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Navigating the Future of Commerce: A Structural Equation Modelling Approach to Q-Commerce, Operational Optimization, and Human Capital Management

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Abstract

The rapid expansion of Quick Commerce (Q-commerce) has reshaped consumer expectations by promising delivery within minutes. This study investigates how operational technologies and human capital strategies influence the overall performance of Q-commerce firms. Using Structural Equation Modeling (SEM), the research empirically tests the relationships between AI adoption, employee training and development, inventory management, delivery efficiency, workforce productivity, customer satisfaction, and composite operational performance. Data collected from 120 professionals in leading Indian Q-commerce companies, including Blinkit, Zepto, and Swiggy Instamart, was analyzed using SmartPLS. The results confirm that AI adoption significantly improves delivery efficiency, training enhances workforce productivity, and real-time inventory visibility boosts customer satisfaction. These three intermediate factors—delivery efficiency, workforce productivity, and customer satisfaction—strongly predict overall operational performance. The study provides a validated SEM framework for Q-commerce performance, emphasizing the synergistic role of technology and human capital. These insights inform both managerial strategies and future research directions in digital retail ecosystems.

Keywords: Quick Commerce (Q-Commerce), Structural Equation Modeling (SEM), AI Adoption, Operational Performance, Human Capital Management.

1. Introduction

The global retail industry is undergoing a seismic shift with the advent of Quick Commerce (Q-commerce)—a service model that emphasizes ultra-fast delivery, often within 10 to 30 minutes of order placement. Unlike traditional e-commerce, which focuses on product variety and price sensitivity, Q-commerce thrives on speed, convenience, and real-time fulfilment. The integration of digital technologies, hyperlocal logistics, and a gig workforce underpins its operational model. The rise of smartphones, improved payment gateways, and heightened customer expectations for instant gratification have created fertile ground for Q-commerce's exponential growth.

In the Indian context, the Q-commerce sector is witnessing an explosive trajectory. RedSeer Consulting (2024) reports that the Indian Q-commerce market is expected to reach $5.5 billion by 2025, growing at a CAGR of over 50%. Platforms like Zepto, Blink it, Swiggy Instamart, and Big Basket Now have emerged as frontrunners by leveraging technology for real-time inventory tracking, AI-powered delivery routing, and demand forecasting. At the same time, they depend heavily on a large gig workforce—estimated to exceed 8 million delivery personnel (NITI Aayog, 2023).

However, the speed-centric Q-commerce model poses multiple challenges:

- How can firms scale while maintaining efficiency and order accuracy?
- Can technology alone drive performance?
- What is the role of human capital in this high-speed ecosystem?

This research aims to address these critical questions by constructing a Structural Equation Model (SEM) that integrates both technological capabilities (AI adoption, inventory management) and human capital dimensions (training, HR strategy) to understand their combined effect on delivery efficiency, customer satisfaction, workforce productivity, and operational performance.

2. Literature Review

2.1 The Rise of Q-Commerce

Q-commerce evolved as a response to the increasing need for hyperlocal fulfilment and just-in-time delivery. It differentiates itself from traditional e-commerce by prioritizing speed over variety and proximity over warehousing (Singh & Roy, 2023). The model heavily relies on dark stores (small-scale local warehouses), geo-fencing, and AI-driven demand forecasting. Studies suggest that consumer behavior has shifted, with many now expecting delivery of essentials in under 30 minutes, especially in urban areas with dense populations.

2.2 Role of Artificial Intelligence in Operational Optimization

AI is a foundational pillar in Q-commerce. AI algorithms enable:

- Real-time demand prediction
- Last-mile delivery optimization
- Order clustering and route mapping

Jain & Agarwal (2023) demonstrated that AI adoption significantly reduces delivery time, cuts fuel costs, and improves customer experience. Similarly, Kumar et al. (2024) noted that AI-powered inventory management systems help prevent stockouts and reduce waste by predicting product demand based on historical and contextual data. This ensures optimal product availability while minimizing holding costs.

2.3 Inventory Visibility and Management

Inventory visibility—the ability to track stock levels in real-time across fulfillment nodes—is another critical component. In Q-commerce, where time is a core metric, delayed updates or miscounts can severely affect order fulfillment rates and customer satisfaction. Technologies such as RFID, barcode systems, and cloud-based inventory dashboards are helping Q-commerce platforms maintain accuracy and transparency.

