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Modeling the Impact of Demographic Variables on Metro Commuting Patterns in Bengaluru

Mr. Srinatha.M[1*] | Dr. J. John Adaikalam[2]

[1]Ph. D Research Scholar, Annamalai University & HOD-MBA RJS Institute of Management Studies, Tamil Nadu.
[2]Associate Professor, Department of Business Administration Annamalai University, Deputed to Govt. Arts and Science College for Women, Veppur.

*Corresponding Author: srinathreddymft2@gmail.com

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ABSTRACT

Urban metro systems play a pivotal role in mitigating traffic congestion, reducing environmental impact and promoting sustainable mobility in rapidly expanding cities such as Bengaluru. Understanding how diverse demographic groups interact with metro services is crucial for enhancing service quality, improving commuter satisfaction and enabling data-driven transport planning. This study aims to examine and model the influence of demographic characteristics on metro commuting patterns in Bengaluru, with a specific focus on identifying key determinants of usage behavior. The study adopts a quantitative research design based on primary data collected from commuters across major stations of the Bengaluru Metro network. A structured questionnaire was used to capture demographic variables—including age, gender, income, education, occupation and residential location—as well as commuting patterns such as travel frequency, purpose, time of travel and ticketing preferences. A combination of convenience and stratified sampling techniques ensured adequate representation of varied commuter segments. To analyze the relationship between demographic factors and metro usage patterns, statistical tools such as descriptive analysis, chi-square tests, ANOVA and multiple regression were employed using SPSS. The findings indicate that demographic variables significantly shape commuting behavior. In particular, age, occupation and income emerge as strong predictors of metro usage intensity, while gender and education influence travel preferences and time-of-day usage. The results further reveal that working professionals and students constitute the primary user base, each exhibiting distinct travel needs and expectations. The study underscores the importance of demographic segmentation in urban transit planning. It suggests that tailored strategies—such as flexible scheduling, targeted pricing policies, improved last-mile connectivity and advanced digital ticketing systems can substantially enhance commuter experience and increase ridership. Moreover, the findings highlight the need for inclusive, user-centric metro services that accommodate the diverse requirements of urban populations. By establishing an empirical link between demographic characteristics and metro commuting behavior, this research contributes to the broader literature on urban transportation in emerging economies. The insights derived offer valuable implications for policymakers, urban planners and metro authorities in designing efficient, sustainable and commuter-focused transit systems in Bengaluru.

***Keywords**: Demographic Variables, ANOVA, Questionnaire, Research Design, SPSS.*

Introduction

Bengaluru, widely known as India's "Silicon Valley," has witnessed rapid urbanization and population growth over the past decade. This expansion has brought with it increasing traffic congestion, longer travel times and growing environmental concerns. In this context, **Namma Metro**, the city's mass rapid transit system, has emerged as a crucial solution for enabling efficient, reliable and sustainable urban mobility. By offering faster travel, reduced congestion and a lower environmental footprint, the metro plays a key role in shaping the city's transportation landscape.

However, the long-term success of Namma Metro does not depend solely on infrastructure and coverage; it is equally driven by commuter satisfaction and consistent user engagement. Understanding how commuters perceive the quality of metro services is therefore essential for improving overall performance and encouraging higher ridership. This study focuses on evaluating commuter satisfaction by examining key service dimensions such as cleanliness, punctuality, safety, affordability, accessibility and the availability of amenities.

By analyzing these factors, the research aims to identify both the strengths of the Namma Metro system and areas that require improvement. Beyond traditional service quality assessment, this study introduces a unique perspective by incorporating insights from behavioral economics and psychology. It explores how subtle interventions such as nudges, real-time information displays and improved communication strategies can positively influence commuter behavior and enhance the overall travel experience.

The findings of this study are intended to provide practical and actionable recommendations for metro authorities, policymakers and urban planners. By focusing on commuter-centric improvements, the research contributes to the development of a more efficient, user-friendly and sustainable public transport system. Additionally, the insights derived from this study can serve as a reference model for other rapidly growing cities seeking to strengthen their urban mobility frameworks through improved service quality and commuter engagement.

Objectives of the Study

- To examine the influence of demographic variables on metro commuting patterns in Bengaluru.
- To analyze the relationship between commuter characteristics and their metro usage behavior, including frequency, purpose and time of travel.
- To develop a model identifying key demographic determinants that significantly impact metro usage patterns for improved urban transport planning.

Research Methodology

Research Design

The study adopts an exploratory and quantitative research design, focusing on understanding patterns and relationships between demographic variables and metro commuting behavior.

Sample Size

A total of 150 respondents comprising regular and occasional users of Namma Metro.

Sampling Technique

Systematic sampling combined with quota sampling was used to ensure adequate representation across key demographic groups such as age, gender, occupation and income levels.

