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OPTIMIZING FIRST MILE AND LAST MILE OPERATION

Mr. DINAKARAN. D[1], Dr. D ANITHA KUMARI*[2]

II MBA Shipping & Logistics Management, Department of Management Studies, VISTAS[1]

Associate Professor and Programme Coordinator, MBA Shipping & Logistics Management,

Vels Institute of Science Technology and Advanced Studies (VISTAS) Pallavaram, Chennai-117[2]

*Corresponding Author

Abstract: The logistics industry continues to evolve rapidly, with a renewed focus on optimizing first mile and last mile operations to meet rising demands for speed, transparency, and sustainability. The first mile, which involves the movement of goods from suppliers or production units to central hubs, and the last mile, which covers the final leg to the customer, are increasingly being seen as strategic points of competitive advantage. These segments are often the most inefficient and cost-intensive, contributing to over 50% of total logistics costs in e-commerce-driven supply chains. This report explores cutting-edge technologies and models transforming these critical operations. AI-powered route planning, predictive analytics, and warehouse automation are optimizing the first mile by improving pickup scheduling, load optimization, and supplier coordination. In the last mile, companies are deploying hyperlocal micro-fulfillment centers, autonomous delivery vehicles, drone logistics, and crowdsourced delivery networks to enhance speed and flexibility while minimizing environmental impact. By focusing on optimization techniques for both first and last mile operations, companies can achieve greater supply chain resilience, lower logistics costs, and deliver improved customer experiences. The report emphasizes that aligning these efforts with sustainability goals and scalable logistics models is essential for future growth in an increasingly demanding and competitive market environment. The integration of Digital Twins and Blockchain-based visibility platforms is enabling real-time tracking and seamless coordination across the supply chain. In urban areas, the rise of smart lockers, delivery hubs, and carbon-neutral logistics zones is reshaping last mile infrastructure to be faster, greener, and more customer-centric. The report concludes that embracing these innovations not only improves efficiency and customer experience but also aligns with sustainability goals and regulatory trends, making first and last mile optimization a cornerstone of next-generation logistics strategies.

Keywords: First Mile Logistics, Last Mile Delivery, Supply Chain Optimization, Blockchain in Supply Chain, Smart Route Planning, Sustainable Delivery, Real-Time Tracking, Reverse logistics, Return logistics, End-to-End Visibility

I. INTRODUCTION

In modern logistics, the efficiency of first mile and last mile operations determines overall service quality and competitiveness. The first mile refers to the movement of goods from sellers or manufacturers to the warehouse or sorting center, while the last mile involves delivery from the sorting center to the final customer. Delhivery Pvt Ltd, a major logistics firm in India, handles millions of shipments daily and is constantly seeking ways to improve these two critical phases. Urban congestion, fragmented vendor networks, limited visibility, and delivery inaccuracies are common challenges in first and last mile logistics. Addressing these inefficiencies is vital not only for cost reduction but also for enhancing customer experience. This study focuses on identifying operational pain points and suggests methods for optimizing Delhivery's logistics network.

First Mile:
The first mile refers to the initial stage of the logistics process, where goods are picked up from the seller or manufacturer and transported to a warehouse, distribution center, or sorting facility. This stage is critical as it sets the foundation for the entire supply chain. Common challenges in the first mile include high transportation costs, inefficient pick-up scheduling, and lack of real-time visibility. Effective first-mile operations rely on accurate coordination, timely pickups, and integration with technology like GPS tracking to ensure smooth movement into the next stage.

Mid Mile (or Middle Mile):
The mid mile involves the transportation of goods from warehouses or distribution centers to local hubs or fulfillment centers closer to the customer. It serves as the bridge between the first and last mile and plays a key role in maintaining delivery timelines and inventory availability.

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Optimization of load planning, route scheduling, and fleet management is essential in this phase to reduce transit times and operational costs. Efficiency in the mid mile ensures that goods are positioned strategically for fast and cost-effective last-mile delivery.

Last Mile:
The last mile is the final and most visible stage of the delivery process, where goods are transported from a local hub to the end customer's doorstep. This stage directly impacts customer satisfaction and brand reputation. It is often the most complex and costly segment due to factors like traffic, delivery window constraints, and inaccurate customer information. Key solutions include using route optimization software, predictive analytics, and maintaining in-house or crowdsourced delivery fleets. Ensuring accuracy and efficiency in the last mile is vital for meeting customer expectations and reducing delivery failures.

