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The Final Mile Maze: Optimising Delivery Networks in High-Density Urban Hubs: An Empirical Study of Urban E-Commerce Delivery Users and Logistics Stakeholders

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ABSTRACT

Last-mile delivery in high-density urban hubs is among the most costly and least efficient stages of the e-commerce supply chain. This study examines how urban e-commerce delivery users and logistics stakeholders perceive the challenges of last-mile delivery and the value of delivery network optimisation. A structured questionnaire covering five objectives (delivery challenges, route optimisation, technology, customer satisfaction and optimisation strategies) was analysed for 50 respondents. Percentages, means, standard deviations and bar charts were used to profile respondents and summarise perceptions. A Chi-square test examined the association between delivery frequency and frequent traffic-related delays, and one-way ANOVA compared the perceived importance of route optimisation across groups defined by perceived delivery difficulty. Traffic congestion (44.0%) and high delivery density (30.0%) were the greatest challenges, and 74.0% of respondents rated last-mile delivery difficulty as high or very high. Route optimisation ($M = 3.82$) and real-time traffic information ($M = 4.00$) were rated important. Neither inferential test was statistically significant ($\chi^2 = 1.282$, $p = 0.258$; $F = 0.377$, $p = 0.688$), indicating that support for optimisation is broad-based rather than confined to particular respondent groups. Responses for the technology, satisfaction and strategy sections (Objectives 3–5) are illustrative and are reported to demonstrate the complete research process.

Keywords: Last-Mile Delivery; Urban Logistics; Route Optimisation; Delivery Network Optimisation; E-Commerce; High-Density Urban Hubs; Customer Satisfaction; Chi-Square; ANOVA.

1. Introduction

The rapid growth of e-commerce has increased parcel volumes, delivery-time expectations and pressure on city streets. Last-mile logistics, the final leg that moves goods from a distribution point to the customer, is widely described as the most expensive and least efficient part of the supply chain, and it creates significant economic, environmental and social impacts in urban areas (Bosona, 2020; Silva, Amaral, & Fontes, 2023). In high-density urban hubs these pressures are amplified by traffic congestion, restricted parking, concentrated delivery points, uneven road infrastructure and unreliable addresses.

Researchers and practitioners have proposed many responses, including route optimisation, real-time traffic information, GPS and AI-based planning, local delivery hubs, parcel lockers, cargo bikes and electric vehicles (Boysen, Fedtke, & Schwerdfeger, 2021). However, no single solution can meet every sustainability and service requirement, and combining solutions requires an understanding of how delivery users and logistics stakeholders actually experience the problem (Silva et al., 2023). The present article therefore asks a practical question: what do urban delivery users and logistics stakeholders regard as the main challenges of last-mile delivery in high-density hubs, and which optimisation measures do they consider most promising?

2. Review of Literature

reviewed 42 peer-reviewed studies on urban freight last-mile logistics and identified population growth, urbanisation, globalisation and e-commerce expansion as the main drivers of rising freight flows. The study found that light cargo vehicles and cargo-bike delivery can be attractive alternatives when delivery failures are minimised, while technological, infrastructural, management, system-related and cost challenges reduce efficiency.

surveyed established and emerging last-mile delivery concepts from an operational research perspective. They showed that cargo bikes, parcel lockers, drones and delivery robots can ease congestion, pollution and cost pressures, but also bring operational complexity, tight time requirements, workforce limitations and a possible loss of human interaction.

reviewed 87 studies published between 2014 and 2021 and showed that sustainable last-mile delivery depends on logistics operations, technology, consumers, public authorities and the characteristics of delivery systems. They concluded that logistics providers must differentiate delivery approaches, for example between one-person and two-person deliveries, and that stakeholder coordination remains a major challenge.

reviewed 102 studies and grouped 14 sustainability solutions into vehicular, operational and organisational categories. Their central conclusion was that no single last-mile solution satisfies all sustainability requirements, so combining solutions and strengthening collaboration among stakeholders with conflicting interests is necessary.

conducted a systematic review and bibliometric analysis of two decades of research on last-mile e-commerce delivery in urban areas. They reported environmental, economic, social, technological and spatial impacts, and noted that the spatial effects of e-commerce delivery and its integration with urban planning remain insufficiently studied.

examined green logistics in developing countries, covering implementation patterns, barriers and performance outcomes. The study found that sustainable transport, warehousing, packaging, reverse logistics and technologies such as AI, IoT and blockchain can reduce emissions and costs, but financial, infrastructural, institutional and technological barriers, especially for SMEs, require coordinated support.

analysed research trends, development stages and hotspots in the application of artificial intelligence to urban planning. They found rapid growth in machine learning, deep learning and smart-city applications, led by China, the United States and India, and expected generative and explainable AI to become important future directions for efficient and sustainable urban development.

compared centralised and decentralised financing of essential medicines and health supplies across supply-chain functions. Functions needing scale and technical expertise generally benefit from national management, whereas ordering and last-mile distribution can benefit from decentralisation when institutional capacity exists. The authors recommended hybrid arrangements matched to function and capacity.

3. Research Gap

Although research on last-mile logistics is expanding quickly, three gaps remain relevant for an empirical study. First, most reviews examine individual solutions such as alternative vehicles, parcel lockers, routing systems or delivery models, while the integration of several solutions that address environmental, economic and social sustainability together receives less attention. Second, the perspectives of logistics providers, consumers and public authorities are usually studied separately, even though their conflicting objectives influence whether optimisation measures succeed. Third, emerging technologies such as AI, IoT and real-time tracking require more empirical evidence on accessibility and practical implementation, particularly in developing economies and among smaller firms. Accordingly, the present study collects the perceptions of delivery users and logistics stakeholders on challenges, route optimisation, technology, customer satisfaction and optimisation strategies in a single integrated framework for high-density urban hubs.

4. Objectives of the Study

The main objective of the study is to examine the role of delivery network optimisation in improving last-mile delivery efficiency and sustainability in high-density urban hubs. The specific objectives are:

1. To identify the major challenges affecting last-mile delivery in high-density urban areas.
2. To examine the impact of delivery network optimisation on delivery efficiency.
3. To assess the role of technology in improving last-mile delivery.
4. To examine customer satisfaction with last-mile delivery services.
5. To evaluate strategies for optimising last-mile delivery networks in high-density urban hubs.