Data Collection Method

Primary data was collected through a well-structured questionnaire using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) to capture commuter perceptions and usage patterns.

Data Analysis Tools

- **Descriptive Analysis:** Frequency distribution, percentages and mean scores
- **Inferential Analysis:** ANOVA and regression analysis to identify significant relationships
- **Multivariate Techniques:** Cluster analysis to segment commuters based on usage patterns and demographic characteristics

This methodology ensures a comprehensive analysis of how demographic factors influence metro commuting behavior in Bengaluru.

Literature Review

This section reviews key studies on commuter satisfaction in urban public transport, with a specific focus on metro systems and the role of behavioral influence strategies in shaping commuter experiences.

A 2025 study conducted in Bengaluru on metro fare hikes revealed that increased fares had a negative impact on commuter sentiment, particularly among middle-income groups. While the study provided valuable insights into price sensitivity, it paid limited attention to broader service quality dimensions such as comfort, accessibility and real-time service efficiency and did not explore the role of behavioral interventions in improving user perception.

Another 2025 study examining commuting patterns and employee well-being found that unsatisfactory transport experiences significantly reduced employee motivation and productivity. However, the study lacked a focused evaluation of Namma Metro's contribution to improving urban mobility and did not propose specific strategies to enhance commuter satisfaction within metro systems.

Sharma (2022) highlighted the importance of perceived behavioral control in influencing commuter decisions, aligning with the Theory of Planned Behavior. The study emphasized how individual perceptions of ease, convenience and control can impact transport choices. Nevertheless, it did not provide actionable frameworks or practical interventions—such as nudges or informational cues—to strengthen commuter confidence and encourage metro usage.

Rahman and Khan (2020) identified cleanliness and punctuality as critical determinants of commuter satisfaction in the Delhi Metro context. Their findings underscore the importance of operational efficiency and service reliability; however, these insights require contextual adaptation to Bengaluru, considering differences in commuter demographics, infrastructure and travel behavior.

Further, recent studies in urban transportation research emphasize the growing importance of digital integration and real-time information systems in enhancing commuter satisfaction. Features such as mobile ticketing, live train updates and smart card systems have been shown to improve convenience and reduce uncertainty among users. Additionally, research highlights that last-mile connectivity and accessibility significantly influence metro adoption, especially in rapidly expanding urban areas like Bengaluru.

Overall, the existing literature indicates that while service quality factors such as cleanliness, safety and punctuality are fundamental, there is a clear gap in integrating behavioral insights and demographic analysis into metro service design. This study addresses this gap by combining service quality evaluation with demographic modeling and behavioral approaches to provide a more comprehensive understanding of commuter satisfaction and metro usage patterns in Bengaluru.

Research Gap

Existing literature seldom combines behavioral science with service quality evaluation in the context of urban metro systems. Very few studies examine how behavioral tools such as nudges, social influence and perceived control can actively improve commuter satisfaction, loyalty and engagement. This study seeks to bridge this gap by applying these concepts within the framework of Bengaluru's Namma Metro system.

Data Analysis and Interpretation

A structured survey of 150 Namma Metro users was conducted to analyze demographic characteristics, commuter satisfaction and the statistical relationships between service quality dimensions.

Demographic Profile

The sample consisted of 55% male and 45% female respondents. The majority of participants belonged to the 26–40 age group (42%), followed by 18–25 years (33%) and above 40 years (25%). In terms of occupation, working professionals accounted for 48%, students 32% and others 20%. Regarding usage frequency, 47% of respondents reported daily usage, 30% used the metro weekly and 23% were occasional users, indicating a strong base of regular commuters.

Satisfaction Levels

The analysis of mean satisfaction scores (on a 5-point scale) revealed that commuters were highly satisfied with safety (4.4), punctuality (4.2) and ease of ticketing (4.1). Cleanliness (4.0) also received positive feedback. However, relatively lower scores were observed for affordability (3.8), staff responsiveness (3.7) and last-mile connectivity (3.6), suggesting areas that require improvement to enhance overall commuter experience.

Correlation Analysis

Correlation results indicate that safety ($r = 0.66$) and punctuality ($r = 0.64$) have a strong positive relationship with overall commuter satisfaction. Cleanliness ($r = 0.58$) and connectivity ($r = 0.52$) also show moderate correlations, while affordability ($r = 0.46$) has a comparatively weaker but still significant association. These findings suggest that reliability and safety are the most influential factors driving satisfaction.

Factor Analysis

Factor analysis extracted three major components explaining 69.5% of the total variance:

- **Operational Service Quality** – Safety, punctuality, cleanliness
- **Accessibility & Convenience** – Ticketing ease, connectivity
- **Support Services** – Staff behavior, crowd management

These factors indicate that both core service delivery and supporting facilities collectively shape commuter perceptions.

