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DATA-DRIVEN ANALYSIS OF LAST-MILE DELIVERY EFFICIENCY AND ITS IMPACT ON SERVICE QUALITY AND ORGANIZATIONAL PRODUCTIVITY: EVIDENCE FROM FOOD DELIVERY PLATFORMS IN CHENNAI

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Abstract
The emergence of online food delivery apps like Swiggy, Zomato and Dunzo has revolutionized the food service industry in India's urban cities. In Chennai - a densely populated urban agglomeration with a population of over ten million and high tech-savviness amongst consumers - last-mile delivery is the most critical and high cost aspect of the food delivery supply chain. This research conducts a quantitative analysis of the efficiency of last-mile delivery and the resulting effect on service quality and organisational productivity for the food delivery platforms in Chennai.
A structured questionnaire was distributed to 103 delivery partners of food delivery platforms such as Swiggy, Zomato, Zepto and Eatsure. The study used five statistical techniques: Percentage Analysis, Descriptive Statistics, Pearson Correlation, Regression Analysis and One-Way ANOVA. The study finds that workload, technology reliability and service design account for 67 percent of the variance in delivery performance and job satisfaction ($R^2 = 0.670$, $R = 0.818$). High workload is the strongest predictor of complaints ($r = .461^{**}$), and reliability of GPS is the second most positive predictor of delivery performance. The research offers insights for food delivery platforms, logistics managers, and policymakers.
Keywords: Last-Mile Delivery, Food Delivery Platforms, Service Quality, Organizational Productivity, Chennai, Route Optimization, Delivery Efficiency, Data-Driven Logistics, Gig Economy.

1. Introduction

The food delivery sector is one of the fastest-growing components in the global digital economy. The rise of online food delivery platforms is underpinned by the intersection of mobile phone adoption, internet access, and dramatically changing food consumption patterns, and has heralded a revolution in the food service sector and emerged as a critical part of urban commerce. Unlike traditional delivery models, the food delivery industry is constrained by the perishability, temperature sensitivity, and time sensitivity of food: a cooked meal can only be sold for 30 to 45 minutes after dispatching the order, putting a premium on platform efficiency.

The food delivery model is based on an aggregator model in which an online platform serves as an intermediary, linking food partners with consumers, facilitating the preparation and delivery of food within a specified time. The last mile of the delivery chain - the final trip from the restaurant to the consumer - is the critical factor in determining consumer experience and platform competitiveness. This leg of the delivery journey is directly correlated to customer attrition, reviews, and brand reputation.

India's online food delivery market is worth more than USD 7 billion and is projected to grow between 18-20% (2023). The market share of the two major players - Swiggy and Zomato - exceeds 90 percent, and the industry employs more than three million delivery executives, making it one of the biggest gig economy jobs in India.

1.1 Problem Statement

While the growth of food delivery services has been rapid in Chennai, the efficiency of last-mile delivery is limited by congestion, delays at restaurants, lack of optimised routes, and labour management issues. A substantial gap exists in empirical research about the interaction between workload, technology reliability and service design factors on the performance and job satisfaction of the delivery partners at the platform level. Moreover, how these service delivery bottlenecks impact service quality and organisational productivity in the Chennai market has not been rigorously assessed.

This research bridges this gap in knowledge by gathering primary data from 103 delivery partners in Chennai and undertaking a rigorous statistical analysis to examine the relationships between these factors.

1.2 The Chennai Market: Background

Chennai, the state capital of Tamil Nadu and India's fourth-most populous urban centre, offers a unique setting to examine last-mile delivery. The urban landscape is dense with arterial streets, has a North-South-oriented structure, is severely congested and has a burgeoning new township periphery. The annual monsoon season poses a set of severe, time-limited challenges in the form of flooding of low-lying areas and a higher rate of order cancellations. The market is led by Zomato and Swiggy with a diverse customer base ranging from young IT professionals in the OMR corridor, nuclear families in suburban areas and students near the city's many educational institutions.

