



Service Quality and Customer Satisfaction of the Delhi Metro: An Exploratory Factor Analysis

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Abstract

This study aims to assess overall commuter satisfaction with the Delhi Metro Rail system and identify the key service quality attributes that influence it. Using survey-based data from 900 respondents, the analysis employs factor analysis to extract latent service dimensions and multiple linear regression to determine their impact on overall satisfaction—defined as the main dependent variable. Thirteen factors were identified, including comfort, accessibility, affordability, timeliness, and environmental concern. The final regression model demonstrated strong explanatory power, accounting for 71.1% of the variance in overall satisfaction. Key positive predictors included metro availability, accessibility, perceived cost, comfort, and service standards, while platform accessibility issues, lack of amenities, and environmental discomfort were found to negatively impact satisfaction. Surprisingly, factors such as customer service, safety, and COVID-19 measures were not statistically significant. The findings provide actionable insights for improving commuter experience and advancing sustainable urban mobility in Delhi.

Keywords: Public transport management; Overall customer satisfaction; Service quality; Factor analysis.

1. Introduction

In the past, the performance review of transit services was primarily focused on the service provider's perspective, considering factors such as cost-effectiveness, operational efficiency, and productivity (Avenali et al., 2020; Hörcher and Tirachini, 2021; Shbeeb, 2022). However, since 2021, there has been a significant shift in public transport research and management toward assessing service quality from the passenger's perspective, with overall commuter satisfaction emerging as a central performance indicator (Halpern and Mwesummo, 2021; Sukhov et al., 2022; Choi et al., 2025). In response, transit service professionals are increasingly prioritizing the identification of key service quality attributes that shape user satisfaction and behavioral intent, with the goal of improving both user experience and system profitability. Extensive research has been conducted in the field of service and customer satisfaction analysis, particularly within the broader context of service industries (Friman et al., 2001; Christy et al., 2022). Although various methodologies, such as customer satisfaction surveys and service performance indices,

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are widely used, there is a growing need for context-specific analysis—particularly in rapidly expanding transit networks like the Delhi Metro. This paper focuses on evaluating overall passenger satisfaction as the primary outcome variable, by capturing user perceptions within the Delhi Metro Rail system. The analysis is rooted in a structured customer satisfaction survey and supported by empirical techniques, including factor analysis and multiple linear regression. By integrating these methods, the study aims to identify and quantify the most influential service quality attributes affecting satisfaction. The broader goal is to minimize service delivery gaps in the Delhi Metro by organizing, analyzing, and interpreting key factors that shape commuter experience.

Accordingly, the primary objective of this study is to evaluate overall satisfaction levels and to determine the service quality attributes that significantly influence user perceptions of the Delhi Metro Rail system. This includes the use of mathematical modeling to explore relationships between service factors and satisfaction outcomes, while also examining algorithmic approaches relevant to large-scale urban transit analysis. Given the central role of the Delhi Metro in the National Capital Region's mobility framework, the findings aim to provide actionable insights for service enhancement and guide future research in transit performance evaluation.

1.1 Delhi Metro

The Delhi Metro, known as India's pioneering modern metro rail project, has profoundly influenced the development of rail-based metro systems in over 20 cities across the nation. Managed by the Delhi Metro Rail Corporation (DMRC), it currently operates a network spanning approximately 395 kilometers, connecting Delhi with major urban centers in the National Capital Region (NCR), including Noida, Gurugram, Faridabad, Ghaziabad, and Bahadurgarh. The Delhi Metro has earned international acclaim for its punctuality, cleanliness, and adoption of advanced technology, including automated fare collection and driverless train operations on selected corridors. As of 2025, the system comprises 10 color-coded lines and 289 operational stations, making it the largest and busiest metro network in India, with a daily ridership exceeding 4.6 million passengers. Several extensions and new lines, including Phase IV developments, are underway, aimed at further enhancing regional connectivity and easing urban congestion (DMRC 2025).

