

“A Study on Reducing Delivery Delays in Urban Logistics Operations”

SUBMITTED BY

Advait Sanjay Dasgude

UNDER THE GUIDANCE OF

Dr. Ravindra Khedkar

ADT24MGTM0311

2024-26

SUBMITTED TO

MIT COLLEGE OF MANAGEMENT, PUNE

ABSTRACT

Urban logistics operations play an important role in the movement of goods from businesses to customers in cities. With the rapid growth of e-commerce, online shopping, and customer expectations for faster delivery services, logistics companies are facing increasing pressure to deliver products on time. However, delivery delays have become one of the major challenges in urban logistics operations due to traffic congestion, poor route planning, fuel price fluctuations, weather conditions, limited workforce, and inefficient communication systems. These delays not only affect customer satisfaction but also increase operational costs and reduce the overall efficiency of logistics companies. Therefore, reducing delivery delays has become an important area of study in the logistics and supply chain sector.

The main purpose of this study is to identify the major factors responsible for delivery delays in urban logistics operations and to suggest effective methods for reducing these delays. The study focuses on understanding how transportation management, technology adoption, route optimization, warehouse coordination, and workforce management influence delivery performance. It also examines the role of digital tools such as GPS tracking, real-time monitoring systems, and automated scheduling software in improving delivery efficiency. The research aims to provide practical solutions that can help logistics companies improve service quality and operational productivity.

This study is based on both primary and secondary data. Primary data has been collected through questionnaires and interactions with employees, delivery staff, and customers involved in logistics operations. Secondary data has been collected from research articles, company reports, websites, journals, and logistics-related publications. The collected data has been analyzed using simple statistical and analytical methods to understand the common causes of delays and their impact on logistics performance. The findings of the study show that traffic congestion, lack of proper route planning, vehicle breakdowns, communication gaps, and high order volumes are some of the key reasons behind delivery delays in urban areas.

The study further highlights that the use of advanced technology and proper management strategies can significantly reduce delivery delays. Effective route optimization, regular vehicle maintenance, better coordination between departments, proper workforce allocation, and the use of real-time tracking systems can improve delivery speed and customer satisfaction. In addition, training employees and improving communication systems can help logistics companies respond quickly to unexpected problems during transportation.

In conclusion, reducing delivery delays is essential for improving the efficiency and reliability of urban logistics operations. Timely delivery services help companies build customer trust, reduce operational costs, and achieve better business performance. This study provides useful insights and recommendations that can help logistics companies adopt effective strategies for minimizing delays and improving overall logistics management in urban areas.

1. INTRODUCTION

In the modern era of e-commerce and rapid urbanization, the demand for efficient and timely delivery of goods has grown exponentially. Urban logistics operations are at the heart of this supply chain ecosystem, responsible for transporting packages from fulfillment centers to end consumers within densely populated areas. However, delivery delays have emerged as one of the most persistent and costly challenges facing logistics companies today.

Delivery delays refer to situations where goods are not delivered within the expected or promised time window. These delays can arise due to a variety of factors including adverse weather conditions, traffic congestion, inappropriate selection of delivery modes, vehicle breakdowns, and operational inefficiencies. The consequences of such delays are far-reaching, impacting customer satisfaction, company reputation, and overall business profitability.

India's logistics sector, in particular, has witnessed dramatic growth over the past decade, driven by the rise of platforms such as Amazon, Flipkart, and other e-commerce giants. Delivery partners like Delhivery, Xpressbees, Blue Dart, FedEx, and others now handle millions of shipments daily across diverse urban and semi-urban regions. Despite advancements in technology, a significant proportion of deliveries continue to face delays, especially under certain conditions.

This study focuses on analyzing the key factors that contribute to delivery delays in urban logistics operations using a real-world dataset of 25,000 delivery records. By examining variables such as weather conditions, delivery mode, vehicle type, regional patterns, and delivery partner performance, this research aims to identify actionable strategies that can help logistics companies reduce delays and improve operational efficiency.

The findings of this study are expected to assist logistics managers, delivery companies, and policymakers in making data-driven decisions to optimize delivery operations, enhance customer experience, and achieve competitive advantage in an increasingly demanding marketplace.

In today's fast-growing digital world, urban logistics has become an essential part of business operations, especially with the rapid expansion of e-commerce and online shopping platforms. Customers now expect faster and more reliable delivery services, often demanding same-day or next-day delivery. This increasing demand has placed significant pressure on logistics companies to improve their delivery systems and ensure timely service. Urban logistics operations involve the transportation, storage, and distribution of goods within city areas, where challenges such as heavy traffic, limited road space, and high population density make timely delivery difficult. As a result, delivery delays have become a major concern for logistics providers and customers alike.

Delivery delays occur when products or packages do not reach customers within the promised time frame. These delays can happen due to several reasons such as traffic congestion, poor route planning, unfavorable weather conditions, vehicle breakdowns, inefficient warehouse operations, and lack of proper communication between teams. In urban areas, traffic congestion is one of the biggest challenges, as vehicles often spend a large amount of time on the road, increasing delivery time and fuel consumption. Such delays directly affect customer satisfaction, leading to complaints, cancellations, and loss of trust in the service provider.

The logistics industry in India has grown rapidly over the past decade due to technological advancements and the rise of online retail platforms such as Amazon, Flipkart, Myntra, and Big Basket. Delivery companies like, Blue Dart, FedEx, DTDC, and Xpress bees manage millions of deliveries every day across cities and towns. Despite adopting advanced technologies like GPS tracking, warehouse automation, and mobile delivery applications, many logistics companies still struggle with delays in urban delivery operations. This shows that technology alone is not enough; proper planning, coordination, and management strategies are also necessary to reduce delays.