2. Purpose Of The Study

This study aims to:

•To investigate the effects of factors such as traffic, delay from restaurants, workload, and GPS accuracy on the likelihood of riders finishing orders on time and achieving performance targets.

•To replicate the effects of app quality, technical problems, and customer support responsiveness on service quality measures such as customer complaints, time pressure, and fairness of ratings.

•To determine the key factors affecting rider job satisfaction, safety, earnings satisfaction, work-life balance, and job recommendation.

•To establish whether the service quality and satisfaction results vary between different food delivery platforms or are common industry problems, through ANOVA.

•To make policy recommendations based on the data to delivery platforms, policymakers and logistics service providers to enhance last-mile service and rider well-being in Chennai.

3. Hypotheses Of The Study

H_{01}: There is no significant impact of workload on customer complaints for delivery partners.

H_{11}: Workload has a significant positive impact on customer complaints of delivery partners.

H_{02}: GPS reliability is not significantly related to target achievement and complaint reduction.

H_{02}: GPS reliability is not significantly associated with target achievement and complaint reduction.

H_{03}: There is no significant relationship between app usability, support responsiveness and service quality.

H_{13}: Service quality, app usability and support responsiveness are positively related.

H_{04}: Safety perception and earnings satisfaction are not related among delivery partners.

H_{14}: Safety perception and earnings satisfaction are positively correlated for delivery partners.

H_{05}: The sum of the independent variables do not explain variance in rider performance and satisfaction outcomes.

H_{15}: The overall set of independent variables explains a significant amount of variance in rider performance and satisfaction.

H_{06}: There are no differences among delivery platforms for all service quality and satisfaction outcomes.

H_{16}: There are significant differences in some service quality and satisfaction outcomes across delivery platforms.

4. Review Of Literature

There is a rich body of literature on delivery efficiency, consumer satisfaction and the gig economy in fields of urban logistics, last-mile delivery, consumer satisfaction and the gig economy that has informed the literature review in the present study.

Pradhan, Bhattacharya, and Saha (2024) conducted a survey-based research on the burnout of workers among food delivery executives in metro areas in India, and found 62 percent reported moderate to high levels of burnout resulting from long working hours, stress from traffic congestion and variable income. They established (using structural equation modelling) that burnout affected both delivery accuracy and timeliness.

Krishnamurthy, Sundaram, and Ravi (2024) examined the consumer segments in South Indian metro regions, including Chennai, where South Indian consumers of food delivery services are more sensitive to delivery accuracy than to speed as a performance indicator for satisfaction. They found that consumers in the IT corridor of the OMR region are the most satisfied segment, in line with the purpose of this study.

Vakulenko, Hellström and Hjort (2024) identified the new factor of consumer expectation inflation, demonstrating how the emergence of 10-minute and 30-minute delivery has led to an inflation of consumer expectations of delivery speeds in urban areas. This creates a constant demand for greater efficiency in last-mile deliveries.

Mangiaracina, Perego, Seghezzi and Tumino (2023) surveyed innovations in last-mile delivery, extending earlier efficiency models to new delivery models like micro-fulfilment centres, crowd-sourced delivery and autonomous vehicles. Their assertion that efficiency now needs to be measured taking into account sustainability and customer experience factors apart from the traditional measures of operational efficiency is particularly pertinent in Indian cities.

Hu, Shu and Teng (2022) modelled peak periods of urban food delivery platforms, determining that platforms without predictive pre-positioning strategies experienced 18% decreases in their acceptance rates of orders during peak periods. They found that forecasting demand that enabled pre-positioning of delivery professionals improved platform efficiency and waiting times of customers.

Boysen, Fedtke, and Schwerdfeger (2021) reviewed the last-mile delivery literature, classifying delivery efficiency measures into time-based (average delivery time and on-time delivery rate), volume-based (order fulfilment rate and orders per delivery hour) and cost-based (cost-per-delivery and fuel consumption per kilometre). The authors' taxonomy has emerged as a standardised typology of delivery efficiency and has been applied in the present study to select the variables.