The necessity for a mass transit system in Delhi was first highlighted in the 1960s by the Central Road Research Institute through a comprehensive study of traffic and travel characteristics. The implementation of a metro system was later recommended in a 1995 report by Rail India Technical and Economic Services (RITES). Consequently, the project was undertaken jointly by the Central Government of India and the Government of the National Capital Territory of Delhi. Construction commenced in October 1998, and by December 2011, Phases I and II were completed, consisting of six lines covering 190 km and 142 stations. Following the completion of Phases I and II, the Delhi Metro expanded rapidly with Phase III, adding around 160 km and improving connectivity through key lines like the Magenta and Pink Lines. Phase IV, currently under development, will further extend the network by about 65 km. With over 395 km in operation, the Delhi Metro now serves as a vital transit backbone for the National Capital Region. Technological upgrades like QR ticketing and real-time tracking have enhanced user convenience and system efficiency. This discussion explores the enduring necessity for a

mass transit system in Delhi, with a particular focus on the Delhi Metro Rail's pivotal role as a sustainable and efficient mode of urban transportation.

2. Literature Review

A substantial body of research has focused on evaluating service quality and customer satisfaction in public transportation systems. These studies span various modes, including buses, metros, trams, and commuter rail, and employ diverse analytical frameworks such as Structural Equation Modeling (SEM), Importance-Performance Analysis, Discrete Choice Models, and SERVQUAL-based assessments.

In Manikandan and Vanniarajan (2016) conducted a study utilizing structural equation modeling to investigate service quality and passenger satisfaction within bus services. Employing a non-profitability judgment sampling technique, they selected 980 samples from the Madurai district in Tamil Nadu, obtaining 624 responses to the questionnaire. The study identified several crucial factors influencing service quality, encompassing service planning, network, safety, cleanliness, comfort, and receptivity. Notably, service planning and network exhibited significant impacts on passenger satisfaction. Furthermore, variables such as reliability, personnel, and information were observed to affect service planning, while bus stop availability, route characteristics, and frequency played pivotal roles in influencing the network.

Machado-León et al. (2017) focused on evaluating the impact of service quality characteristics on the overall service quality provided by metro, tramway, and commuter rail transit systems. Employing Importance-Performance Analysis and decision tree methods, the researchers analyzed data obtained from a customer satisfaction survey administered to passengers of the rail transit service in Algiers. The findings underscored the significance of inclusive design and safety, particularly in the tramway and commuter rail services.

De Oña et al. (2017) investigated the future dimensions of service quality within a metropolitan public transport system during economic crisis conditions. They conducted a Customer Satisfaction Survey targeting users of the public bus transport service in Granada, Spain. Employing Principal Component Analysis and Structural Equation Modeling for data analysis, the researchers identified trip availability as the primary attribute associated with the transport service factor. Additionally, secondary attributes linked to comfort and convenience factors were identified. Factors such as frequency, proximity of stops, vehicle speed, and ticket fare were categorized under the transport service factor, while other attributes were grouped under the Comfort and Convenience Factors dimension.

Verma et al. (2017) conducted research to explore service gaps and challenges encountered by women while using public buses, alongside evaluating their perceptions of safety. This involved conducting a primary survey among women in Bangalore, India. Employing Factor Analysis and Logistic Regression Analysis, the researchers investigated these aspects. The study deduced that highly educated women who perceived bus stops as safe tended to feel more at ease while traveling. Moreover, older and employed women expressed a greater sense of safety during bus journeys. The study highlighted infrastructure as a pivotal factor influencing women's perceptions of safety during travel.

Amponsah et al. (2017) evaluated the correlation between service quality and customer satisfaction in public transport operations within the Vancouver Lower Mainland, British Columbia, Canada. For their study, they utilized an adapted SERVQUAL model

renowned for measuring customer satisfaction. Their findings indicated a noteworthy connection between service quality and customer satisfaction. Notably, overcrowding on buses and late-hour services were identified as factors that negatively impacted overall satisfaction and the perceived value for the fare paid.

Srivastava (2017) conducted an analysis focusing on customer orientation and the influence of employee-driven services on commuter satisfaction within the Delhi Metro system. The study involved analyzing data using correlation and regression analysis, with reliability tested using the Cronbach alpha test. The findings highlighted the significant impact of reliability and empathy shown by employees on customer satisfaction. The study emphasized the high customer orientation of Delhi Metro service personnel.

Díez-Mesa et al. (2018) aimed to model service quality within the Metropolitan Light Rail Transit (LRT) service in Seville, Spain, employing Bayesian Network and SEM methods. Their study highlighted the significance of tangible service equipment in influencing the customer service dimension.