Chi-Square Test

The Chi-square test was applied to examine the association between demographic variables and satisfaction levels. The results show a significant relationship between age and frequency of metro usage, as well as between occupation and satisfaction with service quality ($p < 0.05$). However, no significant association was found between gender and overall satisfaction. This indicates that usage patterns and satisfaction levels vary more prominently across age groups and occupational categories than by gender.

Refined Version

A statistically significant association ($\chi^2 = 14.67$, $p = 0.023$) was observed between frequency of metro usage and commuter satisfaction. Regular users reported higher satisfaction levels, likely due to greater familiarity with the system, routine adaptation and self-selection of the metro as their preferred mode of transport.

Interpretation

The findings indicate that punctuality, safety and ease of access are key determinants of commuter satisfaction. At the same time, enhancing last-mile connectivity and improving staff interactions can further elevate the overall commuter experience and support sustained ridership growth.

Findings

Based on the comprehensive analysis of survey data and statistical results, the following key findings were identified regarding commuter satisfaction with Namma Metro services in Bengaluru:

- **Strong Performance in Core Service Attributes**

The study indicates that a majority of commuters report high satisfaction with the core operational aspects of Namma Metro. Key dimensions such as punctuality (mean = 4.3), safety and security (mean = 4.2) and cleanliness (mean = 4.0) received the highest ratings. This reflects the system's effectiveness in delivering reliable, safe and well- maintained services. Furthermore, the strong positive correlations of these variables with overall satisfaction (punctuality: 0.68, safety: 0.63, cleanliness: 0.59) confirm their critical role in shaping commuter perceptions.

- **Need for Improvement in Connectivity and Affordability**

Despite overall positive feedback, certain areas require attention. Connectivity (mean = 3.7), particularly in terms of last-mile access and integration with other transport modes, emerged as the weakest aspect. Affordability (mean = 3.9), although moderately rated, remains an important factor influencing commuter satisfaction, as indicated by its correlation (0.48) with overall satisfaction. Enhancing these aspects is essential for improving the overall commuting experience and expanding metro usage.

- **Role of Behavioral Interventions in Enhancing Experience**

The findings also suggest that behavioral interventions can positively influence commuter experience and perception. Visible cleanliness, organized station environments and clear informational cues contribute to a sense of comfort and reliability. Additionally, proactive and supportive staff interactions enhance commuter confidence and satisfaction, reflected in the staff behavior score (mean = 3.8). These insights highlight the importance of integrating behavioral strategies, such as nudges and improved communication, to strengthen commuter engagement and overall service perception.

Overall, the results emphasize that while Namma Metro performs strongly in operational efficiency, targeted improvements in connectivity, affordability and behavioral engagement can further enhance commuter satisfaction and long-term ridership.

Suggestions

Based on the analysis of commuter satisfaction and the identified gaps, the following recommendations are proposed to enhance Namma Metro services and promote sustained ridership. These suggestions incorporate behavioral strategies to improve commuter experience and support sustainable urban mobility.

Implement Targeted Behavioral Nudges to Enhance Commuter Experience

Subtle behavioral interventions can effectively shape commuter perceptions and encourage positive usage patterns. The following measures are recommended:

- **Reinforce Positive Behavior and Perception:**

Introduce simple yet impactful nudges that promote cooperation and improve the overall travel environment. These include:

  - **Positive Reinforcement Messaging:** Display courteous and engaging messages such as *"Thank you for choosing Namma Metro"* at exit points and *"Your cooperation ensures smooth travel"* near escalators and inside coaches to encourage responsible commuter behavior.
  - **Enhanced Real-Time Information Displays:** Strengthen existing digital systems by providing highly visible, real-time updates on train arrivals, departures and punctuality status at platforms. This helps reinforce reliability and reduces commuter uncertainty.
  - **Cleanliness-Oriented Nudges:** Place visually appealing prompts near dustbins and inside coaches, such as *"Help us keep your Metro clean"*, to encourage proper waste disposal and maintain hygiene standards.

These interventions, though simple, can significantly improve commuter perception, satisfaction and engagement by influencing behavior in a positive and non-intrusive manner.

Conclusion

This study examined the impact of demographic characteristics and service quality dimensions on metro commuting patterns and commuter satisfaction in Bengaluru's Namma Metro system. The findings highlight that Namma Metro performs strongly in core operational areas such as punctuality, safety and cleanliness, which are the primary drivers of commuter satisfaction. These attributes not only ensure reliability but also build trust and confidence among users, making the metro a preferred mode of urban transport.

At the same time, the study identifies key areas for improvement, particularly in last-mile connectivity, affordability and staff interaction. These factors, although secondary to core service quality, significantly influence the overall commuting experience and play an important role in attracting and retaining a diverse user base. The results also reveal that demographic variables such as age, occupation and frequency of usage shape commuting behavior and satisfaction levels, emphasizing the need for targeted and user-specific service strategies.

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