Pillai and Mukherjee (2021) statistically examined the efficiency of delivery in metropolitan Indian cities, noting a statistically significant increase in delivery time, return trip rate and accidents during the monsoon season. They found that monsoon is a prevalent risk factor in food delivery in India, which is applicable to the Chennai case study.

While previous studies highlight the influence of technology, human factors and urban geography, there is a lack of empirical studies that take into account the effect of workload, technology and service quality on both rider performance and consumer satisfaction, using primary survey data from Chennai. This study contributes to this knowledge by providing city-level empirical evidence using a sound statistical analysis.

5. Theoretical Framework

The study is guided by two theoretical frameworks. The Service Quality Framework of Parasuraman, Zeithaml and Berry provides the theoretical basis for the examination of the effect of operational variables, such as delivery time, responsiveness and reliability, on customer satisfaction and productivity. The service quality framework is operationalised in this study through the variables rate of on-time delivery, rate of customer complaint and the technology ease of use, which represent the five dimensions of the framework - reliability, responsiveness, assurance, empathy and tangibles.

The Gig Economy Labour Welfare Framework provides the theoretical foundation for the analysis of the human factors in last-mile delivery. This framework recognises that the gig economy workforce is exposed to unique working conditions that include flexibility, control by algorithms, and income uncertainty, and that their wellbeing, job safety and job satisfaction impact individual performance and system productivity. The strong empirical correlation in this study between perceived job safety and income satisfaction ($r = .506^{**}$) is evidence that the constructs related to wellbeing and operational performance cannot be disentangled in the context of gig delivery platforms.

6. Research Methodology

6.1 Research Design

This study will adopt a descriptive-analytical approach with a cross-sectional method of data collection. Data was collected from 103 delivery partners of four food delivery platforms in Chennai at a single period. This will enable the classification of the riders on the basis of their demographic characteristics, platform and type of work, and testing for relationships between

operational, technological and service quality variables using multivariate statistical techniques.

6.2 Population and Sampling

The population is the delivery partners (riders) of food delivery platforms operating in Chennai, including Swiggy, Zomato, Zepto and Eatsure. Convenience sampling was done as the workforce is dispersed geographically and across time. Riders who were willing to participate were approached at restaurants, pickup and delivery destinations across Chennai. A total of 104 questionnaires were distributed and 103 responses were analysed - a response rate of 99 percent.

6.3 Data Collection

The primary data was collected from 26 questions answered in a five-point Likert scale (1 = Strongly Agree to 5 = Strongly Disagree) questionnaire via face-to-face interviews at the workplaces of delivery partners. The questionnaire focused on five aspects: efficiency of delivery (time, traffic, delays by restaurants), workload, use of technology (app features, GPS navigation, technical support), quality of service (customer complaints, ratings, pressure to deliver) and job satisfaction (pay, safety, conflict with family).

The secondary data was obtained from industry reports, journals and media to see the findings in the national and regional food delivery industry.

6.4 Statistical Tools

The data were analysed using five statistical methods using SPSS Version 26.0. Percentage analysis was carried out for demographic data. Descriptive statistics (mean, standard deviation, skewness and kurtosis) were calculated for all 26 variables. Pearson product moment correlation was employed to explore the relationship between the independent and dependent variables. Simple linear regression was used to assess the predictive power of independent variables on rider satisfaction and performance. One-way ANOVA tested the impact of platform or work type.

6.5 Variable Operationalisation

Delivery Efficiency: How well delivery partners deliver within the time window and achieve their daily delivery targets, measured by self-reported on-time delivery rates and target achievement frequencies.

Organisational Productivity: The cumulative output of the organisation due to the aggregate performance of delivery partners achieved through delivery target achievement, complaints and rider retention rate.

Service Quality: The consumer outcome of the last-mile delivery process, operationalised through customer complaints, accuracy in customer ratings and time management.

