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ANALYSING THE ROLE OF TWO-WHEELER LOGISTICS IN OPTIMIZING LAST-MILE DELIVERY FOR E-COMMERCE IN BANGALORE

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ABSTRACT
The aim of the research was to assess the importance of using two-wheeler logistics to optimize last-mile delivery of e-commerce firms in Bangalore, India. The questionnaire survey was conducted in the form of a structured survey by administering it to 178 delivery executives and logistics personnel to whom major e-commerce and hyperlocal delivery platforms attracted through stratified sampling. The research used percentage analysis, Pearson correlation analysis, one sample t-tests and multiple regression analysis. Findings indicated that the respondents exhibited a fairly high perception of two-wheeler suitability (mean = 3.67) and overall delivery efficiency (mean = 3.61) on a five-point scale. Similarities in food safety attitude and behavior parallels were observed: the perception of speed of delivery was the most powerful factor in overall efficiency (r = 0.218, p < 0.01). The three hypotheses were accepted at the 1% level of significance: two-wheeler logistics has a significant impact on the delivery time (t = 5.355, p < 0.001), cost efficiency (t = 3.930, p < 0.001), and overall delivery performance (t = 6.354, p < 0.001). Nonetheless, the affordability of fuel was given a lower rating than neutral (mean = 2.94), with heavy traffic as the leading operational hindrance (29.2%). The paper concludes that the two-wheeler logistics is a more strategic choice to use in last-mile e-commerce delivery in high congestion urban areas like Bangalore, as well as operational challenges that need managerial and policy focus.
KEYWORDS: *Two-wheeler logistics, Last-mile delivery, E-commerce, Delivery efficiency, Urban logistics, Bangalore*

1. INTRODUCTION

There has been a transformational change in urban logistics systems, especially the last-mile delivery part, which is the final transportation of goods to the end consumers in the wake of the exponential rise in e-commerce across the world (Gevaers, Van de Voorde, and Vanelslander, 2014). The last-mile delivery has always been the most expensive and operationally intricate part of the supply chain so far, occupying up to 28 53% of overall logistics costs (Boysen, Fedtke, and Schwerdfeger, 2021). The increasing consumer demands and expectations of same-day and next-day delivery combined with the rapid urbanisation have increased the pressure on logistic operators to devise more agile and cost-efficient delivery services (Mangiaracina, Perego, Seghezzi, & Tumino, 2019).

The city of Bangalore (Bengaluru) in India is the capital of technology and innovation; it offers one of the most severe manifestations of these urban logistics issues. The city is also one of the busiest urban centres in the world, and the average speed in the peak hours is not even close to the optimal rates of traditional delivery vehicles (TomTom Traffic Index, 2024). The high rates of motorisation, high density of residential areas, lack of parking facilities and the conditions of small arterial roads all negatively affect the working performance of vans and trucks that are the main basis of traditional last-mile logistics (Asian Transport Observatory, 2024).

To mitigate such structural constraints, large e-commerce platforms and hyperlocal delivery firms, which serve Bangalore such as Amazon, Flipkart, Zomato, Swiggy/Instamart and Blinkit/Zepto/Dunzo have begun to use two-wheelers (motorcycles, scooters and electric two-wheelers) to be their primary last-mile delivery vehicle. Two-wheelers have proven to be more manoeuvrable with congested traffic, less fuel usage, lesser maintenance, and easier access to routes in tight city lanes (Gatta, Marcucci, Le Pira, and Scaccia, 2022). The increased adoption of the electric two-wheelers further aligns the objectives of operation with those of the sustainability of urban plans by cutting carbon emissions of vehicles (ITDP, 2025).

Although it is well known that two-wheeler logistics have been commonly operationalized in the e-commerce ecosystem of Bangalore, there is a lack of empirical scholarly studies looking at its performance, operational limitations, and performance implication in this context. This gap is filled by the present study, which primarily surveys 178 delivery executives. The research examines the efficiency of delivery time, cost-effectiveness, traffic issues and general service performance, and evaluates three formal hypotheses concerning how the two-wheeler logistics affect these aspects.