De Oña et al. (2018) explored the impact of service quality factors on passengers' behavioral intentions regarding the utilization of public transport services. The research employed the ordered probit model and conducted surveys among passengers using the Light Rail Transit system in Seville, Spain. The findings indicated that the availability and accessibility of the service notably influenced passengers' intentions to utilize the LRT system.

Machado et al. (2018) sought to pinpoint service quality variables derived from the behavioral intentions of public transport users and market strategies. The study utilized Structural Equation Modeling, Cluster Analysis, and Importance-Performance Analysis. Concentrating on a light rail transit service in Seville, Spain, the research identified factors like accessibility, environmental impact, information provision, tangible service equipment, and individual space as influential in determining service quality.

Quddus et al. (2019) investigated the correlation between service quality and its influencing factors within the bus services in Dhaka, Bangladesh. Employing discrete choice models such as multinomial logit models, they analyzed the gathered data. The research uncovered relatively low levels of satisfaction concerning bus service quality in Dhaka, emphasizing the necessity to prioritize factors associated with vehicle comfort, condition, and driver skills to foster a dependable and secure bus transport system.

De Oña et al. (2020) aimed to analyze how private vehicle users perceive transit service and identify the most influential factors on overall service quality. The study conducted surveys in Madrid, Spain, and employed a discrete model for analysis. The results suggested that users of public transportation were predominantly content with the transit service, although varying importance was placed on specific attributes. Private vehicle users focused on a limited number of expressions, and certain factors like accessibility and individual space were not identified as significant.

Guo et al. (2020) examined the impact of traffic safety perceptions and attitudes on the mode selection of metro commuters in Shenzhen, China. Through surveys and the application of t-tests and multinomial logistic models, the research explored this aspect. Their findings revealed that walking was the predominant mode for connecting to the metro, followed by bicycles and buses. Moreover, traffic safety perceptions and attitudes showed variations concerning gender and spatial aspects, influencing the mode preferences for first and last-mile connections.

De Oña (2021) investigated the perceptions of service quality, satisfaction levels, and behavioral intentions among private vehicle users in urban and metropolitan public

transport settings. The research conducted surveys among regular private vehicle users in Madrid and Lisbon, utilizing methods such as confirmatory factor analysis, structural equation modeling, multi-group analysis, and a multiple-indicator and multiple-causes approach. The study highlighted the significance of attributes like punctuality, frequency, information availability, intermodality, speed, and service hours in shaping service quality perceptions and behavioral intentions among public transport users.

Solanki et al. (2022) emphasizes the importance of scrutinizing the reliability and framework of the Travel Satisfaction Scale (TSS) within the framework of the Delhi Metro. By leveraging data from Delhi Metro commuter trips, this study addresses the limited existing research in this area and provides valuable insights that can guide future adaptations and applications of the TSS. The findings indicate the need for a single affective dimension and suggest item modifications to improve the scale's usability and data reliability, thereby contributing to a more comprehensive understanding of customer satisfaction in public transportation systems.

Despite the breadth of research, notable gaps remain. First, there is limited empirical work applying standardized frameworks such as the TSS to Indian metro systems. Second, the integration of first- and last-mile connectivity, along with demographic and safety-related variables, is underexplored. Third, methodological inconsistencies across studies hinder comparative evaluations across geographic regions.

In summary, the existing literature demonstrates that service quality significantly affects passenger satisfaction and behavioral intent. However, a more focused, standardized, and context-sensitive analysis is needed for metro systems in rapidly urbanizing Indian cities. This study seeks to bridge that gap by assessing customer satisfaction in the Delhi Metro using structured measurement techniques and user-centered evaluation frameworks.

3. Methodological Framework

3.1 Research Design

The independent variable used in this study centres on the overall satisfaction of users with the Delhi Metro service in India. The dependent variables encompass specific attributes of service quality, including the metro availability, amenity in metros, metro accessibility, environmental concern, metro standards, COVID-19 measures, customer service and platform accessibility at the metro stations. To collect data, a questionnaire was employed, which is a commonly used tool to assess similar objectives. Data analysis was conducted using statistical techniques, enabling the investigation of both global and local satisfaction levels with the public bus transport system.

3.2 Questionnaire

The questionnaire comprised three sections:

1. *Socio-Economic Characteristics of Respondents:* This section collected information on the demographic and socioeconomic background of participants, including variables such as age, gender, occupation, income, and education level. These variables are widely used in transport satisfaction studies to capture variations in perceptions across user profiles (Budiono, 2009).