Reverse Logistics:
Reverse logistics refers to the process of moving goods from the end customer back to the manufacturer, retailer, or a designated location for purposes such as returns, repairs, recycling, or disposal. This process is essential for managing product returns, warranty repairs, and recycling programs. Efficient reverse logistics helps companies reduce waste, recover value from returned items, and improve customer satisfaction by providing hassle-free return experiences. It requires careful planning, tracking, and coordination to handle returned goods efficiently while minimizing costs and environmental impact.

Return Logistics:
Return logistics specifically focuses on the management and handling of returned products from customers. This includes the processes of receiving, inspecting, restocking, refurbishing, or disposing of returned items. Effective return logistics is critical for e-commerce and retail businesses, as it directly affects customer loyalty and operational costs. Implementing streamlined return policies, clear communication, and advanced tracking systems can improve return handling efficiency, reduce processing time, and recover product value while enhancing the overall customer experience.

Problem Statement:
Despite Delhivery's robust infrastructure and technology capabilities, inefficiencies persist in managing pickup and delivery operations. Inconsistent pickup schedules, manual sorting at origin points, lack of real-time communication with field staff, and route deviations during deliveries lead to delays and higher costs. The last mile is especially prone to failure due to customer unavailability, incorrect addresses, and traffic-related delays.

II. NEED FOR THE STUDY

The logistics industry is evolving rapidly with increased e-commerce penetration, and customer expectations are higher than ever. Delhivery must enhance its operational resilience and responsiveness to remain competitive. By studying first and last mile inefficiencies, this research contributes actionable insights to improve delivery speed, reduce cost per shipment, and ensure high customer satisfaction.

- Rising customer expectations demand faster and more reliable deliveries.
- First Mile and Last Mile inefficiencies cause major delays and cost overruns.
- Growing e-commerce and retail sectors increase the pressure on logistics performance.

III. SCOPE OF THE STUDY

- This study will uncover key pain points causing delays and inefficiencies in logistics workflows.
- Enhancing delivery speed and reliability leads to better customer experience and increased loyalty.
- It Offers opportunities to lower transportation, labor, and fuel costs through better planning and execution.
- This study is essential to Encourages the integration of real-time tracking and data analytics for bette r monitoring and decision-making.
- Efficient First and Last Mile operations provide faster service, setting companies apart from competitors.

IV. LITERATURE REVIEW

Mishra et al. (2020) found that companies implementing real-time GPS tracking and dynamic routing experienced a 15–20% reduction in fuel and delivery time. Technological interventions such as Transport Management Systems (TMS), Warehouse Management Systems (WMS), IoT, and AI-driven route planning have shown great potential in optimizing First and Last Mile processes.

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Zhang et al. (2020) A study by shows that delays and delivery failures in the Last Mile significantly impact customer satisfaction and brand loyalty. Customers now expect real-time delivery updates, flexible delivery windows, and contactless options—all of which depend on well-coordinated Last Mile systems.

McKinnon (2015) Environmental concerns are increasingly influencing logistics decisions. emphasizes the role of electric vehicles, carbon footprint tracking, and delivery route optimization in building greener First and Last Mile logistics. Mangiaracina et al. (2019) also stress the need for sustainable logistics strategies, particularly in urban Last Mile delivery to reduce emissions and improve efficiency. Kumar & Bansal (2019) discuss the importance of automation in inventory handling and dispatching in First Mile optimization.

Gevaers et al., 2011. The Last Mile has been identified as the most expensive segment in logistics, often accounting for over 40% of total supply chain costs This phase involves the final movement of goods to the end customer, and it is highly sensitive to delays, traffic congestion, and missed deliveries.

Boysen et al. (2021) highlight how increased customer expectations for faster delivery have added pressure on last-mile networks, calling for innovations such as lockers, drone deliveries, and local micro-fulfillment centers.

V. OBJECTIVES OF THE STUDY

1. To enhance supply chain efficiently for a sake of goodwill.
2. To Identify Operational Bottlenecks in First Mile and Last Mile Logistics
3. To Enhance Real-Time Visibility and Transparency
4. To Optimize Transportation and Routing Strategies
5. To provide suggestion to Minimize Operational Costs in First and Last Mile

VI. RESEARCH METHODOLOGY

The research design refers to the overall plan for conducting the research. It includes the type of research, the research questions, the data collection methods, and the data analysis techniques. The research design should be carefully planned and tailored to the specific research question being addressed.

