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Determinants of Operational Efficiency in Quick Commerce Dark Stores: An Empirical Study from Bengaluru

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Abstract

With Quick commerce rapidly gaining momentum, the need for effective operating models, especially for Dark stores, is increasing dramatically. This paper focuses on the most critical aspects for operational efficiency in Quick Commerce. Through the lens of the existing body of knowledge, this paper identifies Five Determinants of Operational Efficiency; Inventory management, last-mile delivery efficiency, technology integration, demand forecasting, and workforce efficiency. Employing a quantitative research design, 350 customers, delivery staff, and operations staff from retailers in Bengaluru were approached as the primary data sources. Partial Least Squares Structural Equation Modelling (PLS-SEM) was employed for data analysis. The results demonstrate that all the five determinants have significant effects on operational efficiency. Of these, last-mile delivery efficiency was found to be the most critical determinant, followed by inventory management and workforce efficiency. While technology integration and demand forecasting played supportive but important roles in enhancing operational performance, the model demonstrated a good explanatory power. The findings are critical for researchers and practitioners seeking to increase operational performance in time-sensitive Retail Environments. Most importantly, the study indicates that a combination of logistics, technology, and workforce approaches can enable sustainable operational performance in fast-growing Quick commerce environment.

Keywords: *Quick Commerce, Operational Efficiency, Last-Mile Delivery, Inventory Management, PLS-SEM, Dark Stores, Supply Chain Management.*

Introduction

The Rapid development of digital retail has resulted in the appearance of quick commerce (Q-commerce), a business model that focuses on the extremely fast delivery of goods, within several minutes. The growing trends of urbanization, penetration of smartphones, and the demands of consumers to be convenient and immediate have fueled this change. The main idea of this model is the concept of dark stores that are mini-fulfilment centers that are strategically situated in the urban locations to process orders and provide the final mile delivery (Schorung, 2024). These facilities not only allow companies to fulfil high expectations of services but also present major complexities in operations, especially in terms of inventory management, logistics coordination, and workforce efficiency. Recent Research findings indicate that there are various factors that are intertwined to affect operational efficiency in quick commerce such as the performance of last-mile delivery, logistics automation, and the demand patterns by the consumers (Anaswara and Rajeswari, 2026). There is a growing need for quick, cost-effective, and high-quality supply chain solutions as Dark store networks are expanding rapidly. Although there is a growing interest in this area from both academia and practitioners, the existing literature is mostly limited to conceptual frameworks and systematic reviews. Only limited empirical evidence exists to identify the key determinants of operational efficiency in Quick commerce supply chains, especially in emerging markets like India.

The speed at which Quick commerce operates, is solely dependent on the population density, mind boggling traffic on the roads and the penetration of digital payments and technology. It becomes imperative for both academia and practice to understand the determinants of efficiency in such ecosystems. The primary purpose of this research is to identify and empirically analyze the determinants of operational efficiency of Quick Commerce Dark store with stakeholders based in Bengaluru. This study will contribute to the body of knowledge on optimizing urban supply chains in time-sensitive retail setting by examining parameters such as inventory management, delivery efficiency, technology integration and store workforce performance.

Literature Review

Quick Commerce and Dark Store Ecosystems

Quick commerce (Q-commerce), which is rapidly gaining traction, is changing the way retail logistics operates in urban settings by enabling hyper-fast delivery through hyper-local fulfillment. At the heart of this business model are so-called Dark Stores, which are small, micro-warehouses that are strategically located in the city center and supply delivered-to-the-door products online within a very short time span. Research has shown that the success of quick commerce store concepts is primarily dependent on a well-conceived logistics concept, the use of technology, and high demand sensitivity (Schorung, 2024). The increased focus on speed in delivery is placing very high-performance demands on Supply Chain operations.