2. *Respondents' Perception of Service Quality:* In this section, participants evaluated various service quality attributes of the metro system using a five-point Likert scale ranging from "strongly disagree" to "strongly agree." The attributes included cleanliness, reliability, safety, accessibility, frequency, comfort, and staff behavior—selected based on established frameworks in public transport research, including the Benchmarking in European Service of Public Transport survey (Friman et al. 2001 and De Oña et al. 2013), which emphasize reliability, simplicity, physical design, and interpersonal interactions as key indicators of service quality.
3. *Overall Satisfaction with the Metro:* The final part of the questionnaire aimed to assess the respondents' overall satisfaction with the metro system. Employing a Likert-type scale, participants were requested to rate their satisfaction level, spanning options like "strongly disagree," "disagree," "neutral," "agree," and "strongly agree." This enabled a comprehensive understanding of the respondents' collective sentiment and satisfaction level towards the metro system in its entirety.

The design of the questionnaire was guided by previous studies, particularly Srivastava (2017), who explored commuter satisfaction in the Delhi Metro context, and Friman et al. (2001), whose work on service quality dimensions provided the foundational framework for variable selection. Participants were asked to evaluate their contentment concerning two primary facets: overall satisfaction and specific quality attributes linked to public transport. The questionnaire included three main sections. The first section, related to the socio-economic characteristics of respondents, comprised a total of 8 questions. The second section contained 9 questions focused on travel behavior and metro usage. The third section consisted of 43 statements aimed at assessing respondents' perceptions of service quality and overall satisfaction with the metro. This included one item on overall satisfaction and multiple items addressing specific service quality attributes of public transport. By using this approach, the researchers aimed to capture the respondents' perceptions and satisfaction levels concerning the various aspects of public transport, aligning with previous research and established measurement tools.

3.3 Data Collection

Data collection for this study was conducted at metro stations of Delhi. However, to focus efforts on areas with higher passenger traffic, a larger number of responses were acquired from the most frequented metro stations, such as Rajiv Chowk, Kashmiri Gate, Patel Chowk, Vaishali, Laxmi Nagar, and Botanical Garden. By targeting these stations, the researchers aimed to gather insights from a significant portion of metro users. To ensure a balanced representation and minimize gender bias, respondents included both males and females. The goal was to obtain diversified data that would reflect the perspectives of different segments of society. This approach aimed to capture a wide range of opinions and experiences, providing a more comprehensive understanding of the overall satisfaction and perception of service quality among metro users across various sections of society.

A convenience sampling (non-probability sampling method where researchers select participants based on their accessibility and willingness to participate) method was adopted, driven by factors such as accessibility, time efficiency, and cost-effectiveness. Surveys were administered at station platforms and exit points during regular weekdays,

excluding public holidays. A total of 982 responses were initially collected. After screening for completeness and clarity, 900 valid responses were retained for analysis. The resulting response rate was 91.67%, indicating a high proportion of usable data within the convenience sample framework.

4. Results and Discussion

The data collected will be subjected to statistical analysis. During the data analysis stage, several interrelated procedures are implemented to summarize and reorganize the data. Data input and analysis were conducted using the statistical software SPSS. The analysis involved three primary steps. Firstly, correlation analysis was conducted to measure the linear correlation between variables. This step aimed to determine the degree of association between different variables. Subsequently, factor analysis was executed to ascertain clusters of variables exhibiting shared characteristics. This analysis allowed for the identification of underlying factors within the dataset. Finally, a regression analysis was undertaken to evaluate the impact of each factor on the overall satisfaction. The objective was to ascertain the level of influence each factor exerted on the respondents' satisfaction with the metro service.

4.1 Demographics statistics

A total of 900 valid responses were collected and analyzed. The socio-economic and travel characteristics of the respondents are summarized in Table 1. Among the respondents, 74% were male and 26% were female. The age distribution showed that the majority (39.33%) fell in the 18–25 years category, followed by 26% in the 26–40 years range. Educational qualifications were diverse, with 36% being graduates and 19.67% postgraduates.

In terms of employment, 23% were employed in the private sector, 20.33% were self-employed, and 24.67% were unemployed. Regarding income levels, 34.67% reported no personal income, while 27.67% had a monthly income between ₹15,000 and ₹50,000. Vehicle ownership varied, with 57.67% having no two-wheeler and 78.67% having no four-wheeler. About 47% of respondents did not hold any driving license, while 34.67% held both two- and four-wheeler licenses.