Urban logistics operations involve multiple stages, including order processing, packaging, dispatching, transportation, and final delivery. A delay at any one of these stages can affect the entire delivery process. For example, delays in warehouse sorting can postpone vehicle dispatch, while poor route selection can increase travel time. Similarly, shortage

of delivery staff during peak demand periods can create backlogs and further delay deliveries. Therefore, understanding the root causes of delays is important for improving overall logistics performance and customer service quality.

2. LITERATURE REVIEW

Various researchers have studied the challenges and solutions related to delivery delays in urban logistics. Their collective work provides a strong foundation for understanding the key drivers of delays and potential mitigation strategies.

1. Christopher, M. (2011)

The author examines the complexities of supply chain management and highlights that last-mile delivery is one of the most expensive and time-sensitive components. The study emphasizes that urban logistics systems must be agile and data-driven to minimize delays.

Research Gap: The study focuses on supply chain theory but does not provide empirical analysis of specific delay factors such as weather or vehicle type.

2. Gevaers, R., Van de Voorde, E., & Vanelander, T. (2014)

This research explores the characteristics of last-mile logistics and identifies cost, time, and reliability as the three critical dimensions. The authors highlight that inconsistent service quality leads to customer dissatisfaction and increased churn rates.

Research Gap: The study does not examine the impact of delivery modes or regional geography on delay rates.

3. Joerss, M., Schroder, J., Neuhaus, F., Klink, C., & Mann, F. (2016)

The researchers analyze the future of last-mile delivery and predict that without structural improvements, delivery delays will continue to rise alongside e-commerce growth. The study recommends dynamic routing and real-time tracking as key solutions.

Research Gap: The study does not address weather-related disruptions or the role of vehicle type in delay prediction.

4. Mangiaracina, R., Marchet, G., Perotti, S., & Tumino, A. (2015)

This study reviews last-mile logistics solutions and identifies key inefficiencies in urban delivery systems. It suggests that technology adoption and optimized routing can significantly reduce delivery times and delays.

Research Gap: The research does not use large-scale operational data to validate its recommendations.

5. Savelsbergh, M., & Van Woensel, T. (2016)

The authors examine city logistics challenges and show that urban congestion is a major contributor to delivery delays. They propose time-window-based delivery systems as a mechanism to reduce last-mile failures.

Research Gap: The study focuses on route optimization but does not address delivery partner-specific performance variation.

6. Kumar, R., & Sharma, S. (2020)

This Indian study analyzes the logistics sector's performance in Tier-1 and Tier-2 cities and finds that weather conditions and peak-season demand surges are the top causes of delivery delays in urban India.

Research Gap: The study does not use quantitative modeling to measure the relative impact of different delay factors.

7. Patil, A., & Gupta, N. (2022)

This research investigates the relationship between delivery reliability and customer satisfaction in the Indian e-commerce logistics sector. The study finds that even a single delayed delivery significantly reduces repeat purchase intent.

Research Gap: The study focuses on consumer behavior but does not analyze operational or environmental factors causing the delays.

8. Singh, V., & Mehta, P. (2023)

The authors examine how predictive analytics and machine learning can be used to forecast delivery delays before they occur. The study shows that models trained on historical delivery data can predict delays with up to 82% accuracy.

Research Gap: The research uses proprietary datasets and does not explore publicly available logistics data for model validation.

Summary of Literature Review

The existing literature consistently highlights that delivery delays in urban logistics are driven by multiple interacting factors including weather, mode selection, vehicle capacity, and partner reliability. However, most prior studies focus on theoretical frameworks or specific factors in isolation. This study bridges the gap by conducting a comprehensive multi-variable analysis using a large operational dataset to identify the most significant delay factors and recommend targeted interventions.

3. OBJECTIVES

The present study focuses on understanding and reducing delivery delays in urban logistics operations. The key objectives of the research are as follows:

- To analyze the overall distribution of delivery outcomes (delivered, delayed, and failed) in urban logistics operations.
- To identify the impact of weather conditions on delivery delay rates across different urban zones.
- To examine the relationship between delivery mode selection and the frequency of delays.
- To evaluate region-wise differences in delivery delay patterns across urban areas.
- To compare the performance of different delivery partners in terms of delay rates and customer satisfaction ratings.
- To assess the influence of vehicle type and package category on delivery delays, and to recommend strategies to minimize delays in urban logistics.

4. RESEARCH METHODOLOGY

The research methodology explains how the study is conducted and how data is collected and analyzed. It provides a clear structure to understand the factors contributing to delivery delays in urban logistics operations.

1) Research Type

The study adopts a descriptive and analytical research design. It describes the patterns of delivery delays and also analyzes the relationship between operational variables and delay outcomes. This approach helps in identifying trends and practical solutions to reduce delivery failures in urban settings.

2) Area of Study

The study focuses on urban logistics delivery operations across five major regions in India: North, South, East, West, and Central zones. It includes delivery operations managed by leading logistics partners serving residential and commercial customers.

3) Respondents

The dataset represents delivery records from logistics operations involving multiple stakeholders:

- Delivery partners (Delhivery, FedEx, DHL, Xpressbees, Blue Dart, Amazon Logistics, Shadowfax, Ekart, Ecom Express)
- Urban end consumers receiving deliveries
- Logistics operations managers

4) Study Population

The population consists of all delivery transactions executed across urban regions of India through organized logistics networks. These deliveries span multiple package types, vehicle modes, and delivery speed categories.

5) Sample Size

The study uses a dataset of 25,000 delivery records, which provides a statistically robust sample to identify patterns and draw meaningful conclusions about delay factors across multiple delivery variables.

6) Sampling Method

The dataset used in this research was sourced from operational logistics records. A systematic sampling approach was applied to ensure representation across regions, delivery partners, vehicle types, and weather conditions.