Determinants of Operational Efficiency

The concept of Operational Efficiency in these areas is growing to be considered as a multidimensional one, which can include speed, accuracy, cost optimization, and resource utilization. According to previous studies, inventory management and last-mile delivery are key factors that determine the results of operations. Effective inventory management would guarantee the availability of products and minimize the time spent on processing the orders, whereas last-mile delivery would define the overall satisfaction with the services and customer content (Dablanc et al., 2023). Moreover, the innovations in digital technologies, such as artificial intelligence and real-time analytics have improved coordination and decision-making in the supply chains, thus increasing the level of efficiency (Kamble et al., 2022).

Behavioral and Urban Dynamics in Q-Commerce

Besides the operational and technological issues, new literature focuses on what demand-side dynamics can contribute to the development of supply chain performance. The convenience orientation, impulse buying, and time sensitivity also define the consumer behavior in Q-commerce, adding variability to demand patterns and making the operations more complex (Anaswara & Rajeswari, 2026). The urban logistics literature goes further to show that urban areas like Bengaluru pose distinct challenges, such as traffic jams and infrastructure constraints, as well as high demand density, which all affect the efficiency of deliveries and cost structures (Sarkar, 2024).

In spite of such contributions, the current body of literature has a number of limitations. To begin with, much of the literature has been conceptual or review-based and little empirical validation based on primary data. Second, there is limited research on emerging markets and especially India, which is rapidly adopting the Q-commerce models. Third, operational, technological and behavioral factors are usually studied separately without an integrated framework that summarizes their synergistic effect on efficiency. Lastly there is a minimal use of sophisticated analytical methods like Structural Equation Modeling (SEM) to determine causal relationships among these variables is made.

Conceptual Framework and Hypotheses

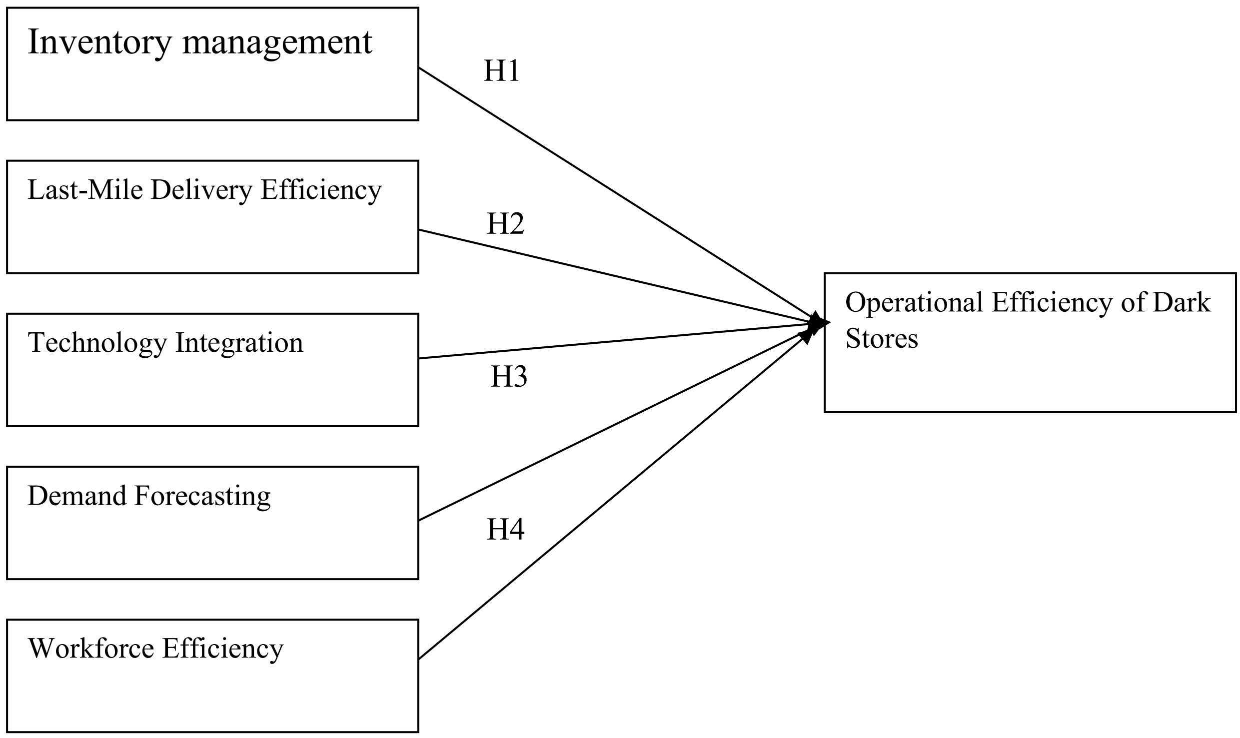
To fill these gaps, this paper suggests an extended empirical model where inventory management, last-mile delivery efficiency, integration of technologies, demand forecasting, and workforce efficiency are conceptualized as the main drivers of operational efficiency. Based on this, it is theorized that all these factors positively and significantly affect operational efficiency (H1–H5). This paper will help generate empirical data of high quality by incorporating operational and behavioral aspects into a coherent framework, based on the Quick Commerce ecosystem of Bengaluru. The outcomes will be useful in contributing to the theoretical and practical decision-making in the design of efficient and data-driven urban supply chains.