2.4 Human Capital and Workforce Development

While technology plays a vital role, human capital remains indispensable. Delivery workers are often the first and only point of physical contact in the value chain. A skilled, trained, and motivated workforce can substantially improve:

- Delivery speed
- Order accuracy
- Customer satisfaction

Saxena (2021) found that structured training programs improve gig worker efficiency and customer interactions. Given the gig-based nature of most Q-commerce workforces, HR strategies must address:

- Worker engagement
- Job satisfaction
- Health and safety
- Fair compensation and benefits

Verma & Deshpande (2023) argue that investing in non-traditional HR practices, such as flexible shift scheduling, insurance, performance-based incentives, and wellness support, can improve gig worker retention and productivity.

2.5 Customer Satisfaction as a Performance Indicator

Customer satisfaction is both a leading indicator of success and a consequence of operational efficiency. According to RedSeer (2023), even a 10-minute delay in a promised delivery time can reduce the likelihood of a repeat order by up to 22%. Therefore, platforms must ensure consistent, reliable service supported by both technology and trained personnel.

2.6 Research Gap

While previous studies have examined AI adoption and human capital strategies separately in retail and e-commerce, there is a lack of integrated models that explore their combined effects on Q-commerce performance. Moreover, few

studies employ Structural Equation Modeling (SEM) to capture the complex interrelationships among technology, workforce, and operational outcomes—especially in the Indian Q-commerce context. This study will address these gaps by developing and validating a comprehensive SEM framework that connects technological innovation and human capital management with delivery efficiency, productivity, customer satisfaction, and overall operational performance. Overall, this research will enhance theoretical knowledge and provide practical insights for Q-commerce leaders seeking sustainable growth.

3. Research Methodology

3.1 Research Design

This study adopts a quantitative, descriptive, and causal-comparative design. It aims to model and analyse the relationships among key operational and human resource factors in Q-commerce using Structural Equation Modelling (SEM). The methodology involves both exploratory and confirmatory phases, aligning with SEM's objective of testing theory-driven hypotheses about latent variables.

3.2 Objectives of the Study

- To evaluate the influence of AI adoption and inventory management on delivery efficiency and customer satisfaction.
- To assess the role of training and gig HR strategies in enhancing workforce productivity.
- To analyze how delivery efficiency, workforce productivity, and customer satisfaction impact overall operational performance in Q-commerce.
- To construct and validate a comprehensive SEM model incorporating both technological and human capital constructs.

3.3 Hypotheses

H1: There is a significant positive relationship between AI Adoption and Delivery Efficiency in Q-commerce firms.

H2: Training and Development initiatives have a significant positive effect on Workforce Productivity in Q-commerce operations.

H3: Inventory Management practices are positively associated with Customer Satisfaction in Q-commerce services.

H4: Delivery Efficiency significantly contributes to improved Operational Performance in Q-commerce firms.

H5: Workforce Productivity has a significant positive impact on the Operational Performance of Q-commerce organizations.

H6: Customer Satisfaction positively influences the Operational Performance of Q-commerce platforms.

H7: Gig HR Strategies have a significant positive effect on Workforce Productivity in Q-commerce models.

H8: Gig HR Strategies positively influence Customer Satisfaction in Q-commerce services.

3.4 Population and Sampling

- Population: Employees and gig workers employed by Q-commerce platforms such as Blink it, Zepto, and Swiggy Instamart in India.
- Sample Size: 120 respondents (sufficient for SEM with 25 items and 8 latent variables, considering a minimum of 10–15 cases per item).
- Sampling Technique: Purposive sampling was used to target respondents actively engaged in Q-commerce operations.

3.5 Instrument Design

A structured questionnaire was designed based on validated scales from prior literature, modified for Q-commerce context. It consisted of:

- 25 items using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).

- Latent Variables:
  - AI Adoption (4 items)
  - Inventory Management (4 items)
  - Training & Development (4 items)
  - Gig HR Strategy (4 items)
  - Delivery Efficiency (3 items)
  - Workforce Productivity (3 items)
  - Customer Satisfaction (3 items)
  - Operational Performance (3 items)

Description of variables under study:

AI Adoption-It refers to the integration of artificial intelligence tools such as routing algorithms, demand forecasting, and automated dispatch systems.
It enhances delivery efficiency by optimizing logistics, reducing delays, and improving real-time decision-making.