5. Conceptual Framework of the Study

The framework assumes that last-mile delivery in high-density urban hubs is shaped by five challenges: traffic congestion, parking and vehicle restrictions, high delivery density, poor road infrastructure and incorrect or incomplete addresses (Objective 1). Delivery network optimisation, comprising route optimisation and real-time traffic information (Objective 2), technology such as GPS, AI, real-time tracking and data analytics (Objective 3), and network strategies such as local delivery hubs, parcel lockers and electric vehicles (Objective 5), is expected to respond to these challenges and improve delivery efficiency and customer satisfaction (Objective 4). Respondent profile and e-commerce usage characteristics are treated as contextual factors.

Conceptual Framework of the Study

The Final Mile Maze: Optimising Delivery Networks in High-Density Urban Hubs

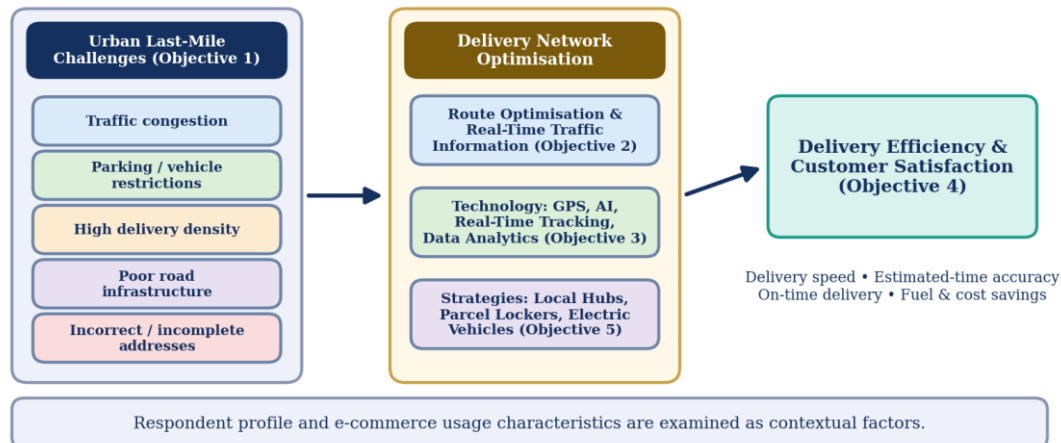


Figure 1. Conceptual Framework of the Study

6. Hypotheses of the Study

Two pairs of hypotheses are tested using questionnaire items for which complete responses are available (Questions 1–15).

H0¹: There is no significant association between the frequency of receiving e-commerce deliveries (lower versus higher) and the frequency of traffic-related delivery delays experienced (frequent versus not frequent).

H1¹: There is a significant association between the frequency of receiving e-commerce deliveries and the frequency of traffic-related delivery delays experienced.

H0²: There is no significant difference in the mean perceived importance of route optimisation across respondent groups defined by perceived difficulty of last-mile delivery (low–moderate, high and very high).

H1²: There is a significant difference in the mean perceived importance of route optimisation across the low–moderate, high and very high perceived-difficulty groups.

7. Research Methodology

Research methodology refers to the systematic plan used to answer the research questions and test the hypotheses. In this study it covers the research approach, research design, population, sample, sampling technique, data source, measurement, analytical tools and ethical considerations.

7.1 Research Approach

A quantitative approach is adopted because the study expresses perceptions numerically and uses statistical techniques to examine patterns, associations and group differences.

7.2 Research Design

The study follows a descriptive and analytical, cross-sectional research design. The descriptive component summarises respondent characteristics and perceptions under each objective; the analytical component tests the proposed hypotheses using the Chi-square test and one-way ANOVA.

7.3 Population of the Study

The conceptual target population consists of people who receive e-commerce deliveries in, or work in the delivery of goods to, high-density urban areas. The dataset represents students, salaried employees, business owners/entrepreneurs and delivery/logistics professionals across five age groups.

7.4 Sample of the Study

The sample consists of 50 respondent records. The sample size is adequate for demonstrating descriptive analysis, cross-tabulation, Chi-square testing and one-way ANOVA, but it is small for generalisation. Complete responses were available for Questions 1–15; responses for Questions 16–28 (Objectives 3–5) are illustrative and were generated to demonstrate the full analytical process (see Data Note in Section 8.4 and Section 12).

7.5 Sampling Technique

A non-probability convenience-sampling approach is assumed. In a publishable field study, the researcher should define the sampling frame and, wherever feasible, use probability or stratified sampling to improve representativeness.

7.6 Sources and Instrument of Data Collection

Primary data were collected through a structured questionnaire of 28 closed-ended questions: Section A (Questions 1–7) captures respondent profile and e-commerce usage, and Section B (Questions 8–28) contains objective-based questions arranged under the five study objectives. Most items use a five-point scale coded 1 (lowest/most negative) to 5 (highest/most positive). Secondary data were drawn from peer-reviewed journal articles and policy papers used in the literature review.

7.7 Variables and Measurement

Table 1 summarises the questionnaire structure and the variables measured. For each objective, a composite index was computed as the mean of the related five-point items, so that every index ranges from 1 (lowest) to 5 (highest). For an actual journal submission, multi-item validated scales should be used and reliability (for example Cronbach's alpha) and construct validity should be reported.

Section / Objective	Questions	Variables measured	Scale / composite index
Section A: Respondent profile	Q1–Q7	Age group, gender, education, occupation, delivery frequency, online platform use, length of use	Categorical
Objective 1: Challenges	Q8–Q11	Overall difficulty (Q8), greatest challenge (Q9), effect of traffic on delivery time (Q10), frequency of traffic delays (Q11)	Five-point; Q9 categorical; Last-Mile Challenge Index (Q8, Q10, Q11)
Objective 2: Network optimisation and efficiency	Q12–Q15	Importance of route optimisation, effectiveness of optimised routes, fuel reduction, importance of real-time traffic information	Five-point; Route Optimisation Index (Q12–Q15)
Objective 3: Role of technology	Q16–Q19	Importance of technology, technology contributing most (Q17), effectiveness of real-time tracking, AI route planning	Five-point; Q17 categorical; Technology Role Index (Q16, Q18, Q19)
Objective 4: Customer satisfaction	Q20–Q23	Satisfaction with speed, accuracy of estimated times, importance of on-time delivery, delays affecting satisfaction	Five-point; Delivery Satisfaction Index (Q20, Q21)
Objective 5: Optimisation strategies	Q24–Q28	Most effective strategy (Q24), local hubs, parcel lockers, eco-friendly vehicles, overall effectiveness	Five-point; Q24 categorical; Network Strategy Index (Q25–Q28)

Table 1. Objective-wise Questionnaire Structure and Measurement

7.8 Statistical Tools Used

Percentages, mean, median, standard deviation, minimum and maximum are used for descriptive analysis. Bar charts and stacked bar charts provide visual summaries. The Chi-square test of independence (Pearson, with the continuity-corrected value as a check and the phi coefficient as an effect size) is used for categorical association, and one-way ANOVA (with eta-squared as an effect size, Levene's test for equality of variances and the Kruskal–Wallis test as a robustness check) is used to compare mean scores across three groups. A 5% level of significance is used. Calculations were performed in Python (SciPy).