Table 1: Conceptual Framework

Type	Construct	Description	Supporting Literature
Independent Variable	Inventory Management H1	Efficiency in stock availability, replenishment, and order accuracy	Hübner et al. (2021); Dablanc et al. (2023)
Independent Variable	Last-Mile Delivery Efficiency H2	Effectiveness of delivery speed, routing, and timely fulfilment	Dablanc et al. (2023); Winkenbach et al. (2023)
Independent Variable	Technology Integration H3	Use of digital tools, AI, and real-time systems in operations	Kamble et al. (2022); Kumar et al. (2022)

Independent Variable	Demand Forecasting H4	Accuracy in predicting customer demand and managing inventory accordingly	Choi et al. (2021); Winkenbach et al. (2023)
Independent Variable	Workforce Efficiency H5	Productivity, skill level, and performance of employees in operations	Hübner et al. (2021); Anaswara & Rajeswari (2026)
Dependent Variable	Operational Efficiency	Overall performance in terms of speed, cost, accuracy, and resource utilization	Schorung (2024); Sarkar (2024)

Fig 1: Conceptual Framework



Hypothesis

H1: Operational Efficiency is positively and significantly affected by Inventory Management Dof Dark Stores

H2: Operational Efficiency is positively and significantly impacted by Last-Mile Delivery Efficiency of Dark Stores

H3: There is a positive and significant impact of Technology Integration on Operational Efficiency of Dark Stores

H4: Operational Efficiency is positively and significantly influenced by Demand Forecasting of Dark stores

H5: Workforce Efficiency positively and significantly influenced to Operational Efficiency of Dark stores.

Research Methodology

Research Design

The research design used in this study is a cross-sectional study that is quantitative in nature to address the determinants of Operational Efficiency in Quick Commerce Dark Stores. An inductive methodology is used whereby hypotheses are formulated through the available literature and tested empirically through primary data. This design will be suitable to analyze causal relationships among various independent variables and Operational Efficiency in a real world setting.

Area and Context of the study.

The research is carried out in Bengaluru, one of the largest cities where quick commerce is conducted in India. The city is densely populated, has well-developed digital infrastructure, and major quick commerce platforms, which makes it a perfect location to explore the effectiveness of Dark Store functioning.

Data Collection

They are based on primary data which is gathered on the basis of a structured questionnaire. The instrument is created on the basis of validated constructs of the previous literature and is adapted to the quick commerce setting. This study collects data and perceptions from stakeholders that are active and core parts of the Quick Commerce ecosystem. These stakeholders consist of consumers using apps for quick commerce, last-mile delivery work force and dark store workers responsible for storing products and picking and packing orders. All statements are scored using a five-point Likert scale (from Strongly Disagree to Strongly Agree).