2. LITERATURE REVIEW

Last-mile delivery is the last part of the supply chain when goods are delivered to the final customer by a local fulfilment centre or hub (Gevaers et al., 2014). It is known to be the most expensive and logistically challenging part of e-commerce order fulfilment

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(Boysen et al., 2021; Pham, Nguyen, and Vo, 2023). The growing operational pressure on last-mile logistics, as e-commerce sales across the world have surpassed USD 5 trillion by 2023, is coupled with the increasing demands of consumers who seek quicker, more open, and reliable delivery services (McKinnon, Browne, Whiteing, and Piecyk, 2018).

Traffic congestion, small roads, lack of parking, and inadequate last-mile infrastructure are the key constraints to the operations of urban logistics (Allen, Browne, Woodburn, and Leonardi, 2012; Patier and Browne, 2010). These limitations put traditional delivery vehicles, such as vans and trucks, at a disadvantage in high-density urban settings as they lead to high fuel usage, extended delivery schedules, and higher operational expenses (Gevaers et al., 2014; Lim, Jin, and Srai, 2018). The problem is especially acute in South Asian metropolitan areas like Bangalore where the increase in vehicle numbers has significantly exceeded that of infrastructure (Asian Transport Observatory, 2024).

The effectiveness of two-wheelers in last-mile delivery in urban areas is becoming a growing body of literature. Mangiaracina et al. (2019) showed that two-wheelers and light delivery vehicles are more flexible and agile in congested areas than traditional delivery vans. The empirical study of electric two-wheelers involved in the last-mile delivery by Gatta et al. (2022) has revealed that there are quantifiable decreases in both the cost of energy and the cost of operations compared to fossil-fuel vehicles. McKinsey and Company (2020) also found out that two-wheelers would decrease the delivery lead times and enhance service responsiveness, particularly during peak times. Nguyen and Vo (2025) suggested optimal route plans of e-cargo bikes that show efficiency benefits in dense urban networks. Ritzer, Negenborn, and Schultmann (2023) discovered that comparative performance advantage of lightweight delivery vehicles is most vivid when the surrounding traffic is intense-conditions that best describe the road network in Bangalore.

Knowledge-attitude-behaviour paradigm, which was initially applied to logistics systems by the researcher based on the behavioural economics, is that the perception of vehicle suitability and attitudes towards traffic management by the delivery executives is a major determinant of their operational behaviour and performance results (Shapiro, Porticella, Jiang, and Gravani, 2011). Recently, Pham et al. (2023) focused on the last-mile delivery optimisation methods, indicating that operator cognition and adaptive behaviour play a significant role in gaining efficiency in delivery. The social and behavioural aspects of adoption of two-wheeler delivery in developing urban economies were reported by the ITDP (2025), which stated that policy environments, safety norms, and infrastructure conditions mediate the social-behavioural relationship between the vehicle type and the performance of the deliveries.

3. RESEARCH GAP

An in-depth analysis of the literature shows that there are a number of gaps that are considered to be very critical and the present study aims to fill these gaps:

1. The available literature on last-mile delivery is predominantly based on a global or developed-country setting, with minimal consideration to the urban-specific issues in rapidly urbanising Indian cities, like Bangalore.
2. Most of the previous studies focus on the traditional type of logistics delivery vehicle (vans, trucks, cargo bikes in European situations), and there is a dearth of empirical research on the logistics of the motorcycles and scooters in Indian e-commerce.
3. The lack of primary research based on data that concurrently measures the delivery time, cost effectiveness, operational difficulties and customer service delivery of two-wheeler logistics in a single analytical framework.
4. The perspective of the delivery executives themselves, who are the key players in two-wheeler logistics, is scarcely considered in existing studies, and this leaves a gap in the knowledge of ground-level reality of operations.
5. The scholarly literature on the comparative performance of two-wheelers and conventional vehicles in the context of the real urban traffic conditions in the Indian setting is scanty.

The current research paper fills these gaps based on primary data that was collected on 178 delivery executives of various e-commerce platforms in Bangalore.

4. OBJECTIVES OF THE STUDY

4.1 Primary Objective

To examine the importance of two-wheeler logistics in the optimization of the last-mile delivery of e-commerce companies in Bangalore.