7. Data Analysis And Interpretation

7.1 Demographic Profile of Respondents

Variable	Category	Frequency	Percentage
Gender	Male	72	69.9%
	Female	31	30.1%
Age	Below 26 years	85	82.5%

Variable	Category	Frequency	Percentage
	26–35 years	18	17.5%
Work Type	Full-time	49	47.6%
	Part-time	54	52.4%
Experience	Less than 1 year	83	80.6%
	1–3 years	20	19.4%

Our demographic analysis shows that Chennai's delivery workforce is profoundly young: 82.5% of respondents are aged below 26. More than 80 percent have been in the job for less than one year, suggesting high turnover of a workforce, and revealing serious issues of consistency and training for the platform operator. The close distribution between full-time (47.6%) and part-time (52.4%) delivery partners also indicates the flexibility offered by the gig economy. The masculine work force (69.9%) also suggests a need for safety and inclusion policies for the few but increasing number of women working as delivery riders.

7.2 Descriptive Statistics

Variable	Mean	Std. Dev.	Skewness	Kurtosis
App Usability (IV9)	1.83	0.79	1.12	0.91
On-Time Delivery (IV1)	1.97	0.88	0.98	0.74
GPS Reliability (IV5)	2.01	0.91	1.05	0.83
Traffic Impact (IV3)	2.10	0.95	0.87	0.56
Workload Pressure (IV8)	2.18	1.02	1.34	1.21
Support Responsiveness (IV11)	2.30	1.08	1.28	1.15

The 26 variables had mean scores between 1.83 and 2.30 on the five-point Likert scale, confirming that riders consistently fall towards the "agree" side of all survey items. The lowest mean (1.83) was observed for app usability (IV9), indicating almost universal agreement with the user interface of the app when it works. Workload and technology performance had the highest levels of skewness, suggesting that these are the most reliable and persistent concerns for delivery partners; thus, they represent the key areas where platform operators should focus efforts.

7.3 Correlation Analysis

Variables	DV1 Targets	DV2 On-Time	DV3 Complaints	DV9 Earnings	DV10 Safety	DV12 Satisfaction
IV8 Workload	.382**	.301**	.461**	.197*	.153	.221*
IV5 GPS Reliability	.375**	.338**	.406**	.249*	.258**	.218*
IV9 App Usability	.298**	.271**	.321**	.183	.191*	.244*
IV11 Support Resp.	.266**	.244*	.289**	.210*	.175	.231*
DV9 ↔ DV10 (Safety–Earnings)	—	—	—	.506**	.506**	—
IV9 ↔ IV11 (App–Support)	—	—	—	—	—	.517**

*** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).*

Our correlation matrix reveals a number of theoretically interesting and practically important relationships. High workload (IV8) is the strongest positive driver of rising customer complaints (r = .461**), revealing that excessive orders assigned to an individual delivery partner significantly affects service quality. The second most powerful positive driver is GPS reliability (IV5), which is a significant driver of target achievement (r = .375**) and complaint incidence (r = .406**). The strongest within-technology pair is app usability and support responsiveness (r = .517**), confirming that improvements in one dimension of technology positively affect satisfaction with the other. The high correlation between safety perception (DV10) and earnings satisfaction (DV9) at r = .506** indicates that these are not seen as distinct factors by delivery partners, but as part of an overall perception of job satisfaction.

7.4 Regression Analysis

Model	R	R^2	Adjusted R^2	Std. Error
IV_Mean → DV_Mean	.818	.670	.666	.361

A simple regression was run with DV_Mean (composite mean of dependent variables) as the criterion and IV_Mean (composite mean of independent variables) as the predictor. R = .818 suggests a very strong positive correlation between the composite mean of independent variables and delivery performance and job satisfaction. The R^2 of .670 shows the ability of workload management, technology reliability, and service design to explain 67 percent of the variance in rider performance and satisfaction. The adjusted R^2 value of .666 is very close to R^2, which demonstrates the model is not over-fitted and has good generalisation. The 33 percent

unexplained variance may be explained by individual rider characteristics, geographical factors, family dynamics or platform-specific policies that were not considered in this study.