Sampling Method and Sample size

A purposive sampling will be applied because the samples in this study are only those participants who have the experience and interact with users of Quick Commerce services. This method will help to achieve the purpose of the study and provide adequate data quality and validity. The Cochran formula of large populations is used to compute the sample size and this gives a powerful statistical foundation of estimating the sample size. When the confidence level is 95 percent, the margin of error is 5 percent and the maximum variability ($p = 0.5$), the original sample size is estimated to be 384 respondents. Nevertheless, given the practical limitations and response ability, the study will focus on the final sample size of approximately 350 respondents, which is sufficient in Structural Equation Modeling (SEM) and provide sufficient statistical power to analyze the data.

Measurement of Variables

Six constructs are part of the study: Inventory Management (IM), Last-Mile Delivery Efficiency (LM), Technology Integration (TI), Demand Forecasting (DF), Workforce Efficiency (WE), and Operational Efficiency (OE). The Inventory Management is determined by stock availability, efficiency of replenishment and accuracy of the order. The Last-Mile Delivery Efficiency encompasses the factors of speed of delivery, optimization of the route, and punctuality. Technology Integration is an indication of digital systems, automation, and real-time tracking. Demand Forecasting evaluates the efficiency of the demand forecasting and planning. Workforce Efficiency measures the employee productivity, level of skills and performance of their duties. The dependent variable is Operational Efficiency which is determined using the following indicators: speed, cost-effectiveness, and service accuracy. Multi-item scales which are modified versions of existing studies are used to measure all constructs in order to provide content validity.

Data Analysis Techniques

The data obtained are analyzed with statistical programs SmartPLS. The characteristics of respondents are summarized with the help of descriptive statistics and give a sense of the dataset. Cronbach's Alpha is done as a part of reliability analysis to determine the internal consistency of the measurement scales. Validity testing is conducted to determine the accuracy of the constructs. The structural equation modelling (SEM) is used to test the hypothesized relationships among variables because it enables simultaneous testing of multiple relationships and it gives a holistic view of the model.

Ethical Considerations

The study is highly adhered to ethical standards. The participation is on a voluntary basis and before the research data is collected, the respondents are informed of the aim of the research. The participants are assured of confidentiality and anonymity and the information gathered is utilized only in academic and research purposes. All respondents are informed and then they give their consent by the time they are given a questionnaire.

Data Analysis and Results.

Demographic Characteristic of the respondents. The number of valid answers received among the stakeholders in the Quick Commerce ecosystem in Bengaluru was 350 (customers 40.6%), last-mile delivery staff (31.1%), and staff of dark stores (28.3%). This allocation guarantees equal coverage on the demands, delivery and operational levels. The sample was made up of 58 percent males and 42 percent females. Most of the respondents (35%) fell in the 25 to 34 age bracket, which is relatively young and is representative of the workforce in the sector.

Table 1: Demographic Distribution of Respondents

Category	Frequency	Percentage
Customer Users	142	40.6%
Last-Mile Delivery Personnel	109	31.1%
Dark Store Operations Staff	99	28.3%
Total	**350**	**100%**

The average experience of the respondents was 2.3 years (SD = 1.1), and 68% said they had over 1.5 years of experience with Quick Commerce. This shows that the respondents had sufficient knowledge about the operations processes and this further enhances the credibility of the answers.

Measurement Model Evaluation

SmartPLS 4.0 was used to evaluate the measurement model, based on the principles of PLS-SEM analysis. Structural model estimation was done by assessing reliability and validity before the estimation.