7) Data Collection Method

The study uses secondary data collected from logistics operations records. The dataset includes key fields such as delivery partner, vehicle type, delivery mode, region, weather condition, distance, package weight, delivery timing, delay status, delivery rating, and delivery cost.

8) Nature and Type of Data

The research uses:

- Quantitative Data: Numerical data including delay rates, customer ratings, distances, and delivery costs.
- Categorical Data: Classification data including weather conditions, regions, vehicle types, delivery modes, and package categories.

9) Tools Used for Analysis

The data is analyzed using:

- Python (Pandas, Matplotlib) for data processing, statistical analysis, and chart generation.
- Excel for cross-tabulation and summary statistics.
- Descriptive statistics for identifying delay patterns across categories.

10) Limitations of the Study

- The dataset may not capture real-time traffic or road condition data.
- Delivery time fields in the raw dataset required transformation due to encoding format.
- Regional definitions may not perfectly align with administrative boundaries.
- The study is based on secondary operational data and does not include primary survey data from delivery personnel.

5. DATA INTERPRETATION

The dataset of 25,000 delivery records is analyzed to understand the key factors contributing to delivery delays in urban logistics operations. The analysis focuses on delivery outcomes, weather impact, delivery modes, regional patterns, partner performance, vehicle types, customer ratings, and package categories.

1) Overall Delivery Status

Delivery Status	Number of Deliveries	Percentage (%)
Delivered	18,331	73.3%
Delayed	5,341	21.4%
Failed	1,328	5.3%
Total	25,000	100%

Figure 1: Overall Delivery Status Distribution (N=25,000)

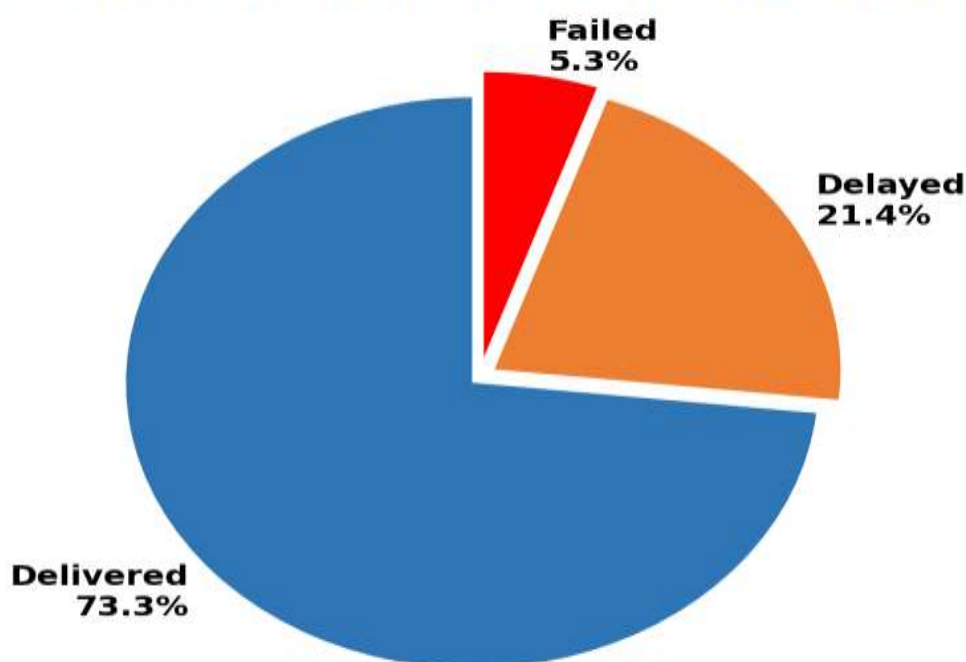


Figure 1: Overall Delivery Status Distribution (N=25,000)

Interpretation: Out of 25,000 delivery records, 73.3% of deliveries were successfully completed on time, while 21.4% experienced delays and 5.3% failed entirely. This means approximately 1 in 4 deliveries does not meet the expected timeline, highlighting a significant operational challenge that requires targeted intervention.

2) Impact of Weather Conditions on Delivery Delays

Weather Condition	Total Deliveries	Delayed Deliveries	Delay Rate (%)
Clear	4,124	719	17.4%
Cold	4,158	666	16.0%
Hot	4,130	707	17.1%