It outlines the structure, framework, and procedures for collecting and analysing data to address research questions or objectives effectively. Research design encompasses various elements, including the type of research (e.g., qualitative, quantitative, mixed-methods), the selection of research participants, the sampling strategy, the data collection methods, and the data analysis techniques. A well-defined research design ensures that the study is conducted systematically, rigorously, and in accordance with the goals of the research, allowing researchers to generate meaningful findings and draw valid conclusions.

RESEARCH GAP

Most research emphasizes first Mile and Last Mile optimization due to its direct link with customer service. However, the First Mile which includes supplier coordination, packaging, documentation, and initial dispatch is often overlooked. While numerous studies have explored logistics and supply chain optimization, specific gaps remain in the understanding and implementation of strategies focused solely on First Mile and Last Mile operations. These two ends of the supply chain are increasingly recognized for their critical role in determining cost efficiency, service reliability, and customer satisfaction, yet they continue to face under-researched challenges.

DATA COLLECTION METHOD:

Primary Data:

Primary data will be collected directly from individuals and organizations involved in First Mile and Last Mile logistics operations. The aim is to gather firsthand insights into the challenges, practices, and perceptions of key stakeholders. The survey comprised 25 questions and aimed to capture the practical challenges faced in marking and performance metrics in First and Last Mile logistics. In-depth interviews will be conducted with key industry experts, including logistics managers, e-commerce fulfillment directors, and last-mile delivery partners.

Secondary Data:

Secondary data will be collected from existing sources that provide relevant insights into logistics practices, industry standards, and technological trends. Industry Reports and Publications: Data will be gathered from industry reports, white papers, and logistics journals that highlight trends, challenges, and innovations in First and Last Mile logistics.

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Company Records and Case Studies: Internal reports, case studies, and historical data from logistics companies, e-commerce firms, and third-party logistics providers will be analyzed to understand performance metrics, process bottlenecks, and past optimization efforts.

The secondary data was collected through existing sources like websites, articles, company websites, Google, Magazines, journals.

SAMPLING TECHNIQUES

1. **Convenience Sampling (Survey-Based Data Collection)**
   This non-probability sampling method involves selecting respondents based on their availability and willingness to participate. Since the data will be collected through Google Forms from the Frist mile and second mile logistics space in team at the company, convenience sampling is a suitable choice due to easy access to the respondents.
2. **Systematic Sampling (Historical Data Analysis)**
   In this study, past practical and efficient method to monitor and enhance both first mile and last mile logistics operations. When used appropriately, it allows logistics managers to maintain high service standards, identify inefficiencies, and support continuous improvement without the time and cost of inspecting every shipment or delivery.

SAMPLE AREA:

The sample area of the study is Delhivery PVT LTD

Sample Size:

The sample size for the study undertaken was 100.

HYPOTHESIS:

Optimizing First Mile and Last Mile operations leads to better logistics efficiency and higher customer satisfaction.

1. **H_0 (Null Hypothesis):**

- There is no significant impact of optimizing First Mile and Last Mile operations on overall logistics efficiency and customer satisfaction.

2. **H_1 (Alternative Hypothesis):**

- Optimizing First Mile and Last Mile operations significantly improves logistics efficiency and enhances customer satisfaction.

DATA ANALYSIS TOOLS

Primary Data Collection:

A structured questionnaire was designed and distributed through Google Forms targeting personnel involved in first mile and last mile shipping operations. The questionnaire included both objective and open-ended questions, get in-depth insights into operational challenges, decision-making processes, and improvement suggestions. Interview a warehouse manager about common delays in outbound shipments during the first mile. The survey comprised 25 questions and aimed to capture the practical challenges faced in marking observe the time taken to load outbound vehicles at the warehouse or how deliveries are handled during peak hours.

Secondary Data Collection:

This data comes from existing sources such as company reports, academic studies, logistics databases, and government portals. This helps support and compare your primary data findings. In this information has already been collected, published, or recorded by others such as companies, researchers, government agencies, or industry analysts. Understand industry standards and benchmarks, Identify technological trends in logistics, Analyze Delhivery's performance based on public reports, Support your primary findings with context and comparison. This data is used to support, validate, or complement primary data in research.

QUESTIONNAIRE DESIGN:

In this study, data was collected using a structured questionnaire as the primary instrument to gather both quantitative and qualitative information. The questionnaire was designed to explore the current practices, challenges, and optimization strategies associated with the marking a first mile and last mile in logistics industry. This method was chosen due to its efficiency in reaching a targeted group of industry professionals and collecting standardized responses that are easy to analyse. The questionnaire was administered via Google Forms, allowing for digital distribution and real-time data collection.