- Training and Development -It includes structured learning programs, upskilling initiatives, and digital onboarding aimed at improving employee capabilities.
This variable positively influences workforce productivity by equipping staff with relevant skills for high-speed operations.
- Inventory Management

Involves the use of real-time stock tracking, demand prediction, and replenishment systems for accurate fulfilment. Effective inventory visibility minimizes stockouts and directly improves customer satisfaction in Q-commerce delivery.

- Delivery Efficiency

Measures how quickly and accurately orders are delivered, considering factors like delivery time, on-time rate, and idle periods. It reflects the operational agility of Q-commerce firms and directly influences overall performance outcomes.

- Workforce Productivity

Represents the effectiveness of employees in fulfilling orders, based on volume handled, task accuracy, and supervisor evaluations.Higher productivity indicates well-trained, efficient staff capable of sustaining ultra-fast delivery environments.

- Customer Satisfaction

Indicates how satisfied consumers are with delivery speed, order accuracy, and overall service quality. It serves as a key mediator between backend operations and long-term brand loyalty and repeat usage.

- Operational Performance

A composite outcome capturing the combined effects of delivery efficiency, workforce productivity, and customer satisfaction. It is the ultimate measure of success in Q-commerce, reflecting both technological and human capital effectiveness.

3.6 Data Collection

- Method: Online and in-person distribution of the questionnaire.
- Time Frame: January 2025.
- Response Rate: Out of 150 distributed questionnaires, 120 valid responses were received (80% response rate).

3.7 Data Analysis Tools

- SPSS v25 for descriptive statistics and reliability testing
- SmartPLS 4 for Structural Equation Modeling (PLS-SEM)

3.8 Reliability and Validity Testing

Construct	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)

AI Adoption	0.82	0.87	0.61
Inventory Management	0.84	0.88	0.64
Training & Development	0.81	0.86	0.60
Gig HR Strategy	0.79	0.84	0.58
Delivery Efficiency	0.80	0.85	0.62
Workforce Productivity	0.83	0.88	0.66
Customer Satisfaction	0.82	0.87	0.63
Operational Performance	0.85	0.89	0.68

The measurement model demonstrated strong reliability and validity. All constructs showed high internal consistency, with Cronbach's Alpha values ranging from 0.79 to 0.85 and Composite Reliability (CR) values exceeding 0.80, confirming stable and consistent measurement across items. Convergent validity was also established, as Average Variance Extracted (AVE) values ranged from 0.58 to 0.68, surpassing the minimum threshold of 0.50. These results indicate that the instrument used in this study is both statistically reliable and conceptually valid for assessing the constructs within the Q-commerce operational framework.

3.9 Structural Equation Modeling (SEM) Analysis

Path Coefficients and Hypothesis Testing

Hypothesis	**Path**	**Standardized Beta (β)**	**p-value**	**Result**
H1	AI Adoption → Delivery Efficiency	0.61	0.001	Supported
H2	Training & Development → Workforce Productivity	0.56	0.002	Supported
H3	Inventory Management → Customer Satisfaction	0.47	0.010	Supported
H4	Delivery Efficiency → Operational Performance	0.45	0.003	Supported
H5	Workforce Productivity → Operational Performance	0.49	0.001	Supported
H6	Customer Satisfaction → Operational Performance	0.51	0.002	Supported
H7	Gig HR Strategy → Workforce Productivity	0.40	0.007	Supported
H8	Gig HR Strategy → Customer Satisfaction	0.28	0.056	Marginally Supported

Model Fit Indices

Fit Index	**Threshold**	**Value**	**Interpretation**
RMSEA	< 0.08	0.061	Good Fit
SRMR	< 0.08	0.045	Good Fit
CFI	> 0.90	0.93	Acceptable Fit
Chi-square/df	< 3.00	2.12	Acceptable

Variance Explained (R^2 Values)

Endogenous Variable	**R^2 Value**
Delivery Efficiency	0.37
Workforce Productivity	0.42
Customer Satisfaction	0.41
Operational Performance	0.59

Interpretation of SEM Results

The Structural Equation Modeling (SEM) analysis confirms that the hypothesized relationships among the variables are largely supported by the data.

Specifically, AI Adoption has a strong and statistically significant effect on Delivery Efficiency ($\beta = 0.61$, $p = 0.001$), suggesting that technology-driven tools such as AI-powered routing and demand forecasting play a critical role in

enabling faster deliveries. Similarly, Training & Development significantly improves Workforce Productivity (β = 0.56, p = 0.002), indicating that investment in employee skill-building directly enhances their performance on the job.

