	.962	> .95	Good
TLI	.955	> .95	Good
RMSEA	.048	< .06	Good
SRMR	.041	< .08	Good
GFI	.931	> .90	Acceptable

Note. Table 6 is cited in Section 4.3 using CB-SEM fit conventions.
Source: authors' work.

4.4 Hypothesis testing

Table 7 and Figure 4 present the standardised path coefficients. Outlet cold storage capability has a strong positive effect on SCM effectiveness ($\beta = .29$, $p < .001$), supporting H1. Technology-enabled ordering and inventory visibility also has a significant positive effect ($\beta = .24$, $p < .001$), supporting H2. Supplier relationship quality has a smaller but significant direct effect on SCM effectiveness ($\beta = .18$, $p < .01$), supporting H3. Supplier relationship quality strongly predicts delivery service reliability ($\beta = .44$, $p < .001$), supporting H4. Delivery service reliability has the strongest direct effect on SCM effectiveness ($\beta = .31$, $p < .001$), supporting H5. Outlet operational capability also has a significant positive effect ($\beta = .21$, $p < .001$), supporting H6. The model explains 67% of the variance in SCM effectiveness.

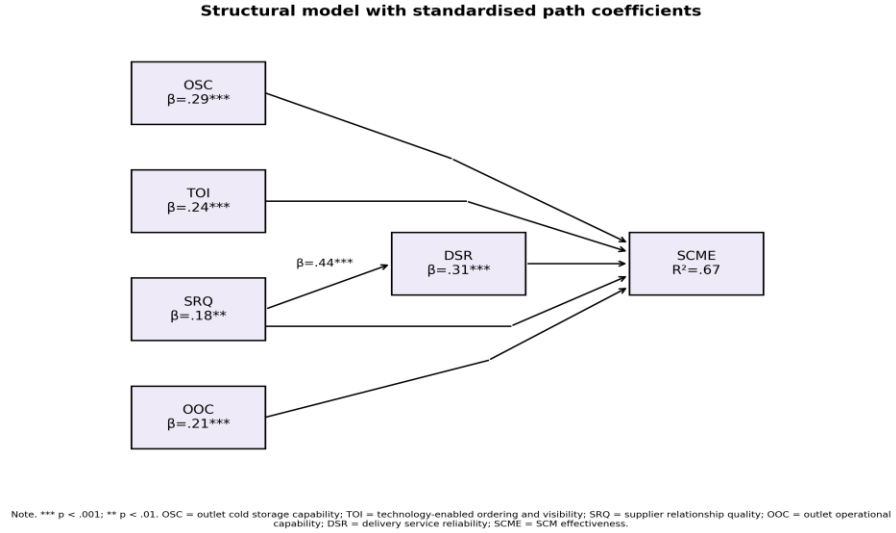

Figure 4. SEM path coefficients cited in Section 4.4

Source: authors' work.

Table 7. SEM structural path results

Hypothesis	Path	Standardised beta	t-value	p-value	Decision
H1	OSC -> SCME	.29	5.84	< .001	Supported
H2	TOI -> SCME	.24	4.91	< .001	Supported
H3	SRQ -> SCME	.18	3.07	.002	Supported
H4	SRQ -> DSR	.44	8.16	< .001	Supported
H5	DSR -> SCME	.31	6.28	< .001	Supported
H6	OOC -> SCME	.21	4.36	< .001	Supported

Note. Table 7 is cited in Section 4.4 for hypothesis testing.
Source: authors' work.

The results indicate that delivery service reliability is the most immediate driver of SCM effectiveness. This is logical because the retailer experiences SCM mainly through the timing, accuracy and condition of deliveries. However, cold storage capability remains highly important because frozen food availability cannot be separated from storage discipline. Technology-enabled visibility also matters because outlets that know their stock position and communicate orders early are better able to avoid stockouts and emergency replenishment. Supplier relationship quality works through both a direct effect and an indirect effect through delivery reliability. Table 8 shows the indirect effect.