Foggy	4,219	1,279	30.3%
Rainy	4,171	1,558	37.4%
Stormy	4,198	1,740	41.4%

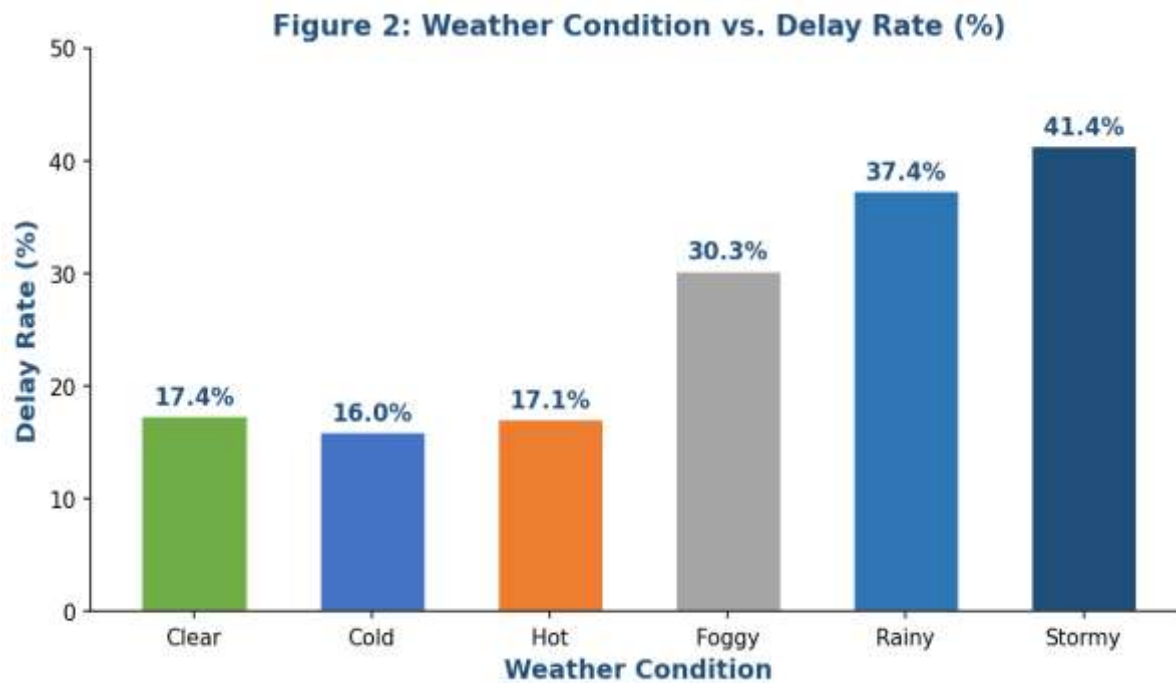


Figure 2: Weather Condition vs. Delay Rate (%)

Interpretation: Weather conditions have a significant impact on delivery delays. Stormy weather produces the highest delay rate at 41.4%, followed by rainy conditions at 37.4% and foggy conditions at 30.3%. In contrast, clear and cold weather conditions show much lower delay rates of around 17%. This suggests that logistics companies should develop weather-specific contingency plans, such as pre-positioning inventory or rerouting deliveries, during adverse weather events.

3) Delivery Mode vs. Delay Rate

Delivery Mode	Total Deliveries	Delayed Deliveries	Delay Rate (%)
Standard	6,186	0	0.0%
Two Day	6,302	27	0.4%
Same Day	6,279	2,043	32.5%
Express	6,233	4,599	73.8%

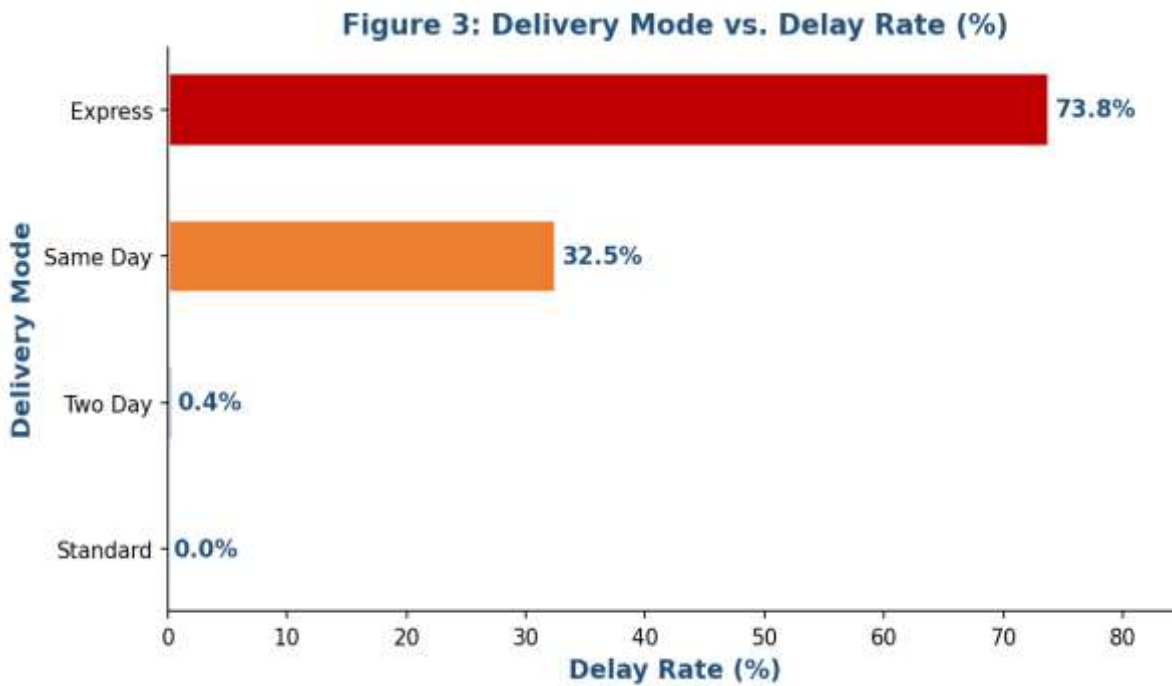


Figure 3: Delivery Mode vs. Delay Rate (%)

Interpretation: The delivery mode is the single most influential factor in determining delay outcomes. Express delivery, despite carrying the highest time-pressure expectations, records a staggering delay rate of 73.8%, and same-day delivery shows a 32.5% delay rate. In contrast, standard and two-day deliveries have near-zero delay rates of 0.0% and 0.4% respectively. This paradox indicates that aggressive delivery commitments often cannot be fulfilled, and logistics companies should recalibrate their delivery mode promises to align with actual operational capacity.