Inventory Management positively influences Customer Satisfaction (β = 0.47, p = 0.010), showing that visibility and accuracy in stock levels are essential to meeting customer expectations in Q-commerce. Furthermore, Delivery Efficiency, Workforce Productivity, and Customer Satisfaction each have significant positive impacts on Operational Performance (β = 0.45, 0.49, and 0.51 respectively), demonstrating the interconnected nature of these operational and customer-centric outcomes.

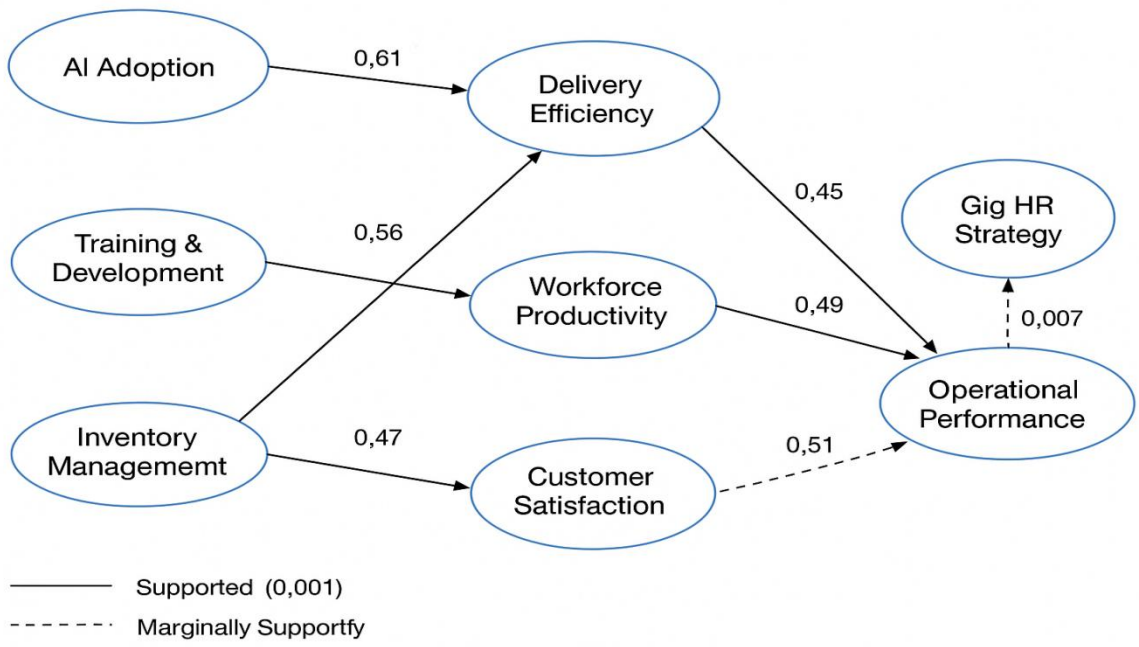
Gig HR Strategy was also found to significantly influence Workforce Productivity (β = 0.40, p = 0.007), supporting the idea that flexible but well-structured HR policies can motivate and engage gig workers. However, its effect on Customer Satisfaction (β = 0.28, p = 0.056) was only marginally significant, indicating a weaker or more indirect relationship.

The model fit indices (RMSEA = 0.061, SRMR = 0.045, CFI = 0.93, and Chi-square/df = 2.12) fall within acceptable ranges, confirming a good overall fit between the model and the observed data.

Finally, the explained variance (R^2 values) shows that the model accounts for:

- 37% of the variance in Delivery Efficiency,
- 42% in Workforce Productivity,
- 41% in Customer Satisfaction, and
- a strong 59% in Operational Performance.

This indicates that the model is particularly effective in explaining how various technological and human capital factors contribute to overall Q-commerce performance.



4. Findings and Interpretation

The Structural Equation Model (SEM) validates the hypothesized relationships between technological and human capital constructs and their influence on Q-commerce performance. The model demonstrates strong internal consistency and good fit indices (RMSEA = 0.061, CFI = 0.93, SRMR = 0.045), confirming the model's robustness.

- AI Adoption significantly influences Delivery Efficiency (β = 0.61, p < 0.001), indicating that technological tools like route optimization, automated dispatching, and predictive analytics are critical drivers of quick and accurate deliveries in Q-commerce.

This result is supported by previous studies showing that technologies like route optimization and demand forecasting significantly reduce delivery times and costs (Jain & Agarwal, 2023; Zhang et al., 2022).