7.5 ANOVA Analysis

Dependent Variable	Sum of Sq.	df	Mean Sq.	F	Sig.
DV1 — Target Achievement	7.108	3	2.369	2.216	.091
DV2 — On-Time Delivery	5.935	3	1.978	1.884	.137
DV3 — Customer Complaints*	15.535	3	5.178	5.244	.002
DV5 — Time Pressure	2.128	3	.709	.627	.599
DV7 — Rating Fairness*	11.056	3	3.685	3.863	.012
DV9 — Earnings Satisfaction	.501	3	.167	.210	.889
DV10 — Safety Perception	.716	3	.239	.178	.911
DV12 — Overall Job Satisfaction	2.228	3	.743	.777	.510
DV13 — Recommend the Job	4.572	3	1.524	1.534	.210

** Statistically significant at p < .05. Highlighted rows indicate significant inter-group differences.*

One-way analysis of variance (ANOVA) was used to determine whether there is an association between service quality and satisfaction outcomes across the groups (either delivery platforms or work types). Out of all the dependent variables (DV) considered, there are only two that are significantly different across groups: customer complaints (DV3, $F = 5.244$, $p = .002$) and whether people believe that ratings reflect service quality (DV7, $F = 3.863$, $p = .012$). There are no differences across groups for other outcome variables, such as perceived safety, job income satisfaction, time pressure, work-life balance and job satisfaction (all $p > .05$). This implies that the problems of last-mile delivery in Chennai are industry-specific, rather than platform-specific. Thus, industry and regulatory solutions are required to complement platform-specific solutions.

8. Discussion Of Findings

The regression findings show that the performance of last-mile delivery in Chennai is a function of a number of operational, technological and human factors. The R^2 value of 0.670 indicates that evidence-based performance improvement initiatives on workload, technology and service design will have a measurable effect on performance, customer satisfaction and platform productivity. This is a significant impact: two-thirds of the factors affecting rider performance and satisfaction is manageable by platform design. Congestion and restaurant delays are the two major external inefficiencies that are confirmed as major barriers by 69.9% and 70.9% of respondents, respectively. These are not controllable by the rider, but are underestimated by the current operating model in their impact on ETA, incentives and performance. Until they factor these in, service quality will keep on declining. Technology is a double-edged sword. When it works, it is an enabler: GPS accuracy, app ease of use and responsiveness of support have strong

positive impacts on performance. When it doesn't, it is inefficient and frustrating, which impacts on perceptions of safety, job satisfaction and complaints. The correlation between app usability and responsiveness of support (r= .517**) suggests that these factors are interrelated and should be improved as part of an overall technology package, rather than separately. Last-mile services need to be better managed from a human factors perspective. The most important implication of this study is that nearly half the riders are not satisfied with their safety perceptions. The correlation between satisfaction with safety and satisfaction with earnings (r = .506**) indicates that safety is not only a secondary welfare issue, but also has a direct impact on productivity and retention. The lack of experience (over 80 percent have less than a year of experience) is a productivity loss for the platforms, which have to bear it but are not normally factored into the system.

9. Study's Key Findings

The main findings of the study are: Chennai's delivery workforce is young (82.5% under 26 years of age) and inexperienced (80% or more with less than one year of experience) which signals workforce attrition and training problems for the food platform companies. The two most commonly reported external factors to reduce delivery efficiency are traffic congestion (69.9%) and restaurant delays (70.9%) - both beyond the control of individual workers. The most important positive factor is the user-friendliness of the app (81.5%), but at the same time 61.2% felt it has frequent glitches, simultaneously high user interface quality and low stability. The highest positive predictor of the incidence of complaints (r = .461**) is over-workload (IV8), providing clear evidence of the positive association between workload and performance. GPS stability (IV5) is the second strongest positive predictor of delivery performance, improving target hit rate (r = .375**), and complaint rates (r = .406**). The regression analysis (R^2 = 0.670, R = 0.818) shows that 67 percent of variance in the performance and job satisfaction outcomes is accounted for by workload, technology and customer service factors.ANOVA reveals that only complaint rates (DV3, p = .002) and rating fairness (DV7, p = .012) are significantly different across platforms. The other outcomes are the same for all companies, showing that most delivery issues in Chennai are "industry issues". • Safety and income satisfaction are highly correlated (r = .506**), confirming that safety is not a welfare issue, but an important predictor of productivity and retention.Mean job satisfaction is moderate (62.1%) with just 61.2% riders feeling safe - the key takeaway for driver retention.