7.9 Ethical Considerations

A real study should obtain informed consent, protect respondent confidentiality, avoid collecting unnecessary personally identifiable information and explain that responses will be used only for academic purposes. In this study respondent names were not used in the analysis and are not reported.

8. Data Analysis and Interpretation

This section analyses 50 respondent records. Responses were coded on the questionnaire's five-point scale (1 = lowest/most negative, 5 = highest/most positive). Sections 8.1 to 8.3 use the collected responses; Sections 8.4 to 8.6 use illustrative responses (see Data Note); Section 8.7 summarises composite indices and Section 8.8 tests the hypotheses.

8.1 Respondent Profile

Variable	Category	Frequency	Percentage
Age group	Below 20 years	8	16.0%
	20–29 years	14	28.0%
	30–39 years	12	24.0%
	40–49 years	11	22.0%
	50 years and above	5	10.0%
Gender	Male	20	40.0%
	Female	28	56.0%
	Prefer not to say	2	4.0%
Highest level of education	School level	3	6.0%
	Undergraduate	21	42.0%
	Postgraduate	14	28.0%
	Diploma/Professional qualification	12	24.0%
Occupation	Student	15	30.0%
	Salaried employee	21	42.0%
	Business owner/Entrepreneur	7	14.0%
	Delivery/logistics professional	7	14.0%

Table 2. Demographic Profile of Respondents (N = 50)

Interpretation: Age: the 20–29 years group is the largest (28.0%), followed by 30–39 (24.0%) and 40–49 (22.0%); only 10.0% are 50 or above, so the sample mainly reflects young and middle-aged digital consumers. Gender: female respondents form the majority (56.0%), followed by male (40.0%), and 4.0% preferred not to say. Education: undergraduates are the largest group (42.0%), followed by postgraduates (28.0%) and diploma/professional holders (24.0%), so the sample is predominantly well educated. Occupation: salaried employees (42.0%) and students (30.0%) together make up 72.0%, while business owners and delivery/logistics professionals each represent 14.0%, adding an operator's viewpoint to a largely consumer sample.

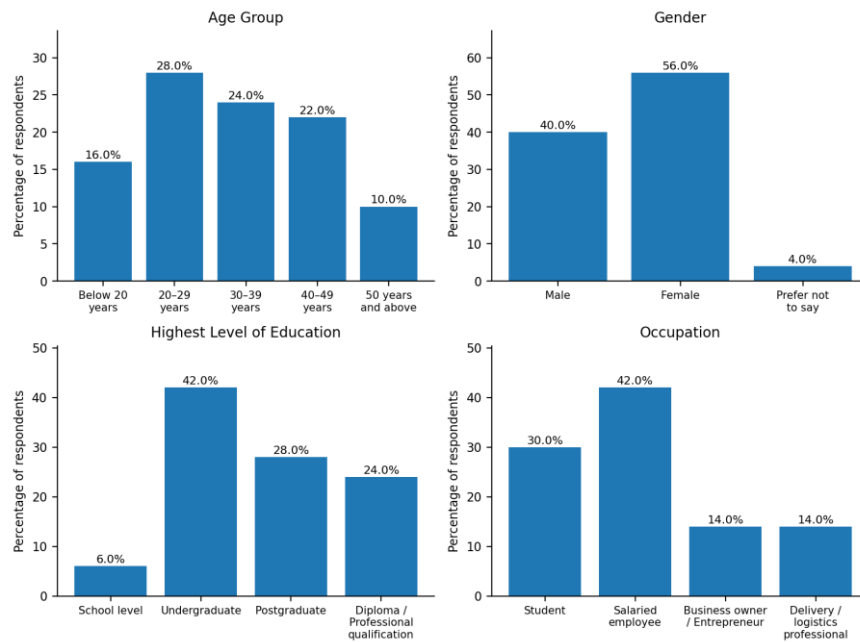


Figure 2. Respondent Profile: Age, Gender, Education and Occupation

Variable	Category	Frequency	Percentage
Delivery frequency	Rarely	1	2.0%
	Once a month	6	12.0%
	2–3 times a month	18	36.0%
	4–6 times a month	18	36.0%
	More than 6 times a month	7	14.0%
Online shopping platform use	Rarely	5	10.0%
	Occasionally	3	6.0%
	Sometimes	14	28.0%
	Frequently	17	34.0%
	Very frequently	11	22.0%
Length of using delivery services	Less than 1 year	9	18.0%
	1–2 years	11	22.0%
	3–5 years	16	32.0%
	More than 5 years	14	28.0%

Table 3. E-Commerce Usage Profile of Respondents

Interpretation: 86.0% of respondents receive e-commerce deliveries at least two to three times a month (including 14.0% who receive more than six a month), and only 2.0% receive them rarely. 56.0% use online shopping platforms frequently or very frequently, and 60.0% have used delivery services for three years or more. Respondents are therefore experienced, regular users of last-mile delivery and well placed to comment on it.



Figure 3. E-Commerce Usage Profile of Respondents

8.2 Objective 1: Challenges Affecting Last-Mile Delivery

Greatest Challenge	Frequency	Percentage
Traffic congestion	22	44.0%
High delivery density	15	30.0%
Parking/vehicle restrictions	7	14.0%
Poor road infrastructure	3	6.0%
Incorrect/incomplete addresses	3	6.0%
Total	50	100.0%

Table 4. Greatest Challenge for Last-Mile Delivery in High-Density Urban Areas

Interpretation: Traffic congestion is regarded as the greatest challenge (44.0%), followed by high delivery density (30.0%); together they account for 74.0% of responses. Parking/vehicle restrictions are chosen by 14.0%, while poor road infrastructure and incorrect/incomplete addresses are each chosen by 6.0%. Respondents therefore see the density and traffic of the urban environment as a bigger obstacle than road quality or address problems.