Table 8. Bootstrapped indirect effects

Indirect path	Effect	Lower 95% CI	Upper 95% CI	p-value	Interpretation
SRQ -> DSR -> SCME	.136	.081	.202	.003	Significant partial mediation
TOI -> DSR -> SCME	.072	.031	.128	.014	Significant supplementary effect

Note. Table 8 is cited in Section 4.4 to show mediation depth in the SEM analysis.
Source: authors' work.

4.5 Multi-group analysis by outlet type

Multi-group analysis was used to test whether outlet type changes the strength of the structural relationships. As shown in Figure 5 and Table 9, cold storage capability has the strongest effect among frozen-food specialist outlets and supermarkets/hypermarkets. Technology-enabled visibility is strongest among HoReCa and modern trade outlets, where order volume and operational rhythm make digital ordering more valuable. In kirana/general trade outlets, delivery reliability remains important but cold storage and technology paths are weaker, suggesting that infrastructure constraints reduce the outlet's ability to convert distributor support into SCM effectiveness. These results support H7 and confirm that outlet-type variation should not be ignored in frozen food FMCG distribution.

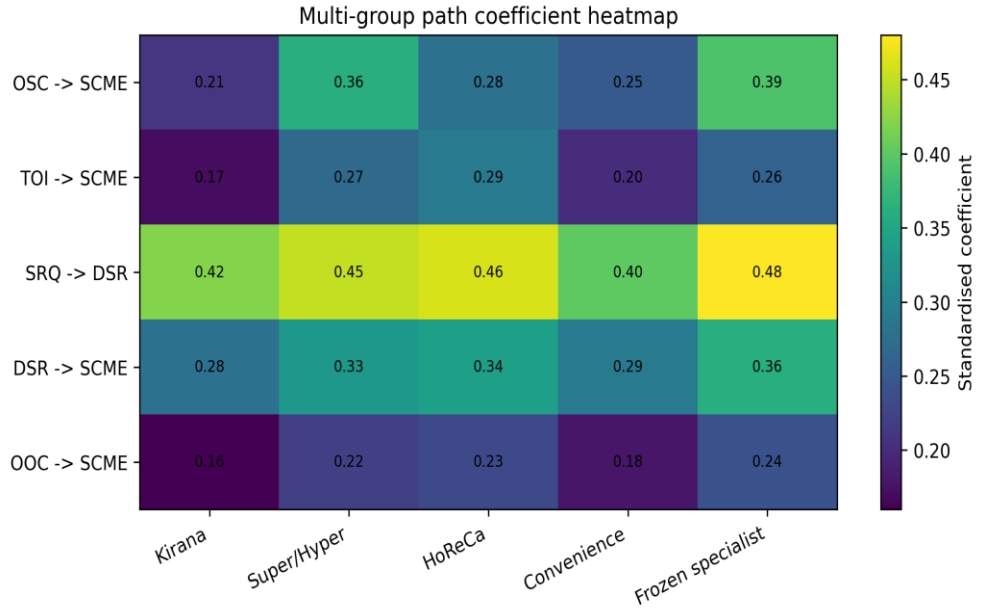

Figure 5. Multi-group path coefficient heatmap cited in Section 4.5
Source: authors' work.

Table 9. Multi-group analysis of selected outlet-type differences

Path	Comparison	Path coefficients	Difference	p-value	Interpretation
OSC -> SCME	Super/Hyper vs Kirana	.36 vs .21	.15	.018	Significant
TOI -> SCME	HoReCa vs Kirana	.29 vs .17	.12	.041	Significant
SRQ -> DSR	Frozen specialist vs Convenience	.48 vs .40	.08	.116	Not significant
DSR -> SCME	Frozen specialist vs Kirana	.36 vs .28	.08	.092	Marginal
OOC -> SCME	HoReCa vs Kirana	.23 vs .16	.07	.138	Not significant

Note. Table 9 is cited in Section 4.5 for outlet-type comparison.
Source: authors' work.