4.2 Secondary Objectives

6. To examine the problem encountered by e-commerce firms in the last-mile delivery in Bangalore.
7. To find out why two-wheelers are preferred to traditional delivery vehicles as e-commerce logistics in urban areas.
8. To assess the effects of the two-wheeler logistics in terms of the delivery time, the cost of operation, and the delivery efficiency.
9. To test formal hypotheses on the statistical significance of the effect of two-wheelers logistics on the dimensions of performance in terms of delivery.

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5. HYPOTHESES

According to the theoretical framework and previous literature (Fig. 1), it was hypothesized that the following were the hypotheses in this study:H01: There is no significant effect of two-wheeler logistics on the delivery time in e-commerce last-mile delivery of delivery.
H11: Two-wheeler logistics is an effective way of improving delivery time in last-mile e-commerce delivery.
H02: Two-wheeler logistics does not play a significant role in cost efficiency.
H12: Two-wheeler logistics is a better cost-efficient way to deliver the last mile.
H03: The use of two-wheelers in logistics does not make any significant difference in overall delivery performance.
H13: Two-wheeler logistics has a significant impact on the performance of the overall delivery in comparison with the normal cars.

6. RESEARCH METHODOLOGY

6.1 Research Design

The study adopted a descriptive and analytical research design. The descriptive part records the current last-mile delivery operations with two-wheelers, whereas the analytical part quantitatively analyzes the effect of two-wheeler logistics on the efficiency of delivery, costs, and the overall performance of operations. This is a dual design that is aligned with other methods in logistics research, which aim at both describing current phenomena and determining causal or associative relationships between variables (Pham et al., 2023).

6.2 Population and Sample Size

The target market included delivery executives and logistics staff that participated in the last-mile delivery business using two-wheelers in e-commerce and hyperlocal businesses in Bangalore. The population size was estimated as 10,000 delivery executives, depending on the size of operations of large platforms operating in the city. The size of the sample was calculated by the Slovin Formula:

$$\mathbf{n = N / (1 + N.e^2) = 10{,}000 / (1 + 10{,}000 \times 0.0025) = 385 \text{ respondents}}$$

where N = population size and e = margin of error (0.05). The study achieved 178 valid responses, representing an exploratory primary sample suitable for descriptive, correlational, and inferential analysis.

6.3 Sampling Technique

Stratified sampling was employed to ensure proportional representation across delivery platforms and operational zones within Bangalore. Respondents were randomly selected within each stratum (platform), with Amazon (n=43), Zomato (n=31), Swiggy/Instamart (n=30), Flipkart (n=29), Blinkit/Zepto/Dunzo (n=27), and Other platforms (n=18) forming the strata.

6.4 Data Collection Method

Primary data was collected through a structured, closed-ended questionnaire administered face-to-face and through digital means to two-wheeler delivery executives and logistics/operations staff. The questionnaire comprised 24 items across six thematic sections: (i) demographic and operational profile, (ii) vehicle and platform characteristics, (iii) delivery speed and efficiency perceptions, (iv) traffic conditions and fuel costs, (v) operational challenges, and (vi) comparative performance versus conventional vehicles. Likert-scale items ranged from 1 (Strongly Disagree/Never) to 5 (Strongly Agree/Always), and ordinal categorical items were used for frequency and performance dimensions.

6.5 Variables of the Study

Independent Variables

Use of two-wheelers for delivery, traffic conditions (frequency and impact), and fuel and operational costs.

Dependent Variables

Delivery time efficiency, cost-effectiveness, overall last-mile delivery performance, and customer satisfaction.

6.6 Tools Used for Analysis

1. Percentage Analysis - to describe and analyse distributions of responses.
2. Tabulation and Graphical Presentation - to systematise and present data patterns.
3. Pearson Correlation Analysis - to test linear relationships between important variables.
4. Multiple Linear Regression - to estimate the predictive effect of independent variables on the overall efficiency.
5. One-Sample t-test - to test hypotheses against a neutral level (0= 3 on the five-point Likert scale).
6. Python (pandas, scipy, sklearn) and Microsoft Excel were used to provide statistical analysis.

7. DATA ANALYSIS AND INTERPRETATION

7.1 Descriptive Statistics: Demographic Profile

Table 1 presents the socio-demographic and operational profile of the 178 respondents.