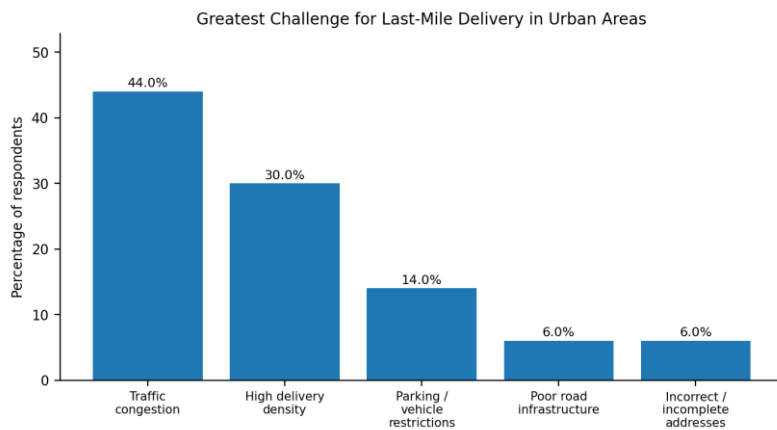


Figure 4. Greatest Challenge for Last-Mile Delivery in High-Density Urban Areas

Item	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Mean	SD	High (4-5)
Overall difficulty of last-mile delivery (Q8)	4.0	4.0	18.0	44.0	30.0	3.92	1.01	74.0%
Effect of traffic congestion on delivery time (Q10)	6.0	8.0	20.0	44.0	22.0	3.68	1.10	66.0%
Frequency of traffic-related delays (Q11)	4.0	14.0	34.0	28.0	20.0	3.46	1.09	48.0%

Table 5. Perceptions of Last-Mile Delivery Challenges (Objective 1)

Note: Scale anchors vary by item (1 = Very low/Not at all/Never ... 5 = Very high/Extremely/Always). High (4–5) is the combined percentage of the top two categories. N = 50.

Interpretation: Overall difficulty of last-mile delivery has a mean of 3.92 (SD = 1.01), with 74.0% rating it high or very high and only 8.0% rating it low or very low. Traffic congestion is perceived to affect delivery time significantly or extremely by 66.0% (M = 3.68). Actual experience of traffic-related delays is more mixed (M = 3.46): 48.0% report delays often or always and 34.0% sometimes. Respondents perceive last-mile delivery in dense areas as demanding and see traffic as a significant cause, although personal experience of delays varies more than the general perception of difficulty.

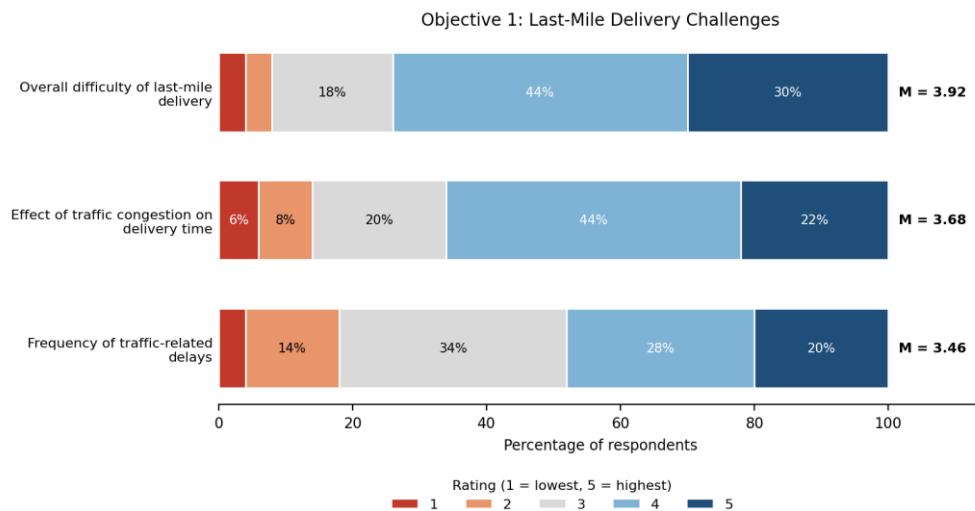


Figure 5. Perceptions of Last-Mile Delivery Challenges (Objective 1)

8.3 Objective 2: Impact of Delivery Network Optimisation on Efficiency

Item	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Mean	SD	High (4–5)
Importance of route optimisation (Q12)	2.0	12.0	18.0	38.0	30.0	3.82	1.06	68.0%
Effectiveness of optimised routes in reducing time (Q13)	0.0	10.0	22.0	42.0	26.0	3.84	0.93	68.0%
Extent route optimisation reduces fuel use (Q14)	6.0	4.0	32.0	36.0	22.0	3.64	1.06	58.0%
Importance of real-time traffic information (Q15)	0.0	4.0	24.0	40.0	32.0	4.00	0.86	72.0%

Table 6. Perceptions of Delivery Network Optimisation and Efficiency (Objective 2)

Note: Scale anchors vary by item (1 = Not important/Very ineffective/Not at all ... 5 = Very important/Very effective/To a very large extent). N = 50.

Interpretation: Route optimisation is considered important (M = 3.82; 68.0% important or very important) and effective in reducing delivery time (M = 3.84; 68.0% effective or very effective, with no respondent choosing very ineffective). Real-time traffic information receives the highest mean in this objective (M = 4.00; 72.0% important or very important; none rated it not important). Fuel savings from route optimisation are rated somewhat lower (M = 3.64; 58.0% to a large or very large extent, while 6.0% said not at all). Overall, respondents support route optimisation, particularly when it uses live traffic data.