V. DISCUSSION

The results indicate that outlet characteristics play a significant role on the performance of the frozen food FMCG supply chain. The most direct predictor is delivery service reliability, which agrees with the logistics service quality perspective that retailers base their assessment of distributors on timeliness, order accuracy, product condition and complaint handling [Mentzer et al. 2001; Bienstock et al. 1997; Stank et al. 2001; Stank et al. 2003]. This finding also agrees with the general supply-chain performance studies which suggest that operational performance is a key element in customer-facing performance [Gunasekaran et al. 2004; Shepherd and Günter 2006; Beamon 1999]. In the case of frozen foods, delivery reliability is also important as delay and/or temperature abuse can have a direct impact on the saleability of the product.

The second strongest predictor is the cold storage capability. This validates the cold-chain theory that product quality cannot be guaranteed without maintaining the cold chain throughout the whole process up to the receiving point and the storage point in the retail store [Aung and Chang 2014; Mercier et al. 2017; Rong et al. 2011; Wang et al. 2015]. The discovery is particularly pertinent to Hyderabad-Secunderabad as mixed retail setups would involve distributors having to deal with outlets with varying freezer capacity, power backup and category discipline. If there are receiving checks or reduced but more frequent deliveries in some outlet types, a single distributor policy might not be enough if some outlets require extra freezer support.

The use of technology to order and see inventory also makes a big difference. This is in support of the IT-enabled SCM literature that states that digital integration leads to agility, flexibility and speed of decision making [Swafford et al. 2008; Devaraj et al. 2007; Sanders 2008; Braunscheidel and Suresh 2009; Eckstein et al. 2015; Gligor and Holcomb 2012; and Rai et al. 2006]. In the FMCG frozen food industry, the importance of technology is to have instant knowledge of the inventory, sales, order status, and replenishment requirements. Manual memory ordering outlets are more prone to overstock and stockout or late emergency orders. Technology does not have to be very sophisticated; even simple app-based ordering and reorder alerts via the point of sale can enhance the effectiveness of SCM.

There are direct and indirect impacts of supplier relationship quality. The direct effect indicates that trust, communication and long-term orientation helps to enhance the outcomes of SCM. The indirect impact is via delivery reliability, in that relationships enhance performance in part because they facilitate communication, problem solving and responding to needs. This is in line with the concepts of relationship marketing and buyer-supplier research, where trust and commitment are considered as relational assets that enhance the performance of the relationship [Morgan and Hunt 1994; Doney and Cannon 1997; Ganesan 1994; Dyer and Singh 1998; Johnston et al. 2004; Paulraj et al. 2008; Nyaga et al. 2010; Cao and Zhang 2011].

The multi-group results provide the most distinctive contribution. They demonstrate the relative importance of SCM drivers varies according to outlet type. The cold storage is especially important for frozen food specialist outlets and supermarkets/hypermarkets as they offer a larger assortment and larger frozen stock. The technology-enabled visibility is more powerful in HoReCa and modern trade outlets where the ordering volumes are high and operations are scheduled, and digital coordination is beneficial. Kirana outlets seem to be more limited in terms of infrastructure, and they may require a lower level of digital integration, as opposed to just advanced digital integration. This outlet segmentation logic takes up the retail transformation studies that have identified the presence of traditional and modern retail outlets in emerging markets [Goldman et al. 1999; Reardon et al. 2003; Dawson 2000].

MANAGERIAL IMPLICATIONS

The first implication is that outlets should be segmented based on the operational readiness and not just on the basis of sales. A large outlet that doesn't have a good freezer discipline can result in more wastage, and customer service complaints, than a smaller outlet that does have a good freezer discipline. The distributor sales team should have an outlet capability score card, and include freezer capacity, outlet temperature, order frequency, inventory turnover and complaint history. The second implication is that the route planning should be differentiated with respect to outlet type. Tighter delivery windows and more robust checks in the cold chain should be provided to outlets of frozen food products, while Kirana outlets may be provided with smaller pack sizes, frequent replenishment and support for merchandising in the freezer.