Respondents cited multiple purposes for using the metro, with 70% indicating shopping, 40.33% work, and 18.33% leisure. Trip frequency revealed that 41% of respondents used the metro daily, while 21.67% were occasional users. For fare payment, 69.33% used metro cards, and 30.67% used daily tokens.

Table 1: Socio-Economic and Travel Behaviour Characteristics of Respondents

Characteristics	Number	Share
Categorical Variables		
Gender		
Male	666	74.00%
Female	234	26.00%
Age of the Respondent		
Less than 18 years	84	9.33%
18-25 years	354	39.33%
26-40 years	234	26.00%
41-60 years	165	18.33%

More than 60 years	63	7.00%
Education Qualification		
Illiterate	69	7.67%
Class 10 th	138	15.33%
Class 12 th	171	19.00%
Graduation	324	36.00%
Post-graduation	177	19.67%
Ph.D.	21	2.33%
Employment type		
Student	90	10.00%
Self-employee	183	20.33%
Govt. Employee	147	16.33%
Private Employee	207	23.00%
Retired	51	5.67%
Unemployed	222	24.67%
Income Level (Indian Rupees)		
No Income	312	34.67%
₹ 0- 15,000	189	21.00%
₹ 15,000 – 50,000	249	27.67%
₹ 50,000 – 90,000	93	10.33%
₹ 90,000 – 1,50,000	42	4.67%
More than ₹ 1,50,000	15	1.67%
Two-wheeler Ownership		
None	519	57.67%
One	345	38.33%
Two	30	3.33%
More than Two	6	0.67%
Four-wheeler Ownership		
None	708	78.67%
One	138	15.33%
Two	42	4.67%
More than Two	12	1.33%
Trip Purpose (multi-option correct data)		
Work	363	40.33%
Study	159	17.67%
Shopping	630	70.00%
Leisure	165	18.33%
Other	60	6.67%
Trip Frequency using Delhi Metro		
Daily	369	41.00%
3-4 Times per week	156	17.33%
1-2 times per week	180	20.00%
Rarely	195	21.67%
Mode of Payment for using Metro		
Metro Card	624	69.33%
Daily Purchase Token System	276	30.67%
Mode chosen to Access Metro		
Walk	369	41.00%
Two-wheeler	45	5.00%
Car	15	1.67%
Bus	138	15.33%
Auto-rickshaw	228	25.33%
Taxi	105	11.67%
Travel companion		

Alone	492	54.67%
With one person	270	30.00%
With two person	96	10.67%
More than two persons	42	4.67%
Reasons of Using Metro as Transport Mode (multi-option correct data)		
Affordable	657	73.00%
Comfortable	699	77.67%
Taking less travel time	654	72.67%
Safety	438	48.67%
Only option of Travel	252	28.00%
Environmental sustainable	357	39.67%
Easily accessible	282	31.33%
Other	12	1.33%

Access modes to the metro from home included walking (41%), bus (15.33%), and auto-rickshaw (25.33%), while a similar pattern was observed for destination access. Regarding travel companionship, 54.67% travelled alone, and 30% with one companion.

In terms of reasons for choosing the metro, comfort (77.67%), affordability (73%), and reduced travel time (72.67%) were the top responses, with others citing safety, sustainability, and accessibility as influencing factors.

By capturing diverse user perspectives across age, income, and travel frequency segments, this research contributes to a deeper understanding of urban transit service delivery. The insights can guide policy-makers and metro authorities in making data-driven decisions to enhance passenger experience and promote greater adoption of sustainable public transport in rapidly growing urban environments like Delhi.

4.2 Factor Analysis

Factor analysis is used to exclude common variance from overall factors and, based on the common variance, convert multiple factors into fewer factors. In our study, we employed Principal Component Factor Analysis. The analysis produced a Kaiser-Meyer-Olkin measure of sampling adequacy at 0.863. Furthermore, Bartlett's test of sphericity indicated an approximate Chi-Square value of 9008.230 with a degree of freedom (df) value of 1035. The analysis produced a thirteen-factor solution, which accounted for 72.88% of the variance. The eigen-values for these factors were as follows: 3.569, 3.114, 3.051, 2.921, 2.867, 2.438, 2.409, 2.379, 2.373, 2.251, 1.884, and 1.834. All factors exhibited a reliability (Cronbach's alpha) greater than 0.580.