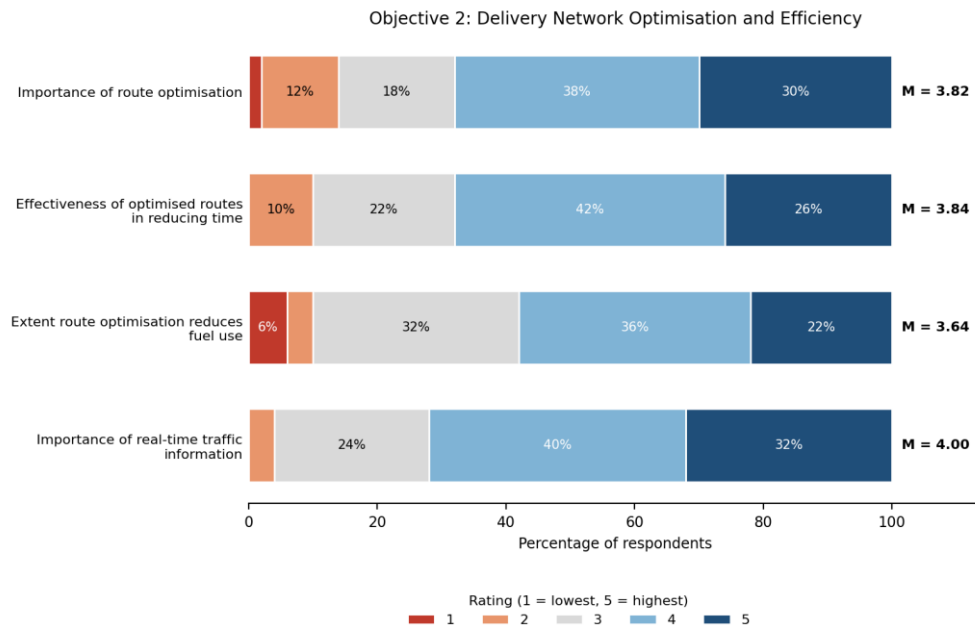


Figure 6. Perceptions of Delivery Network Optimisation and Efficiency (Objective 2)

8.4 Objective 3: Role of Technology in Last-Mile Delivery

Data note: The responses analysed in Sections 8.4 to 8.6 (Questions 16–28) were not available in the response sheet supplied for this draft and are illustrative. They were generated with a seeded random procedure with plausible, positively skewed distributions and a modest link to each respondent's own answers to Questions 1–15. Tables and figures based on them are labelled “Illustrative Responses”, and no hypothesis test in this article uses them. They must be replaced with actual field data before submission.

Technology Contributing Most	Frequency	Percentage
GPS and route optimisation	16	32.0%
Artificial Intelligence (AI)	10	20.0%
Real-time tracking	13	26.0%
Automated delivery systems	5	10.0%
Data analytics	6	12.0%
Total	50	100.0%

Table 7. Technology Contributing Most to Efficient Last-Mile Delivery (Illustrative Responses)

Interpretation: GPS and route optimisation (32.0%) and real-time tracking (26.0%) are the technologies most often named, followed by artificial intelligence (20.0%), data analytics (12.0%) and automated delivery systems (10.0%). In the illustrative data, established, widely available tools are preferred over newer automated systems.

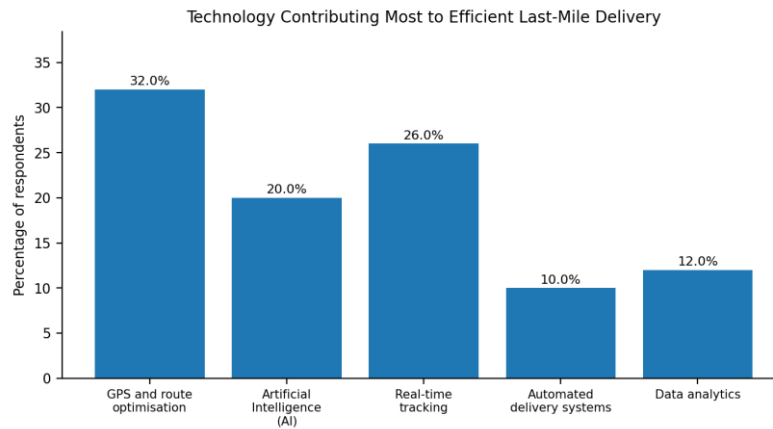


Figure 7. Technology Contributing Most to Efficient Last-Mile Delivery (Illustrative Responses)

Item	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Mean	SD	High (4-5)
Importance of technology in urban delivery (Q16)	0.0	4.0	6.0	40.0	50.0	4.36	0.78	90.0%
Effectiveness of real-time tracking for satisfaction (Q18)	0.0	4.0	22.0	46.0	28.0	3.98	0.82	74.0%
Extent AI-based route planning improves efficiency (Q19)	6.0	8.0	14.0	32.0	40.0	3.92	1.19	72.0%

Table 8. Perceptions of the Role of Technology (Objective 3, Illustrative Responses)

Interpretation: Technology is rated very important for improving urban delivery operations ($M = 4.36$; 90.0% important or very important). Real-time tracking is seen as effective for customer satisfaction ($M = 3.98$; 74.0%), and AI-based route planning is expected to improve efficiency to a large or very large extent by 72.0% ($M = 3.92$), although this item shows the widest spread ($SD = 1.19$).

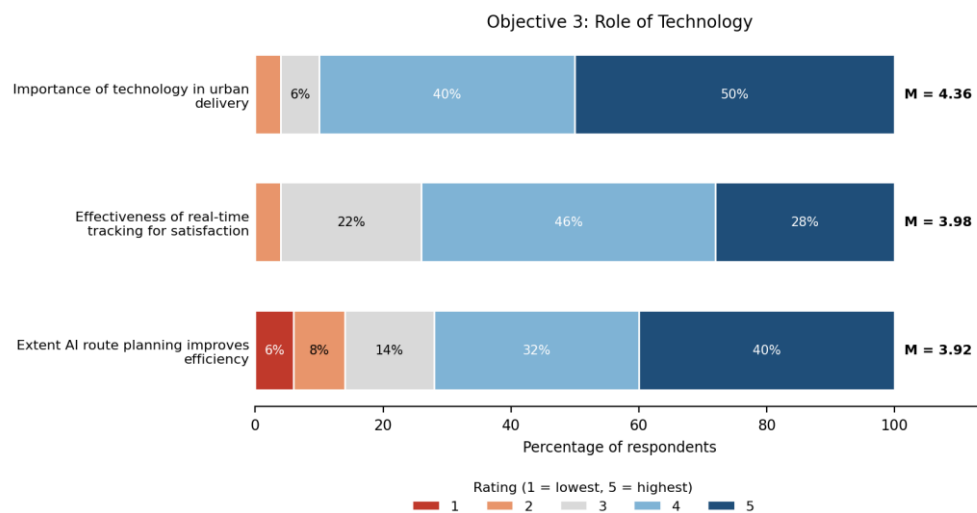


Figure 8. Perceptions of the Role of Technology (Objective 3, Illustrative Responses)

8.5 Objective 4: Customer Satisfaction with Last-Mile Delivery

Item	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Mean	SD	High (4-5)
Satisfaction with delivery speed (Q20)	8.0	12.0	24.0	38.0	18.0	3.46	1.16	56.0%
Satisfaction with accuracy of estimated delivery times (Q21)	6.0	20.0	26.0	34.0	14.0	3.30	1.13	48.0%