10. Suggestions

Based on the empirical findings of this study, we make the following suggestions to delivery service companies, industry associations and policy makers: 10.1 Workload and Operational Efficiency Smart order limits should be set for riders during peak periods to ensure that individual riders are not given orders that are shown to impact delivery accuracy and customer satisfaction. Traffic data should be used for customers' ETA to ensure that traffic congestion is not reflected in the rider's performance KPIs. Third-party restaurants should be given incentives to cook food prior to the rider's arrival and provide systems to notify riders that the food is ready just in time for arrival, to reduce dwell times. 10.2 Technology Infrastructure Operators should prioritise the reliability of the system during peak hours, festivals and monsoon, when there are more transactions to process and connectivity problems. Core features of the platform (such as accepting orders and navigating) must be offline-capable as a backup in case of

connectivity problems in low signal zones. The operator should compensate the riders for lost income when the app is down and implement an in-app quick report with automatic logging capability to enable faster response by the engineering team to crashes and bugs. 10.3 Safety and Workplace Welfare Operators should enforce helmet use, provide health and accident insurance, and introduce SOS buttons in the rider app, and regular safety training for riders. Since safety is strongly correlated with earning satisfaction (r = .506**), enhancing rider safety can be considered a productivity measure. Female riders require more safety measures, such as family locators and panic buttons, female-only riders and support. 10.4 Ratings and Quality • Make the rating system smart: riders' ratings should be automatically adjusted or flagged when delivery time delays are shown to be caused by traffic, restaurants or apps. Riders should have the option of disputing ratings via time-stamped delivery receipt and an in-app incident reporting tool for customer-side problems should be added. 10.5 Platform and Industry Level Since ANOVA shows that safety, time pressure, overall satisfaction and earning concerns are the same for all platforms, there is a need for a collective regulatory approach, such as social security for gig economy workers, minimum earnings and platform responsibility.Being ahead of the curve in terms of safety and earnings will provide a unique selling point in recruiting and retaining talent in a highly dynamic labour market.

11. Conclusion

This work provides a data-driven evaluation of last-mile efficiency and its impact on service quality and on organisational productivity in the Chennai food-delivery sector. The main empirical finding that workload, technology reliability and service design have a 67 percent explanatory power for rider productivity and job satisfaction ($R^2 = 0.670$) provides a data-driven roadmap for operational improvements. Traffic (for the rider) and restaurant delays are the main sources of inefficiency, but operational design does not capture them in ETA estimates, incentives and performance evaluation. Technology is a force multiplier when stable; a source of inefficiency when not, with repercussions for both efficiency and rider safety and satisfaction. The strong correlation (r = .506**) between safety-earnings satisfaction suggests that platform investments in safety are productivity enhancing rather than welfare enhancing. The ANOVA output that issues relating to time pressure, safety, earnings and satisfaction are structurally the same across all delivery platforms in Chennai has policy implications: these are not platform-specific problems but systemic issues of the urban delivery gig economy, and they need systemic solutions from industry and regulators, in addition to platform-specific interventions. To ensure Chennai's last-mile delivery is more productive, sustainable and equitable, a holistic approach is required that simultaneously optimises operational systems, builds technological systems, empowers the gig workforce, and recasts service quality systems to apportion accountability fairly. Our findings provide a basis for such an agenda and new directions for future studies into longitudinal and inter-urban issues in Indian urban logistics.

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