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Characteristic	Category	Frequency (n)	Percentage (%)
Age Group	18–25	58	32.6
	26–35	54	30.3
	36–45	42	23.6
	Above 45	24	13.5
Delivery Platform	Amazon	43	24.2
	Zomato	31	17.4
	Swiggy / Instamart	30	16.9
	Flipkart	29	16.3
	Blinkit / Zepto / Dunzo	27	15.2
	Other	18	10.1
Work Experience	Less than 1 year	66	37.1
	1–3 years	52	29.2
	3–5 years	39	21.9
	More than 5 years	21	11.8
Vehicle Used	Motorcycle	63	35.4
	Scooter	62	34.8
	Electric Two-Wheeler	28	15.7
	Other	25	14.0
Daily Work Hours	Less than 6 hours	26	14.6
	6–8 hours	66	37.1
	8–10 hours	52	29.2
	More than 10 hours	34	19.1
Total	**N = 178**	**178**	**100.0**

Table 1. Demographic and operational profile of respondents (n = 178)

Most of the respondents (62.9) were within the age group of 1835- age group that represents the young and workforce mostly belonging to the gig-economy sector that is involved in delivery activities using two-wheelers in Bangalore. Amazon took the biggest part (24.2%), then Zomato (17.4%) and Swiggy/Instamart (16.9%). A considerable number (37.1%) had a duration of less than one year of experience, which underscores the high turnover nature of logistics based on platforms. The most common types of vehicles were motorcycles (35.4%) and scooters (34.8%), with the proportion of electric two-wheelers steadily increasing to 15.7% - the slow transition towards sustainability in the industry. The majority of the delivery executives were employed 6-10 hours per day (66.3%), which means almost full-time involvement in delivery processes.

7.2 Operational Performance Profile

Metric	Category	Frequency	Percentage (%)
Trips per Day	Less than 10 trips	24	13.5
	10–20 trips	64	35.9
	20–30 trips	49	27.5
	More than 30 trips	41	23.0
Deliveries per Day	Less than 10	33	18.5
	10–20	57	32.0
	20–30	52	29.2
	More than 30	36	20.2
Delivery Distance	Under 2 km	37	20.8
	2 km – 5 km	77	43.3
	5 km – 10 km	34	19.1
	More than 10 km	30	16.9
Product Type	Food / Groceries (Perishable)	54	30.3
	Small E-commerce Parcels	54	30.3
	Large / Bulk E-commerce Items	29	16.3
	Medicine / Healthcare Products	23	12.9
	Documents / Letters	18	10.1

Table 2. Operational performance profile of respondents (n = 178)

Most (63.4) of the respondents made 10-30 trips per day (63.4) and 10-30 deliveries per day (61.2) and it was established that two-wheelers are useful in facilitating high delivery in the urban setting in Bangalore. The 2-5 km (43.3) range of delivery distance,

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which is the most common, is within the operation sweet spot of two-wheelers, where their performance in terms of agility is greatest compared to vans. Food/Groceries and Small E-commerce Parcels were also the most frequent types of products (30.3% each) with the prevalence of hyperlocal and quick-commerce delivery in the logistics ecosystem of Bangalore.

7.3 Descriptive Statistics of Likert-Scale Variables

Variable	Scale	Mean	Std. Deviation	Interpretation
Two-Wheeler Suitability for Urban Routes	1–5	3.674	1.269	Moderately High Suitability
Ease of Navigation with Two-Wheelers	1–5	3.483	1.222	Moderate Navigation Ease
Traffic Impact on Delivery Performance	1–5	3.500	1.268	Moderate-to-High Impact
Fuel Affordability Rating	1–5	2.944	1.305	Below Neutral — Cost Pressure
Overall Delivery Efficiency	1–5	3.612	1.189	Moderately High Efficiency
Perception: Two-Wheelers Faster	1–5	3.483	1.204	Agrees TW is Faster
Perception: Two-Wheelers Reduce Cost	1–5	3.410	1.392	Slightly Agrees Cost Benefit
Perception: TW Outperform Vans	1–5	3.618	1.298	Agrees TW Better than Vans

Table 3. Descriptive statistics for Likert-scale variables (n = 178)

The mean of the key instrument constructs was greatest in two-wheeler suitability on urban routes (M = 3.674, SD = 1.269), meaning that the executives involved in the delivery think that two-wheelers are adequately suited to use on the road network in Bangalore. The overall efficiency of delivery was rated as M = 3.612 with a moderate-to-high perceived operational performance. Notably, the affordability of fuel was lower than neutral (M = 2.944, SD = 1.305), which is an indication of the continued burden on delivery workers. Traffic influence was rated to be at M = 3.500, which implies that congestion is a major constraint in operations even when it comes to two-wheeler operations.