Item	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Mean	SD	High (4–5)
Importance of on-time delivery to satisfaction (Q22)	0.0	4.0	8.0	36.0	52.0	4.36	0.80	88.0%
Frequency of delays affecting satisfaction (Q23)	4.0	6.0	42.0	38.0	10.0	3.44	0.91	48.0%

Table 9. Perceptions of Customer Satisfaction with Last-Mile Delivery (Objective 4, Illustrative Responses)

Interpretation: Satisfaction is moderate: 56.0% are satisfied or very satisfied with delivery speed ($M = 3.46$) and 48.0% with the accuracy of estimated delivery times ($M = 3.30$). By contrast, on-time delivery is rated highly important to overall satisfaction ($M = 4.36$; 88.0%), and 48.0% say delays often or always affect their satisfaction with an e-commerce company ($M = 3.44$). The gap between the importance attached to on-time delivery and the satisfaction reported with speed and time estimates indicates room for improvement, especially in the accuracy of delivery-time estimates.



Figure 9. Perceptions of Customer Satisfaction with Last-Mile Delivery (Objective 4, Illustrative Responses)

8.6 Objective 5: Strategies for Optimising Last-Mile Delivery Networks

Most Effective Strategy	Frequency	Percentage
Route optimisation	11	22.0%
Local delivery hubs	10	20.0%
Parcel lockers/pick-up points	7	14.0%
Electric delivery vehicles	5	10.0%
Better traffic management	17	34.0%
Total	50	100.0%

Table 10. Most Effective Strategy for Improving Urban Last-Mile Delivery (Illustrative Responses)

Interpretation: Better traffic management is chosen most often (34.0%), followed by route optimisation (22.0%), local delivery hubs (20.0%), parcel lockers/pick-up points (14.0%) and electric delivery vehicles (10.0%). In the illustrative data, measures that relieve traffic and improve routing are preferred over fleet-level changes.

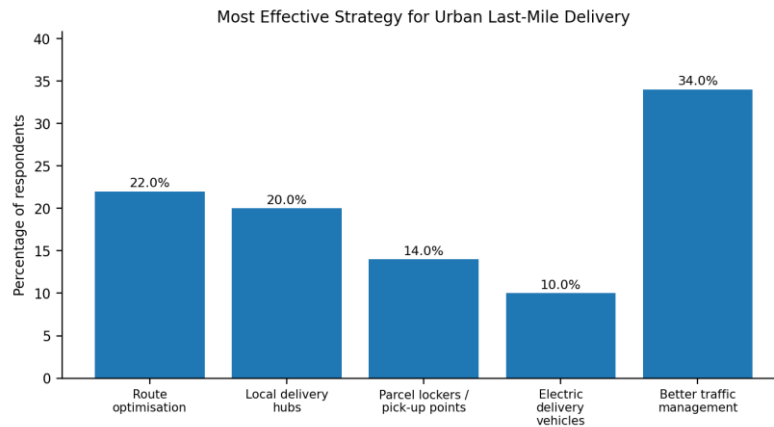


Figure 10. Most Effective Strategy for Improving Urban Last-Mile Delivery (Illustrative Responses)

Item	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Mean	SD	High (4-5)
Effectiveness of local delivery hubs (Q25)	4.0	2.0	24.0	36.0	34.0	3.94	1.02	70.0%
Usefulness of parcel lockers/collection points (Q26)	0.0	18.0	18.0	38.0	26.0	3.72	1.05	64.0%
Importance of environmentally friendly vehicles (Q27)	2.0	22.0	18.0	38.0	20.0	3.52	1.11	58.0%
Overall effectiveness of network optimisation (Q28)	0.0	2.0	16.0	32.0	50.0	4.30	0.81	82.0%

Table 11. Perceptions of Optimisation Strategies (Objective 5, Illustrative Responses)

Interpretation: Local delivery hubs are rated effective in reducing delivery distances ($M = 3.94$; 70.0%), followed by parcel lockers/collection points ($M = 3.72$; 64.0%) and environmentally friendly vehicles ($M = 3.52$; 58.0%). Overall effectiveness of delivery network optimisation receives the highest mean ($M = 4.30$; 82.0% effective or very effective), suggesting a favourable overall view of combining several measures.

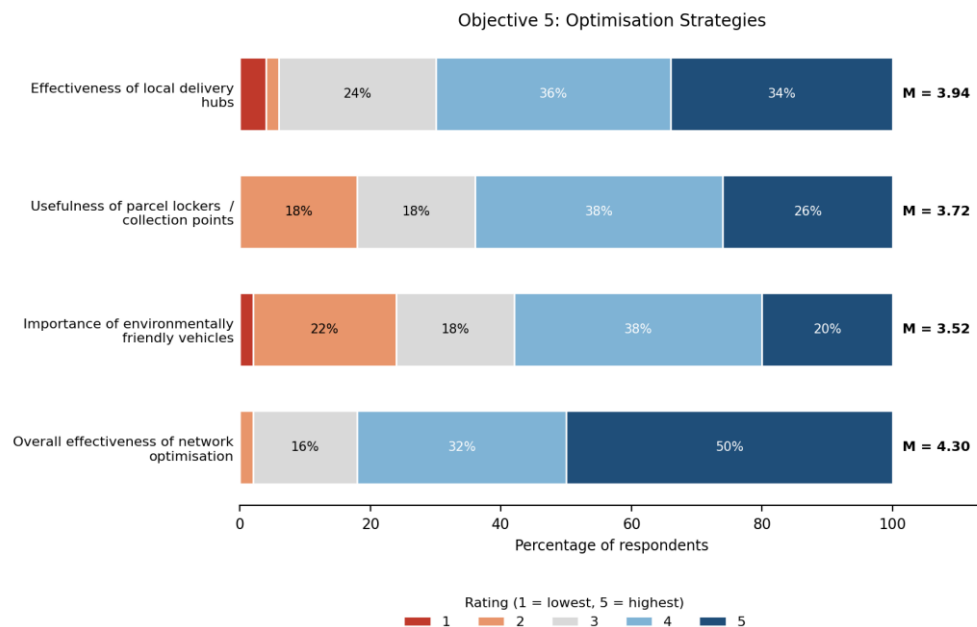


Figure 11. Perceptions of Optimisation Strategies (Objective 5, Illustrative Responses)