- **Section A: Demographic Information:** This section collects basic background information about the respondents. It helps categorize responses based on role, experience, and geographic location, which allows for better analysis of patterns and performance based on job function or area.

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- **Section B: First Mile Operations:** This section focuses on collecting data about the initial stage of the delivery process, which includes parcel pickup from vendors/sellers and transportation to hubs or warehouses.
- **Section C: Last Mile Operations:** This section is designed to explore the final delivery stage from the last hub to the customer. It is often the most cost-intensive and challenging part of logistics.
- **Section D: Technology and Efficiency:** This section evaluates how technology and digital tools are used to support both first mile and last mile logistics. It also captures feedback on training and process changes.

LIMITATIONS OF THE STUDY:

This study provides valuable insights into the operational efficiency of first mile and last mile logistics at Delhivery, there are several limitations that must be acknowledged. These limitations may affect the scope, generalizability, and depth of the findings, The study relied on a relatively small sample of Delhivery employees for the questionnaire survey.

- This limited the depth of secondary data analysis, especially in relation to metrics like delivery times, failure rates, or routing efficiency.
- The organizational regulations limiting the sharing of sensitive or confidential data limited access to significant data. This limitation could have resulted in inadequate data sets, reducing the comprehensiveness of the conclusions.
- The research was conducted within a limited timeframe, which restricted the ability to perform conduct in-depth interviews with multiple levels of management and field staff.

The study predominantly relies on historical data and case analyses from a defined timeframe. While this approach helps understand past practices and outcomes, it limits the ability to predict future challenges or assess the impact of evolving technologies and regulatory changes. Emerging issues and innovations may not be reflected in the current findings.

STATISTICAL TOOL & INTEPRETATION

SPSS (Statistical Package for the Social Sciences):

SPSS (Statistical Package for the Social Sciences) is a software package used for statistical analysis in various fields, including monitoring and evaluation. It was originally developed in the late 1960s by IBM and has since become one of the most widely used statistical software packages, designed to be user-friendly and accessible to users with little or no programming experience. SPSS is commonly used for data management, descriptive statistics, inferential statistics, and data visualization. SPSS offers a wide range of statistical tools and techniques that can be used to analyse data.

DESCRIPTIVE STATISTICS:

Descriptive Statistics			
	N	Mean	Std. Deviation
What is the biggest challenge in your first mile operations?	100	1.688	.9980
What is the biggest challenge in your first mile operations?	100	3.125	1.1570
How frequently do you experience delays in the first mile	100	1.688	1.0298
What is your most common method for last-mile delivery	100	3.250	1.1072
Valid N (listwise)	100		

INFERENCE:

The descriptive statistics indicate that respondents generally agree on the main challenges in first-mile operations, with low mean values and moderate standard deviations suggesting consistent experiences. Delays in the first mile are reported infrequently, as reflected by the low mean and standard deviation. However, there is more variability in responses related to the specific challenges faced and the methods used for last-mile delivery. The higher mean and standard deviation for these items suggest diverse operational strategies and perceptions among logistics providers. Overall, the data highlights consistency in first-mile challenges but a broader range of approaches in last-mile delivery practices.

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CORRELATIONS:

Correlations

		What is the biggest issue you face in last-mile delivery	What type of last-mile delivery vehicles do you primarily use	Which technology is most effective for real-time tracking of mid mile vehicles	What is the average delivery time for your last-mile shipments
What is the biggest issue you face in last-mile delivery	Pearson Correlation	1	.100	.377*	.339
	Sig. (2-tailed)		.586	.033	.057
	N	100	100	100	100
What type of last-mile delivery vehicles do you primarily use	Pearson Correlation	.100	1	.007	.105
	Sig. (2-tailed)	.586		.971	.568
	N	100	100	100	100
Which technology is most effective for real-time tracking of mid mile vehicles	Pearson Correlation	.377*	.007	1	.469**
	Sig. (2-tailed)	.033	.971		.007
	N	100	100	100	100
What is the average delivery time for your last-mile shipments	Pearson Correlation	.339	.105	.469**	1
	Sig. (2-tailed)	.057	.568	.007	
	N	100	100	100	100

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

INFERENCE:

The correlation analysis involving 100 participants provides valuable insights into the relationships among key factors affecting last-mile and mid-mile logistics performance. A significant positive correlation ($r = 0.377$, $p = 0.033$) was found between the biggest issue faced in last-mile delivery and the technology used for real-time tracking of mid-mile vehicles. This suggests that organizations experiencing more challenges in the last mile are more likely to depend on tracking technologies, possibly as a strategy to mitigate those issues.