7.4 Traffic Conditions and Delivery Delay Analysis

Traffic Delay Frequency	Frequency	Percentage (%)	Cumulative (%)
Never	21	11.8	11.8
Rarely	13	7.3	19.1
Sometimes	33	18.5	37.6
Often	56	31.5	69.1
Very Often	55	30.9	100.0
Total (N = 178)	**178**	**100.0**	

Table 4. Frequency of traffic-induced delivery delays (n = 178)

Two-thirds of the respondents (62.4) said they had encountered traffic-related delivery delays at least once in the past year with 62.4 percent saying they had encountered them Often or Very Often, which demonstrates the ubiquitous nature of the chronic road congestion of Bangalore in causing delivery delays. The proportion of those who never experienced traffic delays was only 11.8%. The majority of the respondents (39.9) indicated evening peak hours as the most problematic delivery period, then morning (24.2), afternoon (18.5) and night (17.4) peak hours. These results are in line with the analysis of Bangalore as one of the most congested cities in the world by TomTom (2024).

7.5 Cost Analysis: Fuel and Operational Cost Perceptions

Variable	Category	Frequency	Percentage (%)
Daily Fuel Cost	Less than ₹100	36	20.2
	₹100–₹200	63	35.4
	₹200–₹300	50	28.1
	Above ₹300	29	16.3
TW Reduce Cost (Agreement)	Strongly Disagree	28	15.7
	Disagree	19	10.7
	Neutral	30	16.9
	Agree	54	30.3
	Strongly Agree	47	26.4

Table 5. Fuel cost and cost reduction perceptions (n = 178)

Most of the respondents (55.5%), spent between ₹100 and 300 on daily fuel expenses which is much cheaper compared to the operating expenses of four-wheeler delivery vehicles, and is consistent with the literature describing two-wheelers as affordable modes of delivery (Gevaers et al., 2014; McKinsey and Company, 2020). A total of 56.7% of the respondents believed and strongly believed that two-wheelers lessen operations expenses compared to vans and 26.4% believed that it was neutral or negative. Perception of cost reduction is statistically significant (H2 test results, Section 8), which helps to support the comparative cost advantage of two-wheelers.

7.6 Delivery Time Efficiency and On-Time Performance

Variable	Category	Frequency	Percentage (%)
TW Deliver Faster (Agreement)	Strongly Disagree	15	8.4
	Disagree	25	14.0
	Neutral	33	18.5
	Agree	69	38.8
	Strongly Agree	36	20.2
On-Time Delivery Rate	Never	11	6.2
	Rarely	24	13.5
	Sometimes	48	27.0
	Often	63	35.4
	Always	32	18.0

Table 6. Delivery time efficiency and on-time performance (n = 178)

Fifty-nine point two percent (59.0) of respondents agreed or strongly agreed that in the urban traffic environment of Bangalore two-wheelers are faster than the conventional four-wheelers. Reported on-time delivery performance was often or always, with 53.4% of the respondents reporting the service to be moderately reliable. The average on-time delivery score of 3.46 (5 = Always) indicates a stable, but not flawless, punctuality - traffic congestion is the biggest factor that limits the remaining 46.6% of instances.

7.7 Comparative Performance Against Conventional Delivery Vans

TW Performance vs. Vans	Frequency	Percentage (%)	Cumulative (%)
Strongly Disagree	18	10.1	10.1
Disagree	20	11.2	21.3
Neutral	28	15.7	37.1
Agree	58	32.6	69.7
Strongly Agree	54	30.3	100.0
Total (N = 178)	**178**	**100.0**	

Table 7. Respondents' assessment of two-wheeler performance versus delivery vans (n = 178)

There was a high majority agreement or strong agreement of 62.9% that two-wheelers are better than conventional delivery vans in terms of performance in last-mile delivery in urban areas in Bangalore. The proportion of those who had a negative opinion was only 21.3% and 15.7% were neutral. The result is sound empirical evidence of the strategic reasons why two-wheeler logistics has been widely adopted on the platform in high-congestion cities in India.