Table 2 provides the overview of factor names, variable labels, and their respective factor loadings. The nomenclature of these factors derives from the loadings, representing the correlations between the factors and the statements. Factor scores, determined by the extracted factors, assess the relative importance of perceptions. These scores are computed using factor loadings and Likert-scale (1 (Strongly Disagree) to 5 (Strongly Agree) responses from each observation within the sample.

Table 2: Factor loadings obtained through Principal Component Analysis using Varimax rotation and Kaiser Normalization

Factor Name	Statements	Factor Loading
Factor 1: Comfort in metros Eigen Value: 3.569	Cleanliness of the stations	0.743
	Cleanliness within the metro	0.795

% of Variance: 7.758	Adequate lighting in stations	0.795
	Adequate lighting in metro	0.798
Factor 2: Perceived costs Eigen Value: 3.114 % of Variance: 6.769	In my view, the ticket price is on the higher side.	0.650
	The distance between Metro stations and my starting or ending points is considerable.	0.779
	I perceive the waiting time at the platforms to be excessively long.	0.849
	I find the overall expenses associated with Metro travel to be high in terms of time, finances, and comfort.	0.758
Factor 3: Customer service Eigen Value: 3.051 % of Variance: 6.633	Appearance of employees	0.727
	Are you satisfied with Courtesy of the employees	0.810
	Efficiency and promptness of staff in providing information and addressing daily user concerns	0.795
	Customer Service performance across various platforms (offices, website, phone, complaint resolution, etc.)	0.664
Factor 4 COVID-19 measure Eigen Value: 2.921 % of Variance: 6.349	Is everyone there wearing masks/face shield	0.517
	Satisfaction regarding the sanitation facilities	0.559
	Satisfaction with the implemented social distancing measures	0.655
	Satisfaction with the temperature checking protocols	0.778
	Satisfaction with the adherence to regulations	0.811
Factor 5 Metros accessibility Eigen Value: 2.867 % of Variance: 6.232	Easy Access to the daily commuters	0.598
	Functionality of ticket validators at station entrances and exits	0.821
	User-friendly operation of ticket vending machines	0.802
Factor 6 Information about services Eigen Value: 2.438 % of Variance: 5.300	Availability of accurate and up-to-date information on metros (such as operating hours and stops)	0.799
	Accurate and current information within stations (including pricing, operating hours, and stops)	0.846
	Accessibility of information through alternative communication methods (internet, phone, etc.)	0.565
	Clarity and simplicity of notice boards providing information and directions within stations	0.462
Factor 7 Metros timeliness Eigen Value: 2.438 % of Variance: 5.299	Satisfaction regarding train punctuality	0.775
	Satisfaction with the speed of journeys	0.853
	Satisfaction with platform waiting times	0.723
Factor 8 Metros safety Eigen Value: 2.409 % of Variance: 5.237	Feeling of safety regarding theft and aggression in stations and on the metro	0.767
	Confidence in safety against slipping, falling, and accidents at vehicle doors and escalators	0.854
	Visibility and clarity of emergency exits and fire extinguisher signage	0.748
Factor 9 Metros availability Eigen Value: 2.379 % of Variance: 5.172	Operating hours of the metro are sufficient	0.660
	Frequency of metro services (trains per day)	0.795
	Consistency of metro services concerning interruptions caused by breakdowns or incidents	0.786
Factor 10 Platform accessibility Eigen Value: 2.373 % of Variance: 5.158	Seamless connectivity with alternative transportation modes like bike rentals, taxis, and buses	0.758
	Convenient street-level access to stations/platforms	0.810
	Functionality of elevators, escalators, and similar facilities	0.479
Factor 11 Environmental concern	Ambient noise levels within stations	0.838
	Noise levels experienced within the metro	0.829

Eigen Value: 2.251 % of Variance: 4.893	Levels of vibration experienced within the metro system	0.623
Factor 12 Metros standards Eigen Value: 1.884 % of Variance: 4.095	Comfort within the metro (availability of seating or adequate standing space)	0.628
	Temperature control and ventilation systems within the metro and stations	0.737
	Metros are safe for women	0.402
Factor 13 Amenity in metros Eigen Value: 1.384 % of Variance: 3.987	Availability of seating at stations/platforms	0.660
	Cell-phone and 4G network accessibility at stations and within metros	0.694

4.3 Regression Analysis

The factor analysis extracted thirteen factors from the service quality scale. These factors include comfort in metros, perceived costs, customer service, COVID-19 measures, metros accessibility, information about services, metros timeliness, metros safety, metros availability, platform accessibility, environmental concern, metros standards, and amenities in metros.

