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# Optimization of Last Mile Delivery by Reducing Average Delivery Time per Waybill

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*Last-Mile Delivery, Route Optimisation, Workforce Management, Technology Integration, Average Delivery Time per Waybill, E-Commerce Logistics, Urban Logistics Operations.*

**Abstract:** *Last-mile delivery has become a critical driver of operational efficiency, customer satisfaction, and competitive advantage in the rapidly growing Indian e-commerce logistics sector. Despite significant investments in route planning systems, workforce development, and technology platforms, many logistics companies continue to struggle with high average delivery times per waybill. This study addresses the research problem of understanding the key factors influencing average delivery time per waybill in last-mile delivery operations. The primary objective of the study is to examine the influence of route optimisation, workforce management, and technology integration on average delivery time per waybill. A quantitative research design was adopted, and primary data was collected from 50 respondents using a structured questionnaire. The data was analysed using IBM SPSS Statistics, employing reliability analysis, Pearson correlation, multiple linear regression, and chi-square test to examine relationships and group differences. The findings reveal that route optimisation and workforce management are the most significant predictors of delivery time performance. The regression model explained 62.2 percent of the variance in average delivery time per waybill. Technology integration, while positively correlated, did not emerge as an independent significant predictor in the presence of the other variables. The study concludes that upgrading route planning systems, strengthening workforce training, and improving incentive structures are the primary strategies for reducing average delivery time per waybill in urban last-mile logistics operations.*

## Introduction

Last-mile delivery has increasingly emerged as the most critical and cost-intensive segment of the logistics value chain in the modern e-commerce era. As online shopping continues to grow at a rapid pace, the pressure on logistics companies to deliver faster, more reliably, and at lower costs has never

been greater. Last-mile delivery, which refers to the final leg of the supply chain from a distribution hub to the end customer, accounts for approximately 41 to 53 percent of total shipping costs and is widely regarded as the most inefficient component of the logistics chain.

In India, the e-commerce logistics market has witnessed extraordinary growth, expanding from 3.6 billion US dollars in 2020 to over 12 billion US dollars in 2024. This growth has placed enormous pressure on logistics providers to reduce delivery times and improve service quality. Within this competitive environment, the average delivery time per waybill has emerged as a critical key performance indicator that directly influences customer satisfaction, service level agreement compliance, and operational costs.

Leading logistics companies in India operate across express parcel delivery, warehousing, and supply chain services, handling hundreds of millions of shipments annually. Metropolitan hubs such as Chennai present unique challenges for last-mile delivery efficiency due to traffic congestion, diverse urban topography, seasonal disruptions, and the high proportion of cash-on-delivery transactions. Despite significant investments in technology and network infrastructure, reducing average delivery time per waybill remains a persistent operational challenge in such environments.

Route optimisation, workforce management, and technology integration are widely recognised as the three principal drivers of last-mile delivery performance. Route optimisation ensures that delivery vehicles follow the most efficient paths while dynamically responding to real-time traffic conditions. Workforce management encompasses the planning, training, motivation, and performance monitoring of delivery associates. Technology integration involves the effective adoption of digital tools such as GPS tracking, handheld devices, and route planning software across delivery operations.

Understanding how these three dimensions individually and collectively influence average delivery time per waybill is essential for logistics companies seeking to improve operational efficiency and meet the growing demands of e-commerce customers in complex urban environments.

**Problem Statement**

Despite significant investments in logistics infrastructure and technology, reducing average delivery time per waybill continues to remain a persistent challenge in urban last-mile delivery operations. Dense traffic conditions, address ambiguity, seasonal disruptions, and high proportions of cash-on-delivery transactions collectively create an environment where delivery time variability is difficult to manage. Understanding the key operational factors influencing this variability and identifying evidence-based strategies for improvement is essential for enhancing last-mile delivery efficiency.