7.8 Operational Challenges

Biggest Operational Hindrance	Frequency	Percentage (%)	Rank
Heavy Traffic	52	29.2	1
Road Conditions	35	19.7	2
Fuel Cost	27	15.2	3
Parking Issues	27	15.2	3
Delivery Deadlines	22	12.4	5
Weather	15	8.4	6
Total (N = 178)	**178**	**100.0**	

Table 8. Primary operational hindrances reported by respondents (n = 178)

The greatest operational hindrance identified by the respondents was heavy traffic at 29.2 percent, poor road conditions (19.7 percent), fuel cost (15.2 percent) and parking problems (15.2 percent). Weather (8.4) - especially monsoon weather and strict delivery schedules (12.4) were also rated to be major constraints. When the multi-select challenge responses of the respondents were analysed, the five most common operational challenges that the two-wheeler delivery executives in Bangalore face were safety risks (mentioned 48 times), heavy traffic, bad weather, fuel cost, and limited load capacity.

8. RESULTS

8.1 Pearson's Correlation Analysis

Variable Pair	Pearson r	p-Value	Significance	Interpretation
Traffic Impact ↔ Overall Efficiency	0.223	0.003	**	Moderate Positive — Significant
TW Faster Perception ↔ Overall Efficiency	0.218	0.003	**	Moderate Positive — Significant
TW Suitability ↔ Overall Efficiency	-0.050	0.503	n.s.	Weak Negative — Not Significant
TW Reduces Cost ↔ Overall Efficiency	0.049	0.518	n.s.	Negligible — Not Significant
TW vs Vans ↔ Overall Efficiency	0.094	0.213	n.s.	Weak Positive — Not Significant

Table 9. Pearson correlation between key study variables and overall delivery efficiency (n = 178; ** p < 0.01)

A statistically significant positive correlation with overall efficiency of delivery was found at the 1 percent level with traffic impact on delivery (r = 0.223, p = 0.003) and the perception that two-wheelers deliver faster (r = 0.218, p = 0.003). Executives who acknowledge the high traffic pressure score rating overall efficiency more positively - as would be consistent with the interpretation that two-wheelers prove their best comparative advantage in exactly the traffic-congested environment prevalent in Bangalore. Two-wheeler suitability per se (r = -0.050, p = 0.503) and cost-reduction perceptions (r = 0.049, p = 0.518), on the other hand, did not have statistically significant direct relationships with overall efficiency.

8.2 Multiple Regression Analysis

Predictor Variable	Coefficient (B)	Std. Error	t-Value	Interpretation
Intercept	2.493	0.321	7.764	Base efficiency level
TW Suitability (1–5)	-0.083	0.062	-1.339	Non-significant weak negative
Traffic Impact (1–5)	0.192	0.062	3.097	Significant positive predictor
TW Faster Perception (1–5)	0.205	0.065	3.154	Strongest positive predictor
TW Reduces Cost (1–5)	0.011	0.056	0.196	Negligible marginal effect
R^2 = 0.096 | Adjusted R^2 = 0.075 | n = 178				

Table 10. Multiple regression analysis — dependent variable: overall delivery efficiency (n = 178)

Nine point six percent of overall delivery efficiency (R 2 = 0.096, Adjusted R 2 = 0.075) was explained by the regression model. The most significant and efficient predictor was speed perception (TW Faster: B = 0.205), then there was traffic impact awareness (B = 0.192). This shows that time saving achieved in high-congestion scenarios is the main mediator of the two-wheeler logistics efficiency in Bangalore. The small value of R 2 is not a surprise because delivery efficiency is a multidimensional variable due to the presence of a large number of contextual variables outside of the four predictors used by this model.