Subsequently, a regression analysis was performed to forecast the values of the dependent variable (overall satisfaction) using thirteen distinct independent factors.

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki} + \varepsilon_i \quad (1)$$

Where:

Y_i : Dependent variable – overall satisfaction of respondent i

$X_{1i}, X_{2i}, \dots, X_{ki}$: Independent variables representing service quality attributes (e.g., cleanliness, punctuality, comfort, safety, information availability)

β_0 : Intercept term

$\beta_1, \beta_2, \dots, \beta_k$: Coefficients indicating the strength and direction of the relationship between each independent variable and the dependent variable

ε_i : Error term, capturing the unobserved factors affecting overall satisfaction

To aid interpretation, the overall satisfaction scores can be categorized as follows:

Table 3: Categorization of Overall Satisfaction Scores Based on Likert Scale

Overall Satisfaction Score	Interpretation
1.00 – 1.99	Very dissatisfied
2.00 – 2.49	Dissatisfied
2.50 – 2.99	Slightly dissatisfied / leaning toward neutral
3.00 – 3.49	Neutral to slightly satisfied
3.50 – 3.99	Satisfied
4.00 – 4.49	Very satisfied
4.50 – 5.00	Extremely satisfied

Table 3 shows the categorization of overall satisfaction scores based on likert scale. This categorization allows for a clearer understanding of what predicted satisfaction values represent in practical terms. For example, a commuter with a predicted score of 4.2 falls into the “very satisfied” category, while a score of 2.3 would indicate dissatisfaction. These thresholds also help transit planners and service managers translate numerical outputs into actionable benchmarks for service improvement.

To examine the influence of service quality dimensions on commuter satisfaction in the Delhi Metro, Table 4 presents the results of a multiple linear regression (using stepwise regression modelling) analysis conducted using thirteen independent variables derived from factor analysis. The dependent variable in the model was the overall satisfaction score of the respondents. The regression results demonstrated a strong model fit, with a coefficient of determination (R^2) of 0.711, indicating that approximately 71.1% of the variance in overall satisfaction was explained by the model. The adjusted R^2 value of 0.635 accounts for the number of predictors included and reinforces the robustness of the model. The F-statistic (91.203) was highly significant ($p < 0.001$), confirming that the model as a whole reliably predicts commuter satisfaction.

Table 4: Multiple Linear Regression Analysis Predicting Overall Satisfaction

Overall Satisfaction	Coefficient (β)	p-value
Intercept	3.211***	<0.001
Metro Availability	0.228***	0.001
Amenity in Metros	-0.192***	0.001
Metros Accessibility	0.211***	0.001
Platform Accessibility	-0.175**	0.03
Environmental Concern	-0.187***	0.001
Metros Standards	0.173***	0.002
COVID-19 Measures	0.066	0.18
Perceived Cost	0.101**	0.03
Comfort in Metros	0.165***	0.001
Customer Service	0.087	0.115
Information About Services	0.069	0.125
Metro Timeliness	0.139**	0.03
Metro Safety	0.072	0.13
R ² (Coefficient of Determination): 0.711		
Adjusted R ² : 0.635		
F-statistic : 91.203		
p-value (F-test) : < 0.001		

Note: ***, **, * ==> Variables are significance at 1%, 5%, and 10% confidence level.

The results revealed that several factors had a statistically significant positive influence on overall satisfaction. These included metro availability ($\beta = 0.228$, $p = 0.001$), metros accessibility ($\beta = 0.211$, $p = 0.001$), metros standards ($\beta = 0.173$, $p = 0.002$), comfort in metros ($\beta = 0.165$, $p = 0.001$), perceived cost ($\beta = 0.101$, $p = 0.030$), and metro timeliness ($\beta = 0.139$, $p = 0.030$). These findings suggest that improving operational aspects such as train frequency, accessibility of stations, service quality, and maintaining affordable fares can significantly enhance commuter satisfaction. Conversely, some factors exhibited statistically significant negative relationships with satisfaction. These included amenities in metros ($\beta = -0.192$, $p = 0.001$), platform accessibility ($\beta = -0.175$, $p = 0.030$), and environmental concerns ($\beta = -0.187$, $p = 0.001$), indicating that deficiencies in these areas may lead to reduced satisfaction among users.