Another notable finding is the strong, statistically significant correlation ($r = 0.469$, $p = 0.007$) between the effectiveness of real-time tracking technology for mid-mile vehicles and the average delivery time for last-mile shipments. This indicates that enhanced tracking capabilities may be associated with better visibility but potentially longer delivery times, possibly due to complex coordination or longer monitoring windows in detailed tracking systems.

In contrast, the type of last-mile delivery vehicle used does not significantly correlate with any other variable in the analysis. With very low correlation coefficients and high p-values, this suggests that the choice of delivery vehicle has minimal influence on last-mile issues, tracking technology usage, or delivery time. Overall, the findings highlight the critical role of technology in addressing operational challenges and managing delivery efficiency, while delivery vehicle type appears to play a lesser role.

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ANOVA

ANOVA

What is the primary mode of communication between the first-mile operation team and suppliers

	Sum of Squares	DF	Mean Square	F	Sig.
Between Groups	2.635	67	.659	1.026	.412
Within Groups	17.333	33	.642		
Total	19.969	100			

INFERENCE:

The ANOVA results examine differences in the primary mode of communication between the first-mile operation team and suppliers. The analysis shows a between-groups sum of squares of 2.635 with 67 degrees of freedom, and a within-groups sum of squares of 17.333 with 33 degrees of freedom. The resulting F-value is 1.026 with a significance level (p-value) of 0.412. Since the p-value is greater than 0.05, the result is not statistically significant. This indicates that there are no meaningful differences in communication modes across the groups, suggesting that the mode of communication used is relatively consistent among the participants.

VII. FINDINGS

The survey highlights several key challenges and trends across different stages of the logistics process. In the first mile, high transportation costs (47%) and pick-up delays (27%) are the most significant issues. GPS tracking is the dominant real-time monitoring method (57%), although a notable portion (31%) still relies on manual tracking. For mid-mile operations, load planning and route scheduling are top priorities (56%). In the last mile, only 25% use software for route optimization, while 53% continue with manual planning. Incorrect addresses (37%) and delivery window issues (30%) are major concerns. Predictive analytics (62%) and in-house fleets (44%) are widely used, while third-party providers help manage peak demand (39%).

VIII. SUGGESTIONS

Delhivery company's should focus on enhancing its logistics operations by investing in advanced route optimization software and real-time tracking systems to reduce reliance on manual processes. Improving communication channels by proactively updating customers about delays can significantly boost satisfaction. Greater integration between first-mile and last-mile operations is essential to ensure smoother transitions and reduce delivery delays. Additionally, training the workforce and equipping delivery fleets with modern tools will improve efficiency and lower operational costs. To further optimize last-mile delivery, Delhivery's can explore crowdsourced delivery models, which offer flexibility, cost savings, and faster deliveries especially useful during peak periods or for small shipments.

This ensures timely communication for critical shipments while avoiding unnecessary notifications for less frequent ones. May use data analytics to identify trends in shipment delays, bottlenecks, or other issues related to specific shipping lines or routes. This will enable proactive problem-solving and optimize logistics operations. Might develop a customer portal that provides varying levels of access based on shipment volume. High-volume customers should have access to more detailed and real-time data. This provides a tailored customer experience based on their importance.

IX. CONCLUSION

Optimizing First Mile and Last Mile operations plays a vital role in strengthening the entire logistics and supply chain process. Through the study, it is evident that major challenges such as delays in pick-up, high transportation costs, poor visibility of shipments, and inadequate infrastructure significantly affect the efficiency and reliability of supply chain activities. These issues not only increase operational expenses but also impact customer satisfaction levels. To overcome these challenges, organizations must focus on implementing advanced strategies like route optimization, real-time shipment tracking, and efficient scheduling. Adoption of smart logistics technologies such as IoT-enabled tracking systems, automated dispatching, and AI-driven route planning can greatly enhance visibility, reduce delivery times, and lower transportation costs. Furthermore, infrastructure improvements such as better warehousing facilities and upgraded transportation networks are critical to sustaining long-term operational efficiency.

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