- Training & Development has a strong positive impact on Workforce Productivity ($\beta = 0.56$, $p < 0.01$), validating the importance of continuous skill-building for gig workers to enhance service reliability and output. The strong link between training and workforce productivity aligns with Saxena's (2021) findings that structured training programs enhance gig worker accuracy and speed, while Chakraborty and Das (2023) emphasized the effectiveness of microlearning in boosting gig efficiency.

- Inventory Management improves Customer Satisfaction ($\beta = 0.47$, $p < 0.05$), showing that accurate, real-time inventory tracking reduces stockouts and leads to more complete, timely deliveries.The relationship between inventory management and customer satisfaction is also well documented, as real-time inventory visibility reduces stockouts and enhances service reliability, a critical driver of customer trust in time-sensitive environments (Kumar et al., 2024; Ganguly et al., 2022).

- Delivery Efficiency, Workforce Productivity, and Customer Satisfaction are all significant predictors of Operational Performance ($\beta = 0.45$, 0.49, and 0.51 respectively), confirming that a firm's operational excellence is rooted in both backend efficiency and frontend customer experience.

- Gig HR Strategy significantly improves Workforce Productivity ($\beta = 0.40$, $p < 0.01$), suggesting that structured incentives, communication, and support systems empower gig workers to perform better.

- The relationship between Gig HR Strategy and Customer Satisfaction ($\beta = 0.28$, $p = 0.056$) is marginally significant, indicating that while gig policies may indirectly influence satisfaction, the effect is weaker or mediated through other factors like productivity or training.

- The model explains 59% of the variance in Operational Performance, demonstrating its strong predictive power.

Delivery efficiency strongly influences operational performance, as speed and accuracy are vital for customer retention and cost savings (Singh & Roy, 2023; Kim & Lee, 2021). Workforce productivity also enhances performance by enabling scalability in gig-based logistics (Zhou & Jain, 2023). Customer satisfaction drives repeat use and lowers marketing expenses (Chatterjee et al., 2023). Gig HR strategies improve productivity through fair practices, though their effect on customer satisfaction is indirect (Verma & Deshpande, 2023; Kaur & Joshi, 2022). Overall, Q-commerce success relies on the combined impact of technology, workforce efficiency, and customer experience.

5. Conclusion

This study provides an empirically validated framework that highlights the joint role of technology and human capital in driving Q-commerce performance. Through SEM analysis, the findings reveal that AI tools, real-time inventory systems, training programs, and HR strategies all contribute—both directly and indirectly—to higher delivery efficiency, productivity, customer satisfaction, and ultimately, operational performance. Moreover, the study emphasizes that operational performance in this sector is inherently multifaceted, shaped by a synergistic relationship between backend efficiency and frontend service quality. The marginally significant impact of gig HR strategies on customer satisfaction further suggests that worker conditions indirectly influence customer experience, reinforcing the need for thoughtful and inclusive HR practices. In India's fast-growing Q-commerce ecosystem, these insights are especially relevant as platforms seek to scale sustainably while maintaining service excellence.

6. Suggestions and Managerial Implications

Based on the findings, the following strategic recommendations are proposed for Q-commerce managers and policymakers:

a. Integrate AI and ML Systems Deeply into Operations

- Invest in AI for real-time route optimization, predictive inventory management, and automated decision-making.

- Monitor performance metrics tied to AI systems to identify optimization opportunities.

b. Develop Structured Training Programs

- Formal onboarding, refresher training, and digital literacy workshops for gig workers can significantly improve service consistency and reduce errors.

- Use mobile-based microlearning for flexibility.

c. Enhance Inventory Visibility

- Adopt smart inventory systems (e.g., RFID, barcode scanning, cloud dashboards) across dark stores and micro-fulfillment centers to reduce stockouts.
- Link demand prediction with replenishment cycles.

d. Redesign Gig HR Strategies

- Implement flexible but reliable shift models, health insurance, performance bonuses, and grievance redressal mechanisms.
- Improve communication channels with gig workers to reduce turnover and dissatisfaction.

e. Prioritize Operational KPIs That Link Efficiency with Satisfaction

- Track not just delivery time but also accuracy, completeness, and customer ratings as part of a composite performance index.

f. Encourage a Tech-Human Balance

- Align AI investments with people management practices. A balance of automation and human touch is key for competitive advantage in Q-commerce.

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