In summary, the regression model identifies key areas for policy and operational intervention. Emphasizing metro availability, accessibility, service standards, comfort, pricing, and timeliness can substantially improve commuter satisfaction. Simultaneously, addressing negative factors such as platform access issues and inadequate amenities may prevent dissatisfaction. The model thus provides empirical support for prioritizing

specific service quality dimensions to enhance user experience in mass rapid transit systems like the Delhi Metro.

4.4 Discussion

The findings of this study provide meaningful insights into the factors influencing overall commuter satisfaction in the Delhi Metro system. The multiple linear regression model, derived from factor-analyzed survey data, explains a substantial 71.1% of the variance in satisfaction, highlighting the robustness of the model and the relevance of the selected service quality attributes. This aligns with the primary objective of the study: to evaluate customer satisfaction levels and identify the most influential service quality dimensions. Among the positively significant predictors, metro availability, accessibility, and comfort emerged as strong contributors to satisfaction. This is consistent with previous research by De Oña et al. (2017) and Machado-León et al. (2017), which emphasized the importance of service frequency, ease of access, and physical comfort in influencing user perceptions. The significance of metro standards and timeliness further supports the idea that operational efficiency and adherence to schedules are central to the user experience, as also noted by Díez-Mesa et al. (2018) in the context of Spanish LRT systems.

The positive influence of perceived cost on satisfaction is particularly noteworthy. Contrary to studies that suggest fare sensitivity can diminish satisfaction (e.g., Quddus et al., 2019), this result implies that Delhi Metro users may view the pricing structure as reasonable and reflective of value for money—perhaps due to the service quality they associate with the fare. This may also be influenced by the economic diversity of the respondent base, where even low-income groups might perceive the metro as an affordable and dependable mode of transport. Conversely, variables such as amenities in metros, platform accessibility, and environmental concern negatively impacted satisfaction, corroborating findings by Verma et al. (2017) and Srivastava (2017), who highlighted the significance of infrastructure and sensory experience in shaping user satisfaction. These results suggest that despite strong operational performance, deficiencies in physical facilities and environmental conditions—such as crowding, noise, or limited platform access—may erode commuter perceptions of quality. Interestingly, variables such as customer service, metro safety, COVID-19 measures, and information availability were statistically insignificant in the final model. While these aspects are often emphasized in literature (e.g., Amponsah et al., 2017; Solanki et al., 2022), their limited predictive power in this study could be attributed to either consistently high performance (resulting in low variability) or commuters prioritizing tangible, day-to-day service dimensions over abstract or normalized concerns.

5. Conclusion

This study assessed commuter satisfaction with the Delhi Metro Rail system through a data-driven approach, combining factor analysis and multiple linear regression to identify thirteen key service quality dimensions. The model demonstrated strong explanatory power, accounting for 71.1% of the variance in overall satisfaction, thereby validating the relevance of the identified attributes. Statistically significant positive predictors included metro availability, accessibility, comfort, perceived cost, timeliness, and service standards. These findings reaffirm prior research emphasizing operational reliability and commuter-oriented infrastructure as critical drivers of satisfaction (De Oña et al., 2017;

Díez-Mesa et al., 2018). In contrast, issues related to platform accessibility, limited amenities, and environmental discomfort had a negative impact, pointing to infrastructure-related gaps that merit attention (Srivastava, 2017; Verma et al., 2017). Interestingly, COVID-19 measures, customer service, and safety—commonly highlighted in earlier studies (Amponsah et al., 2017; Solanki et al., 2022)—did not significantly affect satisfaction in this model, suggesting that daily service attributes have taken precedence in user priorities post-pandemic.

To enhance commuter experience and reduce reliance on private vehicles, the Delhi Metro Rail Corporation (DMRC) should institutionalize annual satisfaction assessments and act on passenger feedback, as practiced in European systems (Friman et al., 2001). This approach will not only sustain ridership but also advance Delhi's urban mobility goals through a more inclusive and sustainable transit system.

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