8.3 Hypothesis Testing

Hypothesis	Variable Tested	Mean ($\bar{x}$)	t-Value	p-Value	95% CI	Decision
H1: TW reduces delivery time	TW Faster (1–5)	3.483	5.355	<0.001***	[3.305, 3.661]	Reject H_{01}
H2: TW improves cost efficiency	TW Reduces Cost (1–5)	3.410	3.930	<0.001***	[3.204, 3.616]	Reject H_{02}
H3: TW improves overall performance	TW vs Vans (1–5)	3.618	6.354	<0.001***	[3.426, 3.810]	Reject H_{03}

Table 11. Hypothesis testing results — one-sample t-test (benchmark μ_0 = 3.0; df = 177; *** p < 0.001)

Hypothesis 1

H_{01} Rejected. The average score of the agreement with the statement that two-wheelers are faster is 3.483, which is far much higher than the neutral value of 3.0 (t = 5.355, p < 0.001). Still the 95% confidence interval [3.305, 3.661] does not contain the neutral point, which also serves as a further confirmation of statistical significance. The fact that two-wheelers can get through the traffic jams, small streets, and gridlocks can lead to material time savings compared to regular cars, which was confirmed by Gatta et al. (2022) and McKinsey and Company (2020).

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Hypothesis 2
H_{02} Rejected. The mean cost reduction agreement score is 3.410, significantly above neutral ($t = 3.930$, $p < 0.001$), with a 95% confidence interval of [3.204, 3.616]. Two-wheeler logistics is seen to contribute positively to the operations cost by consuming less fuel, less maintenance and less parking space. The effect size is less than that of delivery time, indicating that the aggregate cost advantage is moderated by pressures on fuel costs (mean affordability = 2.944).

Hypothesis 3
H_{03} Rejected. The average of TW outperform vans of 3.618 is far higher than the neutral ($t = 6.354$, $p < 0.001$), and the t-statistic of this hypothesis is the highest of all three. This finding demonstrates an overall performance benefit of two-wheelers that includes speed, maneuverability, accessibility to routes, and responsiveness to service compared to conventional delivery trucks in an urban environment in Bangalore.

9. DISCUSSION

The results of this research project are highly empirical evidence of the strategic use of two-wheeler logistics in the e-commerce last-mile delivery system in Bangalore. All the three hypotheses were accepted at the 1% level of significance and proved the positive influence of the use of two-wheeler logistics on all the three dimensions of delivery time, cost efficiency, and overall performance. These findings are aligned with and supplement previous studies conducted by Mangiaracina et al. (2019), Gatta et al. (2022), and McKinsey and Company (2020) and one of the first empirical validations of these relationships in the Indian urban setting by primary data.

The first goal of the study, which is to investigate the issue of last-mile delivery problems in Bangalore, was thoroughly covered. The major constraints to operations identified were heavy traffic (29.2%), poor road conditions (19.7%), the cost of fuel (15.2%), safety risk, and the size of the load. These results are in line with the structural features of the transport environment in Bangalore recorded by TomTom (2024) and other Asian Transport Observatory (2024). One of the key things to understand is the paradox that on the one hand, traffic is the biggest operational issue that two-wheelers have had to grapple with, and, on the other hand, it is namely due to the congestion of Bangalore that two-wheelers can outperform vans by even a larger margin.

Table 5, Table 6, and Table 7 deal with the second objective which is to examine the reasons behind the preference of two-wheeler. The economic benefit of cost (55.5% agreeing on lower costs) and the speed benefit (59.0% agreeing on faster delivery) and the strong 62.9% benefit on outperforming vans all speak to the fact that two-wheelers are chosen due to the economic and performance benefits they achieve.

The hypothesis testing and regression analysis confirm the third objective the impact on the delivery time, cost, and efficiency. Speed perception was the best predictor of the total efficiency of the regression model (B = 0.205) indicating that time saving is the main determinant of the value of logistics of two-wheeler, and not the reduction of costs alone. This result has significant implications on platform strategy: routing optimisation, dynamic traffic adaptation, and scheduling technology investments are bound to provide higher returns in efficiency than fuel cost subsidies alone.

The rating of below-neutral fuel affordability (M = 2.944) is an important discovery that has been under-researched in previous literature. Although two-wheelers use less fuel than vans, the per-litre fuel price paid out of pocket by gig delivery workers in most instances, not to mention employer subsidies, is a significant amount of money. This is especially worrying considering that 37.1% of the respondents had less experience of one year and above implying high turnover partly attributed to cost pressures of operation.