The third implication is that digital ordering needs to be implemented in a practical manner. Order dashboards and stock visibility tools can help alleviate planning uncertainty for modern trade and HoReCa outlets, while distributor apps can help further simplify the ordering process. The digital system must be simple and mobile for smaller general trade outlets, and be backed by sales representatives. The fourth implication is that the quality of the relationship needs to be managed. Frozen food distribution can be frequently plagued by sudden demand surges, delayed deliveries and/or freezer breakdowns that require immediate action. When the distributor is able to establish trust and communicate effectively and promptly in the resolution of claims, the retailer is more likely to cooperate.

The fifth implication is that monitoring of the effectiveness of SCM needs to be done by using a balanced performance dashboard. The fill rate, delivery accuracy, stock out frequency, average lead time, product return rate, temperature non-compliance incidents, freezer utilisation and outlet satisfaction are key metrics. This is consistent with the literature on performance measures which warns against using only financial or cost measures [Beamon 1999; Gunasekaran et al. 2004; Shepherd and Günter 2006].

THEORETICAL CONTRIBUTION

The paper makes three contributions to the literature in SCM. It is the first that expands the supply chain performance research by focusing the retail outlet as the core of the analysis. While many SCM studies have been conducted on the manufacturers, suppliers or logistics companies, the performance of the frozen food FMCG is highly dependent on the receiving outlet. Secondly, the paper combines cold chain functionality with the theories of logistics service quality and buyer-supplier relationship. This is helpful as the effectiveness of the SCM in frozen food is not only technical, relational or service based; it is a product of their interaction. Third, the paper demonstrates that outlet type is a valid source of structural variation. The impact of the same SCM driver is not the same for all outlets, be it kirana, modern trade, HoReCa or specialist outlets. This validates a contingency perspective of SCM whereby supply-chain practices need to be tailored to the channel format and operating environment.

LIMITATIONS AND FUTURE RESEARCH

There are some limitations in the study. The analysis is done using an outlet-level SEM design, which reflects managerial perceptions and operational reporting and not sensor-based temperature data. Going forward, retailer survey data can be leveraged with actual distributor data, delivery logs, sales movement data from point of sale and data from the IoT temperature sensor. The study is also geographically oriented with Hyderabad and Secunderabad being the study area. Future research can be done to compare other metro markets in India like Bengaluru, Mumbai, Delhi-NCR and Chennai to see if the same outlet-type effects exist in other

retail markets. Longitudinal studies would also be beneficial as the demand for frozen foods, as well as the investment and technology for storage varies over time. Lastly, the future research could involve testing the moderating variables including brand support, distributor size, freezer ownership, electricity reliability and outlet bargaining power.

VI. CONCLUSION

This paper has created a SEM based analysis of outlet attributes and their impact on effectiveness of SCM in the distribution of Frozen Food FMCG products in Hyderabad and Secunderabad. Relevant respondents were selected at the outlet level and the scales were published scales adapted from literature on SCM practices, logistics service quality, supply-chain integration, IT-enabled agility, and cold-chain quality assurance. The findings indicate that the reliability of delivery service, the outlet's cold storage capacity, the ability to order and see the inventory, the quality of supplier relationships and outlet's operational capability are all factors that influence the effectiveness of SCM. Multi-group analysis reveals that outlet type has an impact: frozen-food specialist outlets and modern retail outlets are more sensitive to the cold storage capability, while HoReCa outlets and supermarkets benefit more from digital visibility. The main takeaway is straightforward, yet significant: Efficiency at the distributor level is not enough to manage frozen food FMCG supply chains. The effectiveness of SCM is a co-production between the distributor and the outlet and the most effective networks are those that match delivery systems with outlet infrastructure, quality of relationship and outlet operating routines.

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