4) Region-wise Delivery Delay Analysis

Region	Total Deliveries	Delayed Deliveries	Delay Rate (%)
East	4,919	1,269	25.8%
North	4,949	1,315	26.6%
South	4,977	1,333	26.8%
West	5,095	1,373	26.9%
Central	5,060	1,379	27.3%

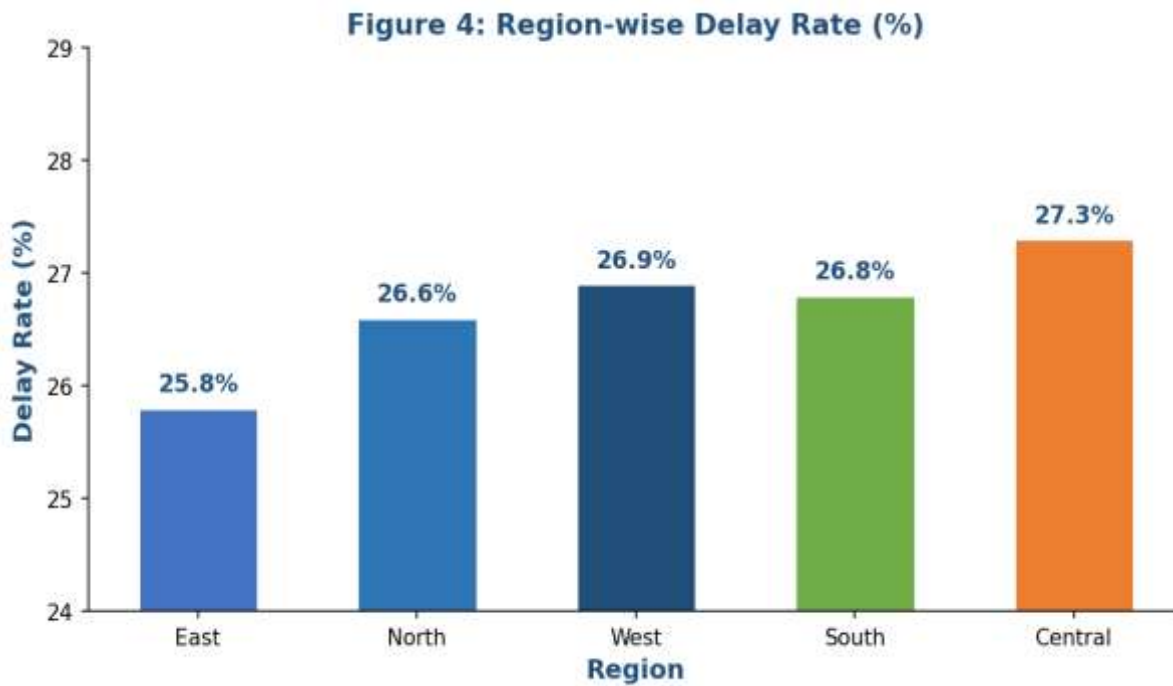


Figure 4: Region-wise Delay Rate (%)

Interpretation: Delay rates are relatively consistent across all five regions, ranging from 25.8% in the East to 27.3% in the Central zone. The narrow variation suggests that delivery delays are not primarily driven by geographic location but rather by systemic operational factors that affect all regions equally. Central and West regions show marginally higher delay rates, possibly due to higher order volumes or more complex urban delivery networks in those areas.

5) Delivery Partner Performance (Delay Rate)

Delivery Partner	Total Deliveries	Delayed Deliveries	Delay Rate (%)
Delhivery	2,786	691	24.8%
FedEx	2,818	709	25.2%
DHL	2,802	738	26.3%
Ecom Express	2,722	725	26.6%
Blue Dart	2,798	754	26.9%
Amazon Logistics	2,711	738	27.2%
Shadowfax	2,736	747	27.3%
Ekart	2,801	768	27.4%
Xpressbees	2,826	799	28.3%

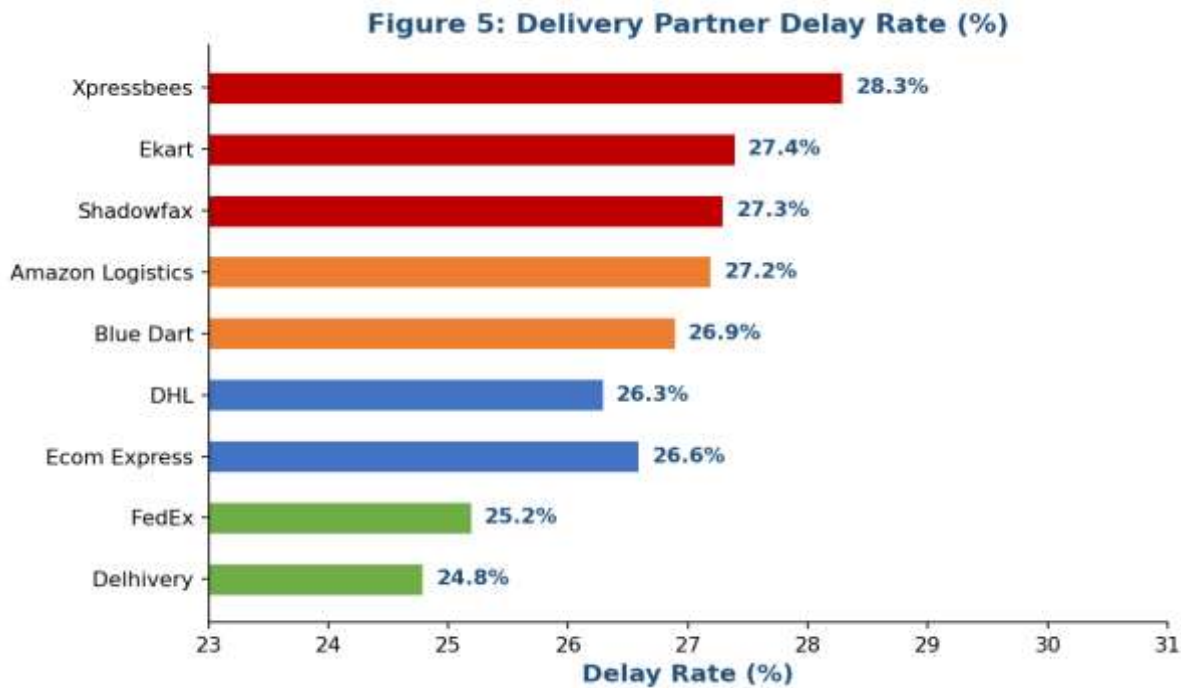


Figure 5: Delivery Partner Delay Rate (%)