8.7 Descriptive Statistics of Composite Indices

Composite Index	Mean	Median	Std. Deviation	Minimum	Maximum
Last-Mile Challenge Index (Q8, Q10, Q11)	3.687	4.000	0.615	2.33	4.67
Route Optimisation Index (Q12–Q15)	3.825	3.750	0.455	2.75	5.00
Technology Role Index (Q16, Q18, Q19)	4.087	4.000	0.529	2.67	5.00
Delivery Satisfaction Index (Q20, Q21)	3.380	3.500	0.812	1.50	4.50
Network Strategy Index (Q25–Q28)	3.870	3.750	0.533	2.75	5.00

Table 12. Descriptive Statistics of Composite Indices (Indices for Objectives 3–5 Use Illustrative Responses)

Interpretation: All indices lie above the neutral point of 3.0. The Technology Role Index has the highest mean (4.087), followed by the Network Strategy Index (3.870), the Route Optimisation Index (3.825) and the Last-Mile Challenge Index (3.687). The Delivery Satisfaction Index is the lowest (M = 3.380) and has the widest dispersion (SD = 0.812), indicating that satisfaction is the least settled dimension while support for optimisation measures is consistently positive.

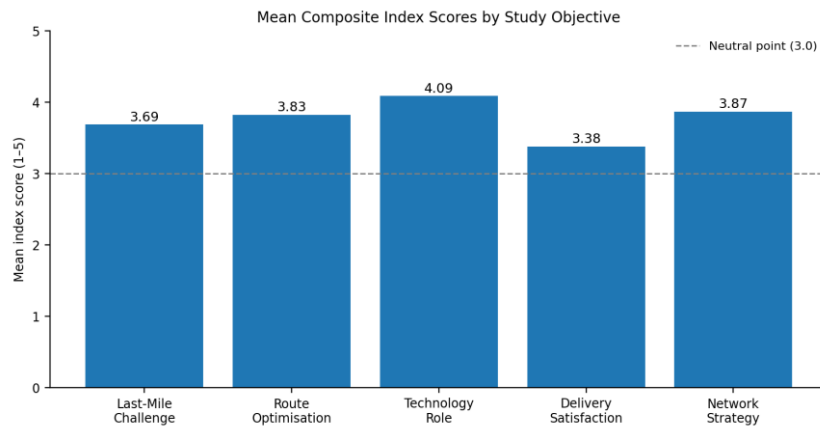


Figure 12. Mean Composite Index Scores by Study Objective

8.8 Hypothesis Testing

Hypothesis 1 (Chi-square test). Delivery frequency was grouped as lower (rarely, once a month, 2–3 times a month; n = 25) and higher (4–6 or more than 6 times a month; n = 25). Frequent traffic delays were defined as reporting delays often or always.

Delivery Frequency	Not Frequent Delays (Never/Rarely/Sometimes)	Frequent Delays (Often/Always)	Row Total
Low (up to 3 per month)	15	10	25
High (4 or more per month)	11	14	25
Column Total	26	24	50

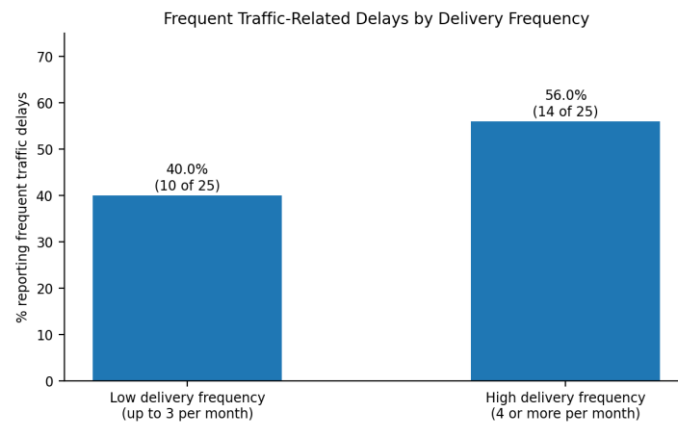
Table 13. Cross-Tabulation: Delivery Frequency and Frequent Traffic-Related Delays

Statistic	Value
Chi-square (χ^2)	1.282
Degrees of freedom	1
p-value	0.2575
Continuity-corrected χ^2 (p-value)	0.721 (0.3958)

Statistic	Value
Phi coefficient (effect size)	0.160
Minimum expected cell count	12.0
Decision at 5% level	Do not reject H ₀

Table 14. Chi-Square Test Results

Interpretation: Among respondents receiving deliveries up to three times a month, 40.0% (10 of 25) report frequent traffic delays, compared with 56.0% (14 of 25) of those receiving four or more deliveries a month. The direction suggests heavier users meet delays more often, but the Chi-square statistic is $\chi^2 = 1.282$ with 1 degree of freedom and $p = 0.2575$. Because the p-value is above 0.05, the null hypothesis is not rejected. The continuity-corrected test gives the same conclusion ($p = 0.3958$), the effect size is small ($\phi = 0.16$), and all expected counts exceed 5. In this sample, delivery frequency is not significantly associated with frequent traffic-related delays, which is consistent with congestion being experienced across user groups.

**Figure 13. Frequent Traffic Delays by Delivery Frequency Group**

Hypothesis 2 (One-way ANOVA). Respondents were grouped by perceived difficulty of last-mile delivery (Question 8) into low-moderate (very low, low or moderate), high and very high groups, and the mean importance of route optimisation (Question 12) was compared.

Perceived Difficulty Group	N	Mean Importance of Route Optimisation	Std. Deviation
Low-Moderate	13	4.000	1.080
High	22	3.682	0.839
Very high	15	3.867	1.356

Table 15. Group Descriptives for One-Way ANOVA

Source	Sum of Squares	df	Mean Square	F	p-value
Between Groups	0.874	2	0.437	0.377	0.6881
Within Groups	54.506	47	1.160	—	—
Total	55.380	49	—	—	—

Table 16. One-Way ANOVA: Importance of Route Optimisation by Perceived Difficulty Group

Interpretation: One-way ANOVA produces $F(2, 47) = 0.377$, $p = 0.6881$. The p-value is above 0.05; therefore H₀₂ is not rejected. Mean importance scores are 4.00 (low-moderate), 3.68 (high) and 3.87 (very high), with no systematic pattern, and group membership explains only 1.6% of the variance ($\eta^2 = 0.016$). Levene's test ($p = 0.156$) supports equal variances, and the Kruskal-Wallis test agrees ($H = 1.785$, $p = 0.409$). Respondents regard route optimisation as important regardless of how difficult they perceive last-mile delivery to be, so support is broad-based rather than concentrated among those who perceive the greatest difficulty. The group sizes (13, 22 and 15) are small, so a larger sample is advisable before drawing firm conclusions.