**Objectives of the Study**

- To analyse the impact of route optimisation practices on average delivery time per waybill in last-mile delivery operations.
- To evaluate the influence of workforce management practices on average delivery time per waybill in last-mile delivery operations.
- To assess the role of technology integration in reducing average delivery time per waybill in last-mile delivery operations.
- To examine the combined predictive power of route optimisation, workforce management, and technology integration on average delivery time per waybill.
- To identify the key challenges faced by delivery associates in achieving optimal delivery times.

**Research Questions**

- What is the level of route optimisation effectiveness as perceived by delivery staff in last-mile delivery operations?
- How does workforce management influence average delivery time per waybill in last-mile delivery operations?
- What is the role of technology integration in reducing average delivery time per waybill?
- Is there a significant relationship between route optimisation, workforce management, technology integration, and average delivery time per waybill?
- Is there a significant association between age group and delivery time performance category among delivery operations staff?

**Structure of the Study**

The study is organized into several sections. The introduction provides the background and context of the study. The literature review discusses previous research on route optimisation, workforce management, and technology integration, and identifies research gaps. The research methodology explains the methods used for data collection and analysis. The results and data analysis section presents and interprets the findings. The discussion section explains the implications of the results. Finally, the conclusion summarizes the study and provides suggestions and future research directions.

**Literature Review**

**Boysen, Fedtke, and Schwerdfeger (2021)** conducted an extensive review of last-mile delivery concepts from an operational research perspective. Their work established that vehicle routing optimisation plays a central role in reducing travel time and operational costs, especially in congested urban settings. The authors showed that dynamic routing models, which adapt to real-time traffic conditions, outperform traditional static planning approaches. Their findings highlight that efficient route design is fundamental to improving last-mile delivery performance.

**Savelsbergh and Van Woensel (2022)** explored research trends and emerging challenges in last-mile logistics. They emphasized that urban delivery systems are becoming increasingly complex due to traffic uncertainty, customer expectations, and time-window constraints. Their study stressed that integrating advanced routing algorithms with real-time traffic data significantly enhances delivery reliability and time efficiency. This work strengthens the relevance of the Vehicle Routing Problem framework in modern logistics environments.

**Dahle, Bakker, Strauss, and Ulmer (2023)** examined strategic workforce planning in hybrid and crowdsourced delivery systems. Their findings demonstrated that structured shift scheduling, optimized driver allocation, and demand-responsive staffing reduce service delays and variability in delivery performance. The study aligns with the Resource-Based View theory by positioning workforce capability as a strategic asset that directly influences operational outcomes in last-mile delivery.

**Schulz, Jena, and Beinke (2024)** further expanded this perspective by developing a machine learning-based workforce forecasting model. Their results showed that predictive workforce alignment improves punctuality and route adherence. This research underscores that workforce management, when supported by analytical tools, contributes significantly to reducing inefficiencies in delivery operations.

**Lam, Tang, and Wong (2024)** investigated the role of digital transformation in improving logistics performance. Their study found that technologies such as GPS-enabled fleet tracking, automated dispatch systems, and digital performance dashboards enhance operational transparency and coordination. However, they also emphasized that technology alone does not guarantee improved performance unless it is effectively integrated with routing systems and workforce processes. This insight supports the argument that technology functions as an enabler rather than an independent driver of delivery time efficiency.

These studies establish that route optimisation and workforce management are primary determinants of delivery time performance, while technology integration enhances efficiency when embedded within structured operational systems.

**Conceptual Framework**

Based on established theoretical frameworks including the Vehicle Routing Problem theory, Resource-Based View of the firm, Technology Acceptance Model, and Supply Chain Management theory, the study proposes that average delivery time per waybill is influenced by three key operational dimensions. Route optimisation affects delivery time by determining the efficiency of delivery paths and the ability to respond dynamically to real-time traffic conditions. Workforce management influences delivery time through the quality of staffing, training, motivation, and performance monitoring of delivery associates. Technology integration affects delivery time through the adoption and effective use of digital tools such as GPS navigation, handheld devices, and route planning software.These three factors collectively shape the average delivery time per waybill in last-mile delivery operations.