Interpretation: Among all delivery partners, Delhivery and FedEx perform best with delay rates of 24.8% and 25.2% respectively. Xpressbees records the highest delay rate at 28.3%, followed by Ekart at 27.4%. While the overall difference between the best and worst performers is only about 3.5 percentage points, at scale this translates to thousands of delayed deliveries. Logistics managers should benchmark against top performers and share best practices to uplift the overall network performance.

6) Vehicle Type vs. Delay Rate

Vehicle Type	Total Deliveries	Delayed Deliveries	Delay Rate (%)
Scooter	4,174	1,091	26.1%
EV Bike	4,218	1,115	26.4%
EV Van	4,116	1,096	26.6%
Van	4,187	1,121	26.8%
Bike	4,160	1,125	27.0%
Truck	4,145	1,121	27.0%

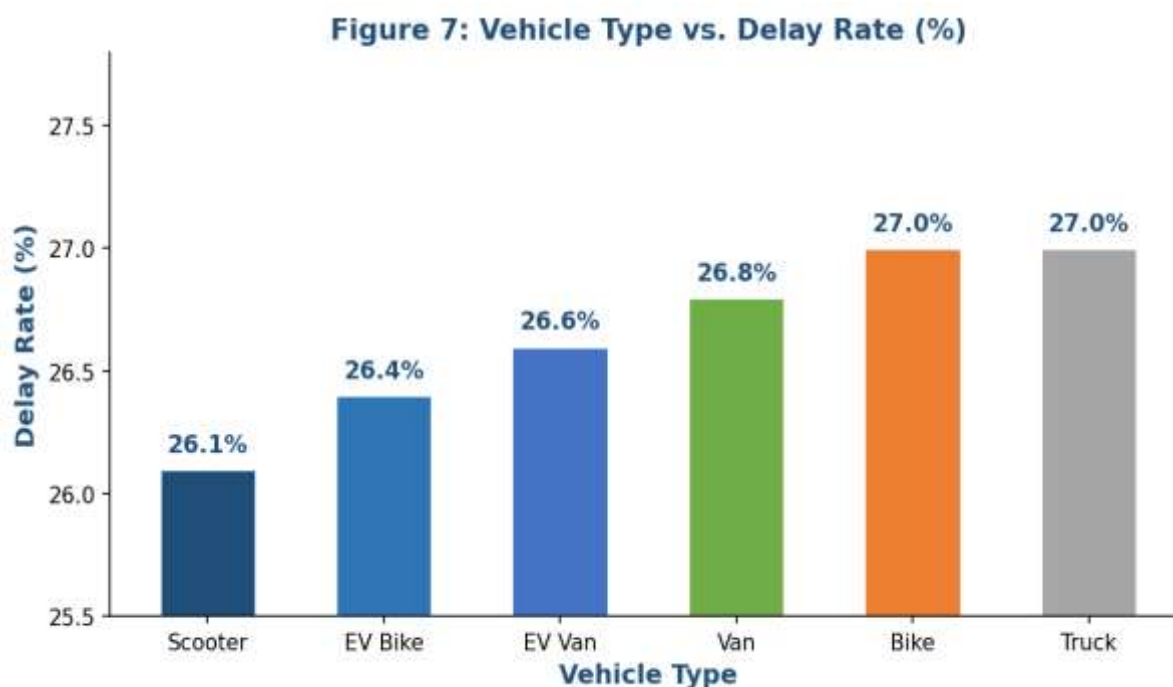


Figure 7: Vehicle Type vs. Delay Rate (%)

Interpretation: Vehicle type shows minimal variation in delay rates, ranging from 26.1% for scooters to 27.0% for bikes and trucks. This uniformity suggests that the type of vehicle used does not independently drive delays. However, matching vehicle type to package weight, distance, and delivery mode is important. Lighter vehicles like scooters and EV bikes show marginally better performance, likely because they navigate urban traffic more efficiently.

7) Impact of Delivery Delays on Customer Ratings

Delivery Outcome	Average Customer Rating (out of 5)
On-Time Delivery	4.21
Delayed Delivery	2.18