The small regression R2 (0.096) can be explained by the complexity of the efficiency of delivery as an outcome, as it depends on the number of contextual factors that affect it: weather, route characteristics, product type, customer availability, and not on the four predictors that are modelled. The use of objective, GPS-tracked delivery performance data should be a future research addition to enhance explanatory power and go beyond self-reported perceptions.

10. CONCLUSION

This paper has assessed how logistics of two-wheelers have been used to optimize the last-mile delivery of e-commerce firms in Bangalore based on primary data of 178 delivery executives. The study established that the two-wheeler logistics is a major contributor of shortening delivery times, enhancing cost efficiency, and overall better delivery performance than the traditional four-wheeler delivery vehicles- statistically significant at the 1% level. All the null hypotheses were rejected.

The special urban features of Bangalore such as extreme traffic congestion, vehicle mix (two-wheelers), high density of demand of e-commerce and the narrow arterial roads present an excellent operational environment of two-wheeler logistics. The most common range of delivery distance (250 km) at 250 km (43.3) fits exactly into the range of highest comparative advantage of two-wheelers. Simultaneously, the research points out such operational issues as heavy traffic, poor road conditions, fuel costs, safety risks, and limited load capacity as major challenges that should be addressed with specific managerial and policy actions.

11. RECOMMENDATIONS

11.1 For E-commerce Platforms and Logistics Operators

10. Switch to electric two-wheelers as soon as possible to decrease the burden of fuel costs on the delivery executives and decrease the carbon footprints.
11. Install AI-based dynamic routing and real-time traffic adjustment systems to take full advantage of the time benefit of two-wheelers compared to traditional cars during the most congested times.
12. Open micro-fulfilment centres in residential areas with high population density to ensure that average delivery distances fall within the 2-5 km two-wheeler efficiency sweet spot.
13. To mitigate the safety risk issues highlighted by delivery executives, invest in safety training, protective equipment and accident insurance programmes.
14. Add performance-based fuel subsidies or electric vehicle acquisition programmes to reduce the burden of the below-neutral fuel affordability (mean = 2.944) on delivery workers.

11.2 For Urban Policy Makers

15. Develop special two-wheeler delivery lanes and loading/unloading areas in the densely populated commercial and residential areas.
16. Fiscal incentives should be offered to adopt electric two-wheelers within the logistics industry, such as subsidies and access to preferential charging systems.
17. Include two-wheeler logistics within the urban mobility master plan in Bangalore to minimize the conflict between the delivery processes and the overall traffic movement.

12. LIMITATIONS OF THE STUDY

There are a number of limitations that must be considered when reading the results of this research. To start with, the sample of 178 respondents that was achieved is sufficient to make inferences using exploratory statistics, but is insufficient to satisfy the theoretically necessary 385 respondents of the Slovin Formula, potentially reducing the statistical power of certain tests. Second, delivery executives self-report all the data and are subject to social desirability and recall problems, no objective operational data (GPS-recorded delivery times, actual fuel consumption records, etc.) were available. Third, it was an analysis that was done at only one instance in time and might not adequately reflect seasonal or cycle variation in performance of delivery (e.g., monsoon effect). Fourth, the questionnaire was created in English to be administered by delivery executives that might speak mainly Kannada or Hindi that might create variability in interpretation of responses. Fifth, the research is restricted to the city of Bangalore and its results might not be directly applicable to other Indian cities with varying patterns of traffic and level of e-commerce penetration.

13. FUTURE SCOPE OF RESEARCH

18. Further research ought to gather objective GPS track performance records of delivery performance in the future to confirm and expand on the self-reported perceptions collected during this research.
19. Multi-city analysis comparing the Indian metros of Mumbai, Delhi, Chennai and Hyderabad would provide generalisable information on the situation in which two-wheeler logistics delivers the best efficiency benefit.
20. Longitudinal research that observes adoption, performance of electric two-wheelers in operation, and their environmental impact over years would help in the sustainability aspect of last-mile logistics in cities.
21. The Structural Equation Modelling (SEM) could be applied to jointly test the intricate causal connections among attitudes of delivery executives, vehicle features, traffic conditions, and delivery performance outcomes - the limits of the analysis of the current research.
22. This supply-side analysis would be complemented by customer-side research on the degree of satisfaction and its determinants, in two-wheeler compared with conventional delivery.

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