**Hypothesis**

**$H_1$:** There is a significant relationship between route optimisation and average delivery time per waybill in last-mile delivery operations.

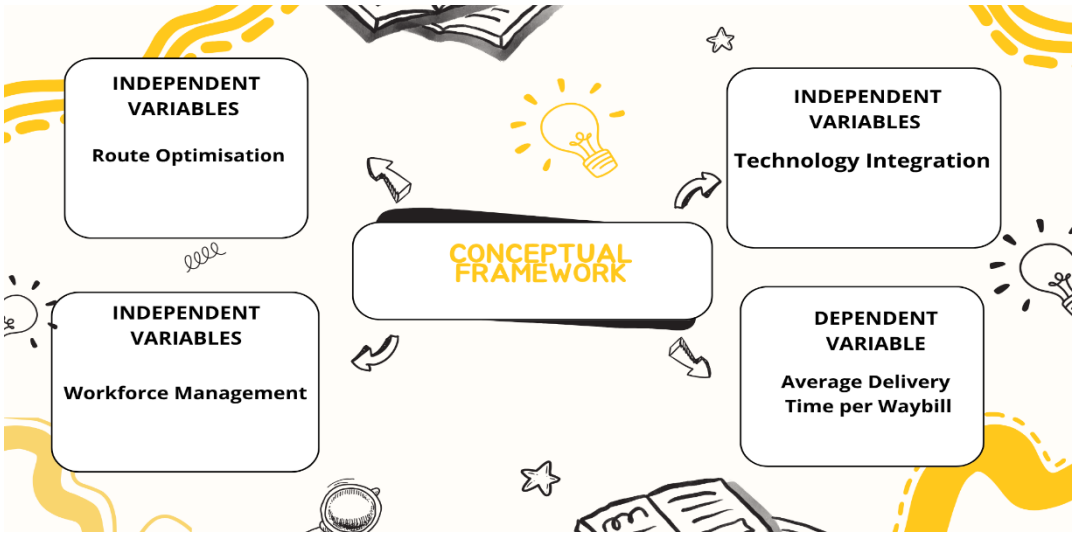
**$H_2$:** There is a significant relationship between workforce management and average delivery time per waybill in last-mile delivery operations.

**$H_3$:** There is a significant relationship between technology integration and average delivery time per waybill in last-mile delivery operations.

**$H_4$:** Route optimisation, workforce management, and technology integration significantly and collectively predict average delivery time per waybill in last-mile delivery operations.

**$H_5$:** There is a significant association between age group and delivery time performance category among delivery operations staff.

**Conceptual Framework: Diagram**




**Research Design**

Quantitative research design

**Target Population**

The target population includes delivery associates, hub managers, and operations supervisors involved in last-mile delivery. They work across different delivery hubs and centres in urban areas.

**Sampling Technique**

The study uses a convenience sampling technique.

**Sample Size -** 50 respondents.

**Data Collection Methods**

This study is based on primary data sources.

Primary: Questionaries

These techniques help in testing hypotheses and drawing meaningful conclusion from the data.

**Data Analysis Techniques**

The collected data was analysed using IBM SPSS Statistics.

- Reliability Analysis (Cronbach's Alpha): Used to measure the internal consistency of the measurement scales.
- Pearson Correlation: Used to measure the strength and direction of relationships between variables.
- Multiple Linear Regression: Used to examine the combined and individual predictive power of the independent variables on delivery time performance.

- Anova- examine differences in average delivery time per waybill across operational factors. This technique helped identify significant variations and support the optimization of last-mile delivery performance.
- Chi-Square Test: Used to examine the association between age group and delivery time performance category.