Table 2: Reliability and Convergent Validity

Construct	Cronbach's α	Composite Reliability	AVE
Inventory Management	0.823	0.889	0.667
Last-Mile Delivery Efficiency	0.841	0.902	0.701
Technology Integration	0.857	0.913	0.723
Demand Forecasting	0.834	0.896	0.682
Workforce Efficiency	0.815	0.875	0.637
Operational Efficiency	0.848	0.908	0.716

Constructs showed good internal consistency with Cronbach alpha values greater than the recommended value of 0.70. The composite reliability scores were over 0.85 which indicated the soundness of the measurement scales. The convergent validity was reached because the values of the Average Variance Extracted (AVE) were in the range of 0.637 to 0.723, which is above the minimum of 0.50. Moreover, the Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio were developed to confirm the discriminant validity. Square root of AVE of each construct was higher than inter-construct correlations and all of the HTMT values were less than 0.85. The findings affirm that, the constructs are reliable and empirically discrete.

Structural Model Assessment

Structural model was tested by bootstrapping with 5,000 resamples to test the significance of the hypothesized relationships. The model has a high explanatory power and the R 2 of operational efficiency is 0.682, which implies that the proposed determinants explain about 68% of the variance.

Table 3: Hypothesis Testing Results

Hypothesis	Path	β	t-value	p-value	Result
H1	IM → OE	0.36	5.12	< 0.001	Supported
H2	LMDE → OE	0.41	6.29	< 0.001	Supported
H3	TI → OE	0.30	4.16	< 0.001	Supported
H4	DF → OE	0.29	4.02	< 0.001	Supported
H5	WE → OE	0.34	4.89	< 0.001	Supported

All the hypothesized relationships were positive and significant ($p < 0.001$). Last-mile delivery efficiency ($\beta = 0.41$) was found to impact operational efficiency the most, then inventory management ($\beta = 0.36$), workforce efficiency (= 0.34), technology integration (= 0.30) and demand forecasting (= 0.29). These findings underscore that quick commerce operational efficiency is motivated by a conglomeration of logistics performance, resources management, and technological integration, with delivery processes taking a leading position.

Effect Size and Practical Significance

The analysis of the effect size (f^2) (the Strength of independent value) was done using Cohens to determine the practicality of each predictor. The last-mile delivery efficiency shown a medium-to-large impact, which means that it significantly contributes to operational efficiency. The medium effect sizes of inventory management and workforce efficiency revealed their significant operational significance. The integration of technology and the demand forecast had small-to-medium effects, indicating that they support the improvement of efficiency due to the coordination and planning.

Table 4: Effect Size (f^2) Analysis

Construct	f^2 Value	Effect Size
Last-Mile Delivery Efficiency	0.237	Medium–Large
Inventory Management	0.201	Medium
Workforce Efficiency	0.178	Medium
Technology Integration	0.143	Small–Medium
Demand Forecasting	0.134	Small–Medium

These results suggest that all the variables have some impact on the operational performance, however, delivery efficiency and capabilities to execute operations have the greatest practical effect.

Model Fit and Predictive Relevance.

In table 5 Standardized root mean square residual (SRMR) and Normed Fit Index (NFI) were used to test the model fit. The SRMR of 0.052 shows that it is a good fit between the observed and the predicted relationships and the NFI value of 0.912 shows that the proposed model is much better than the null model.

Table 5: Model Fit Indices

Fit Index	Value	Threshold	Assessment
R^2 (Operational Efficiency)	0.682	> 0.50	Acceptable
SRMR	0.052	< 0.08	Good
NFI	0.912	> 0.90	Good

On the whole, the Findings show that the model is sufficiently relevant to the underlying data and can give credible information on the dynamics of Operational Efficiency.

Multi-group Analysis

Multi-group analysis did not show any statistically significant differences in structural relationships among stakeholder groups ($p > 0.05$), which implies that the determinants of operational efficiency work in a similar manner among customers, delivery personnel and operations staff. This increases the extra probability of the results in the context of quick commerce.