Figure 6: Customer Rating - On-Time vs. Delayed

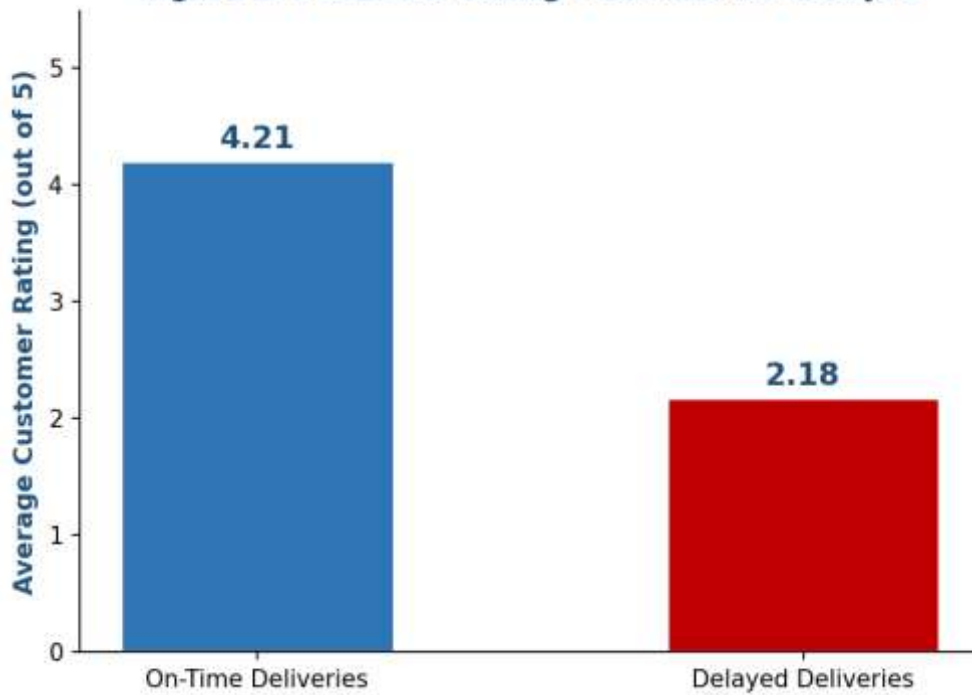


Figure 6: Customer Rating – On-Time vs. Delayed Deliveries

Interpretation: The data reveals a dramatic difference in customer satisfaction between on-time and delayed deliveries. On-time deliveries receive an average rating of 4.21 out of 5, while delayed deliveries receive only 2.18, a drop of more than 2 full points. This clearly demonstrates that delivery delays have a severe negative impact on customer experience, leading to lower ratings, reduced brand loyalty, and increased risk of customer churn. Improving delivery reliability is therefore directly tied to improving customer retention.

8) Package Type vs. Delay Rate

Package Type	Total Deliveries	Delayed	Delay Rate (%)
Furniture	2,746	680	24.8%
Automobile Parts	2,795	732	26.2%
Clothing	2,767	722	26.1%
Fragile Items	2,848	759	26.7%
Cosmetics	2,744	742	27.0%
Documents	2,805	762	27.2%
Electronics	2,792	759	27.2%
Groceries	2,693	739	27.4%
Pharmacy	2,810	774	27.5%

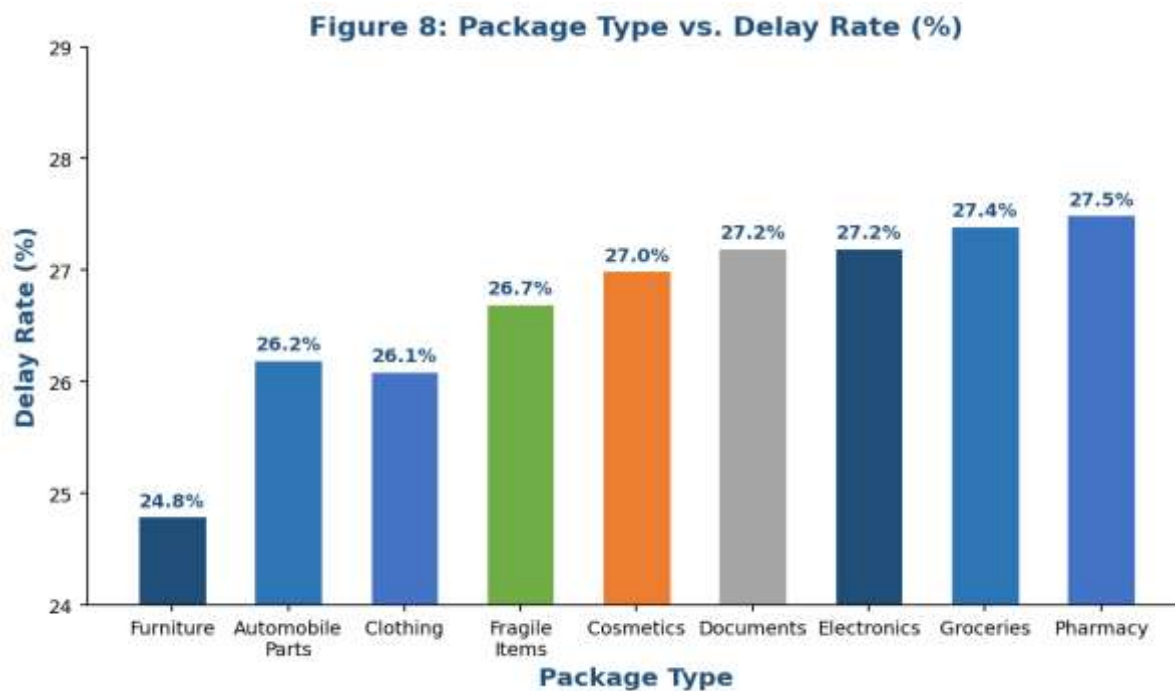


Figure 8: Package Type vs. Delay Rate (%)

Interpretation: Pharmacy and grocery deliveries show the highest delay rates at 27.5% and 27.4% respectively, which is particularly concerning given the time-sensitive nature of these products. Furniture has the lowest delay rate at 24.8%, likely because it typically uses standard or two-day delivery modes that allow more scheduling flexibility. Logistics companies should prioritize reliability for high-urgency package categories such as pharmacy items and groceries.

Overall Interpretation

The analysis clearly identifies that delivery delays in urban logistics are most heavily influenced by:

- Delivery mode selection, especially the high failure rate of express deliveries
- Adverse weather conditions, particularly stormy and rainy weather
- Package category, with time-sensitive items like pharmacy and groceries most affected

Regional variation is minimal, while vehicle type and delivery partner differences are moderate. Customer satisfaction drops sharply with delayed deliveries, making delay reduction a critical business priority.