**Results and Data Analysis**

**Pearson Correlation Analysis**

| | Route Optimisation | Workforce Management | Technology Integration | Avg Delivery Time |
|---|---|---|---|---|
| **Route Optimisation** | 1 | .771 | .779 | .748 |
| **Sig.(2-tailed)** | | .000 | .000 | .000 |
| **N** | 50 | 50 | 50 | 50 |
| **Workforce Management** | .771 | 1 | .759 | .735 |
| **Sig.(2-tailed)** | .000 | | .000 | .000 |
| **N** | 50 | 50 | 50 | 50 |
| **Technology Integration** | .779 | .759 | 1 | .654 |
| **Sig.(2-tailed)** | .000 | .000 | | .000 |
| **N** | 50 | 50 | 50 | 50 |
| **Avg Delivery Time** | .748 | .735 | .654 | 1 |
| **Sig.(2-tailed)** | .000 | .000 | .000 | |
| **N** | 50 | 50 | 50 | 50 |

**Chi-SquareTest**

| Test | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| PearsonChi-Square | 8.376 | 8 | .398 |
| Likelihood Ratio | 9.578 | 8 | .296 |
| Linear-by-Linear Association | .183 | 1 | .669 |
| NofValidCases | 50 | | |

**Multiple LinearAnalysis**

| Model | R | RSquare | AdjustedR Square | Std.Errorof Estimate |
|---|---|---|---|---|
| 1 | .789 | .622 | .597 | .49862 |

**ANOVA**

| Model | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Regression | 18.827 | 3 | 6.276 | 25.241 | .000 |
| Residual | 11.437 | 46 | .249 | | |
| Total | 30.263 | 49 | | | |

**Coefficients**

| Model | B | Std. Error | Beta | t | Sig. | Tolerance | VIF |
|---|---|---|---|---|---|---|---|
| (Constant) | .347 | .429 | | .809 | .423 | | |
| Route Optimisation | .455 | .169 | .434 | 2.697 | .010 | .317 | 3.154 |
| Workforce Mgmt | .440 | ,180 | .379 | 2.442 | .018 | .341 | 2.931 |
| Technology Integ | .033 | .182 | .028 | .180 | .858 | .332 | 3.015 |

**Discussion**

The study findings show that route optimisation, workforce management, and technology integration all have a positive relationship with average delivery time per waybill in last-mile delivery operations.

Route optimisation emerged as the strongest predictor of delivery performance. Efficient route planning, dynamic re-routing, and better traffic management help reduce delivery delays and improve

service speed. This finding supports previous studies by Boysen et al. (2021) and Savelsbergh and Van Woensel (2022), which explained that real-time route planning improves delivery efficiency.

Workforce management also showed a significant influence on delivery time performance. Proper shift scheduling, employee training, and motivation help delivery associate's complete deliveries on time. This supports the studies of Dahle et al. (2023) and Schulz et al. (2024), which highlighted that strong workforce planning improves punctuality and reduces delays.

Technology integration showed a positive relationship with delivery performance, but it was not an individually significant predictor in regression analysis. This means technology supports delivery efficiency mainly when combined with strong route planning and workforce management. This finding is consistent with Lam et al. (2024), who stated that technology works best as a supporting tool rather than a standalone solution.

The chi-square test showed no significant association between age group and delivery time performance. This indicates that delivery efficiency depends more on operational systems and management practices than on employee age.

**Conclusion**

The study aimed to examine the factors influencing average delivery time per waybill in last-mile delivery operations. The findings indicate that route optimisation and workforce management are the primary drivers of last-mile delivery efficiency, while technology integration contributes indirectly through its influence on the other two variables.The study concludes that route optimisation is the strongest predictor of delivery time performance, followed by workforce management. Upgrading route planning software with advanced real-time algorithms, strengthening training programmes, and enhancing performance feedback and incentive structures are recommended as the key strategies for reducing average delivery time per waybill. Technology integration should be viewed as an enabling platform that supports and amplifies the effectiveness of route optimisation and workforce management rather than as an independent operational lever.The findings further highlight that delivery time performance is not significantly associated with the age of delivery associates, suggesting that systemic operational improvements are more impactful than demographic factors. In conclusion, last-mile delivery operations have strong potential for improvement, but this potential needs to be fully realised through evidence-based enhancements in route planning, workforce development, and integrated technology deployment to consistently achieve optimal delivery time performance.

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