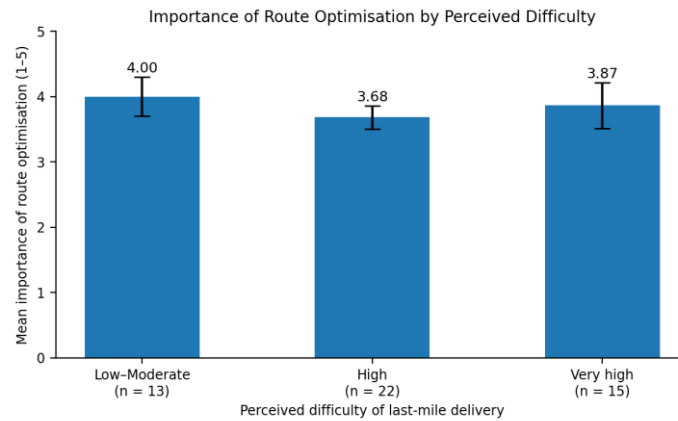


Figure 14. Mean Importance of Route Optimisation by Perceived Difficulty Group

9. Major Findings

- Respondents are mainly young and middle-aged regular users: 74.0% are aged 20–49 years, and 86.0% receive e-commerce deliveries at least two to three times a month.
- Traffic congestion (44.0%) and high delivery density (30.0%) are the two greatest challenges for last-mile delivery in high-density urban areas.
- 74.0% of respondents rate the overall difficulty of last-mile delivery as high or very high ($M = 3.92$), and 66.0% say traffic congestion affects delivery time significantly or extremely.
- Route optimisation is considered important ($M = 3.82$) and effective in reducing delivery time ($M = 3.84$); real-time traffic information is rated highest in this objective ($M = 4.00$).
- The Chi-square test shows no statistically significant association between delivery frequency and frequent traffic-related delays ($p = 0.2575$).
- The one-way ANOVA shows no statistically significant difference in the importance of route optimisation across perceived-difficulty groups ($p = 0.6881$).
- Illustrative responses indicate that technology is rated very important ($M = 4.36$), that GPS-based route optimisation (32.0%) and real-time tracking (26.0%) are the most favoured technologies, and that on-time delivery matters more ($M = 4.36$) than current satisfaction with delivery speed ($M = 3.46$) and time estimates ($M = 3.30$).
- Illustrative responses also indicate that better traffic management (34.0%) is the most preferred strategy and that overall delivery network optimisation is rated highly effective ($M = 4.30$).
- Taken together, the results point to a broad consensus on the value of route optimisation and traffic-aware delivery planning, shared across respondent groups, rather than to group-specific differences.

10. Findings & Suggestions

Based on the findings, the following suggestions are offered for logistics providers, e-commerce companies and city authorities:

1. Adopt congestion-aware, dynamic route optimisation that uses real-time traffic information, because traffic congestion is the most frequently cited challenge and real-time traffic information is rated most important within the route-optimisation items.
2. Reduce delivery density on the final leg through local delivery hubs or micro-distribution points and consolidated delivery rounds, so that vehicles travel shorter distances inside dense areas.
3. Introduce parcel lockers and designated collection points in dense residential and commercial clusters to reduce failed and repeated delivery attempts and kerbside parking demand.
4. Coordinate with city authorities on traffic management, kerb-space allocation and delivery time windows, since parking and vehicle restrictions and traffic conditions are major operating constraints.
5. Improve address quality through address validation and geocoding at checkout; although incorrect addresses were cited by fewer respondents, they are a low-cost problem to fix.

6. Improve the accuracy of estimated delivery times and share real-time tracking with customers, as satisfaction with time estimates is lower than the importance customers attach to on-time delivery.
7. Phase in electric and other low-emission vehicles, and pilot cargo bikes where delivery conditions suit them, alongside operational measures rather than as a substitute for them.
8. Track delivery time, fuel use, failed-delivery rates and customer satisfaction before and after each intervention to confirm that expected benefits are actually achieved.

11. Limitations and Scope for Future Research

The most important limitation is that responses for Questions 16–28 are illustrative, so the findings for Objectives 3–5 cannot be treated as empirical evidence until they are replaced with actual field data. In addition, the sample of 50 respondents is small and assumed to be a convenience sample, which limits generalisation and the statistical power of the hypothesis tests; the non-significant results should therefore not be read as evidence of no relationship. The study relies on single-item, self-reported perceptions rather than operational data such as delivery times, fuel consumption or failed-delivery counts, and it is cross-sectional.

A journal submission should collect original data from a clearly defined urban population using probability or stratified sampling, use validated multi-item scales with reliability and validity reported, and include larger groups for each analysis. Future research may combine perception data with operational data from delivery fleets, compare several cities, include carriers and city authorities as separate stakeholder groups, test models such as ordinal regression or structural equation modelling, and evaluate real pilots of local hubs, parcel lockers, electric vehicles and AI-based route planning over time.

12. Conclusion

This study demonstrates a complete research process for examining delivery network optimisation in high-density urban hubs. Respondents see last-mile delivery as difficult (74.0% high or very high) and identify traffic congestion and high delivery density as the main obstacles. Route optimisation and real-time traffic information are rated important, and the illustrative responses for technology, satisfaction and strategy sections are consistent with a favourable view of combining several optimisation measures. The two hypothesis tests did not find statistically significant differences or associations ($p = 0.258$ and $p = 0.688$), which suggests that support for optimisation does not depend on how often respondents receive deliveries or on how difficult they perceive delivery to be. The broader implication is that last-mile optimisation should be treated as an integrated effort combining traffic-aware routing, local network design, technology, better customer communication and coordination with city authorities. The article also shows how a research problem can be converted into objectives, hypotheses, a conceptual framework, methodology, data analysis, interpretations, findings and recommendations in a systematic journal-style format.

13. References

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Appendix A. Questionnaire Structure and Coding Scheme

Section A: Respondent profile and e-commerce usage (Q1–Q7): age group, gender, highest level of education, occupation, frequency of online/e-commerce deliveries, frequency of using online shopping platforms and length of using e-commerce delivery services.

Section B: Objective-based questions (Q8–Q28) arranged under the five study objectives, as summarised in Table 1.

Coding: Five-point items are coded 1 (strongly negative / very low) to 5 (strongly positive / very high), with 3 as neutral or moderate; categorical items (Q9, Q17 and Q24) are analysed as frequencies.