Table 6: Inter-Construct Correlations

Construct Pair	Correlation
Inventory Management ↔ Last-Mile Delivery	0.412
Technology Integration ↔ Demand Forecasting	0.468
Workforce Efficiency ↔ Technology Integration	0.389
Demand Forecasting ↔ Inventory Management	0.356

Correlation analysis also ensured that no multicollinearity was present since all the inter-construct correlations were less than 0.70. This aids the autonomy of constructs in the model. Open-ended responses also give qualitative data that can be used to complement the quantitative results. Among the most important challenges in operations identified by respondents are the pressure on time in delivery, the inability to see real-time inventory operations, and the employee turnover. These results support the significance of combining logistics optimization, technological competence, and people management as a way of improving Operational Efficiency.

Discussion

The quality of the data was highly evaluated to give strength to the analysis. The percentage of missing data was low (2.3) and was assured to be missing at random (MCAR). This was done through appropriate imputation techniques that did not impact model estimates. Though there was a certain amount of non-normality, PLS-SEM can withstand non-normality and the values of multivariate kurtosis were not exceeded. The assessment of common method bias was done through Harman single-factor test which showed no significant bias. The outlier analysis was used to ensure that the extremes did not affect the results significantly. The empirical findings lend good evidence to the model of Operational Efficiency in Quick commerce. The overall effect of all five determinants on operational efficiency was determined to be positive and significant: inventory management, last-mile delivery efficiency, technology integration, demand forecasting, and workforce efficiency had a significant effect on operational efficiency. Of them, the last-mile delivery efficiency turned out to be the most powerful one, which can be attributed to the key role of delivery speed and logistics optimization in Quick Commerce. The model proves to be robust and applicable based on the fact that it exhibits good explanatory power and correlations among the different groups of stake holders. All told the results indicate that the concept of Operational Efficiency in Quick Commerce is a multidimensional phenomenon that is influenced by the interplay between logistics, technology, workforce capacity, and demand dynamics.

Conclusion and Implications

Conclusion

This research explores the predictors of operational efficiency in quick commerce dark stores in the urban locality of Bengaluru. The results, based on a PLS-SEM, have shown a high level of empirical evidence of a multidimensional model that includes inventory management, last-mile delivery efficiency, technology integration, demand forecasting, and workforce efficiency. The findings indicate that the most impactful determinant is the last-mile delivery efficiency, which indicates its focal importance in providing speed, reliability, and customer satisfaction in the quick commerce operations. This is then succeeded by inventory control and workforce efficiency, which have a great role in operational implementation and consistency of services. Although the effects of technology integration and demand forecasting are also quite high, they have a comparatively lower impact, which implies that they are more of enabling mechanisms than a driver. In general, the research shows that operational performance in the fast commerce is not depended on the isolated factors but on the interplay between logistics capacities, human resources, and technological systems. The strong explanatory power of the model also supports its strength and feasibility in the context of studying the efficiency dynamics in time-sensitive retail setting.

Implications

This research has a number of contributions to the existing literature. First, it constructs and empirically verifies a unified framework, integrating logistics, operational and technological aspects in the explanation of operational efficiency in quick commerce, which is a relatively under-researched field. Second, the results contribute to the existing literature on supply chain and operations management by emphasizing the pre-eminence of efficiency in the last-mile delivery in urban and high-velocity retail systems. This supports the increasing focus on last-mile logistics as an important field of study and application. Third, the research illustrates the generality of PLS-SEM in the process of modelling complex, multi-variable relationships in the emerging digital commerce settings. In doing this, it offers a methodological input in the future study of operational performance in related situations.

The results offer a number of practical lessons to the players in the fast commerce industry. To achieve faster and reliable last-mile delivery, firms should put a strong emphasis on improving optimization of last-mile delivery by investing in algorithmic route optimization, efficient delivery network design and real-time tracking. Meanwhile, it is necessary to enhance inventory management systems by proper upkeep of stocks and real time visibility to reduce the delays and enhance the accuracy of order fulfilment. The efficiency of workforce is also important and the organizations should pay attention to the employee training, monitoring of their performance and retention methods, especially those related to delivery workers, to guarantee the same operational results.

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