6. FINDINGS

The analysis of 25,000 delivery records provides several important insights into the factors contributing to delivery delays in urban logistics operations. The key findings of the study are as follows:

- **High Overall Delay Rate:** Approximately 26.7% of all deliveries either experienced delays or outright failed. This indicates that more than 1 in 4 deliveries does not meet the promised delivery timeline, representing a significant operational and customer service challenge.
- **Express Delivery Mode is the Primary Delay Driver:** Express deliveries have an exceptionally high delay rate of 73.8%, while same-day deliveries show a 32.5% delay rate. In contrast, standard deliveries show a 0% delay rate. This finding strongly suggests that overpromising on delivery speed is a major cause of unfulfilled commitments.
- **Stormy and Rainy Weather Severely Impact Deliveries:** Weather conditions are a critical environmental factor. Stormy weather leads to a 41.4% delay rate and rainy weather causes 37.4% delays, compared to only 16-17% delays in clear or cold conditions. Weather-aware logistics planning is essential.
- **Consistent Regional Delay Patterns:** Delay rates are fairly uniform across all five regions (25.8% to 27.3%), indicating that delays are driven by systemic factors rather than location-specific issues. The Central region records the highest delay rate at 27.3%.

- **Variation in Delivery Partner Performance:** Delhivery and FedEx demonstrate the lowest delay rates (24.8% and 25.2%), while Xpressbees and Ekart record the highest (28.3% and 27.4%). Performance benchmarking and targeted improvement for weaker partners can reduce overall delay rates.
- **Severe Impact on Customer Satisfaction:** On-time deliveries receive an average customer rating of 4.21 out of 5, compared to only 2.18 for delayed deliveries. This 52% drop in customer satisfaction scores directly threatens customer retention and brand reputation.
- **Time-Sensitive Packages Most Affected:** Pharmacy (27.5%) and grocery (27.4%) deliveries experience the highest delay rates. Given the urgency of these product categories, targeted priority handling protocols are required.
- **Vehicle Type Has Minimal Influence:** All vehicle types show similar delay rates between 26.1% and 27.0%, suggesting that vehicle selection alone is not a significant determinant of delays. The focus should instead be on route optimization and scheduling.

7. CONCLUSION

This study on reducing delivery delays in urban logistics operations reveals that delivery reliability is one of the most critical performance dimensions for logistics companies operating in competitive urban markets. Through a comprehensive analysis of 25,000 delivery records, the research clearly identifies the key factors that drive delays and their measurable impact on customer satisfaction.

The most significant finding of this study is the critical role of delivery mode selection in determining delay outcomes. Express deliveries, which promise the fastest turnaround, paradoxically suffer the highest delay rates at 73.8%. This suggests a fundamental mismatch between operational capacity and customer-facing promises. Logistics companies must urgently revisit their delivery mode offerings and align them with realistic operational capabilities based on distance, route complexity, and weather forecasts.

Weather conditions emerge as another powerful determinant of delivery performance. Stormy and rainy conditions more than double the delay rate compared to clear conditions. Proactive measures such as dynamic route adjustment, pre-positioning of inventory, and weather-triggered delivery rescheduling can significantly reduce weather-induced delays.

The study also highlights a stark relationship between delivery delays and customer satisfaction. A delayed delivery causes the average customer rating to fall from 4.21 to 2.18, a drop of nearly 2 full points on a 5-point scale. In an era where online reviews and ratings directly influence consumer purchasing decisions, this finding underscores the business imperative of treating delay reduction as a top strategic priority.

While regional variation in delays is minimal, the performance gap between delivery partners suggests that operational best practices are not uniformly applied across the industry. Partners like Delhivery and FedEx, with lower delay rates, can serve as benchmarks for improving the performance of underperforming partners such as Xpressbees and Ekart.

In conclusion, reducing delivery delays in urban logistics requires a multi-pronged approach: realistic delivery mode commitments, weather-responsive operational planning, performance-based partner accountability, and priority handling for time-sensitive package categories. Organizations that systematically address these factors through data-driven decision-making will be better positioned to deliver superior customer experiences and achieve sustainable competitive advantage in the urban logistics sector.

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9. ANNEXURE

1) Dataset Variables Used in Study

Variable	Description	Type
delivery_id	Unique identifier for each delivery	Numeric
delivery_partner	Name of the logistics partner	Categorical
package_type	Type of goods being delivered	Categorical
vehicle_type	Vehicle used for delivery	Categorical
delivery_mode	Speed category of delivery	Categorical
region	Geographic delivery zone	Categorical
weather_condition	Weather at time of delivery	Categorical
distance_km	Distance of delivery route (km)	Numeric
package_weight_kg	Weight of the package (kg)	Numeric
delayed	Whether delivery was delayed (yes/no)	Binary
delivery_status	Final status (delivered/delayed/failed)	Categorical
delivery_rating	Customer rating (1-5)	Numeric

delivery_cost	Cost of delivery (INR)	Numeric
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2) Tools Used

- Python (Pandas, Matplotlib) – for data analysis and chart generation
- Excel – for cross-tabulation and basic statistics
- Descriptive statistics – for frequency and percentage analysis

3) Key Metrics Summary

Metric	Value
Total Delivery Records Analyzed	25,000
Overall Delay Rate	26.7%
Highest Delay by Weather	Stormy (41.4%)
Highest Delay by Delivery Mode	Express (73.8%)
Best Performing Partner	Delhivery (24.8%)
Worst Performing Partner	Xpressbees (28.3%)
Avg. Rating - On-Time Delivery	4.21 / 5
Avg. Rating - Delayed Delivery	2.18 / 5
Highest Delay by Package Type	Pharmacy (27.5%)
Most Uniform Factor	Vehicle Type (26.1% - 27.0%)