

Women's Perceptions of Metro Rail Service Quality using Structural Equation Modelling - A Case study of Delhi and Lucknow, India

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Abstract - Public transport forms the backbone of meeting any city's mobility needs. Paying extra attention to service quality in public transport can play an important role in catering to existing customers as well as attracting new transit users. Men and women tend to exhibit different behavioral tendencies in use of transportation modes such as buses and metro systems. The existing level of research carried out do not adequately answer how gender perception differs across cities with diverse geographies, systems of government, and public transport service availability. This paper is an attempt to assess which particular service characteristics distinguishes women's opinion of public transportation in across two administratively and culturally distinct cities in India. The empirical study carried out in cities of Delhi and Lucknow reveals that there are significant differences in women's mobility patterns between two cities in terms access mode, egress mode, and trip purpose. It was found that women in Delhi have a high level of concern about safety at metro stations whereas women in Lucknow placed less emphasis on metro station safety. Access time and egress time were more significant for women in Delhi while travel time and waiting time were more significant for women in Lucknow.

Key Words: Women's Mobility, Mobility Patterns, Structural Equation Modelling, Women's Safety, Public Transport

1. INTRODUCTION

The significant increase in the number of private vehicles has resulted in a slew of issues, including pollution and time and money loss. Encouragement of public transportation is proposed as a long-term option to meet travel demand while reducing the use of private vehicles. Passengers who are satisfied with public transportation are more likely to continue using it; also, the public transportation system can improve its mode share by boosting passenger satisfaction. Paying extra attention to service quality can play an important role in both catering to existing customers and attracting new transit users [1][2].

To assess public transport users' satisfaction, there are objective and subjective dimensions that are evaluated using performance indicators (e.g., reliability and capacity) or by understanding users' perceptions, respectively [3]. Public transport user survey is typically used to collect the

subjective component. The key determinant of customer happiness and an important component of any system is users' experience [1]. The users' experience measures the gap between expected and perceived performance [4]. Following WWII, significant changes occurred in the economic and social roles of women. For example, the number of women obtaining a driver's license and entering into the labour field has dramatically grown [5], resulting in more trips by women. Gender roles and lifestyles have altered in emerging countries such as India, as in developed countries. In India, men and women's roles at work and at home have become more similar in recent decades. Men and women may exhibit different behavioral tendencies in transportation, as they do in other disciplines [6].

Previous research on gender disparities in transit, such as riding behavior [7] and public transport usage [8], has focused on the effects of gender on transit. Researchers examine user variables such as gender in transportation research and policymaking [9]. Since the late 1970s, gender-based analysis has assisted policymakers in developing more personalized approaches to increase transit use [10]. Men and women travel differently, have different expectations, and have different perceptions of public transportation [9]. Wachs emphasized the significance of gender differences in mobility [11]. Tsami and Nathanail discovered that lower fares, more frequent lines, and more trustworthy public transit are needed by women [1]. Rojo et al. created a model to distinguish behavioral differences between male and female transportation consumers. They analyses gender variations in assessment of interurban bus service quality; results show that women favour safety on the road, bus seat comfort, and timeliness [12]. Hatamzadeh et al. conducted a gender-based investigation to discover differences in walking behavior in an Iranian metropolis [6][13], discovering that women are more sensitive to walking distances [6]. Another study found that security (against crime and harassment) is a significant concern that can influence women's use of public transportation, which is highly debated around the world [14][15].

While numerous studies and pieces of research have been attempted globally on gender-based inequities within a particular study region, however very little effort has been focused to analyse how user perception towards public transport service quality differs between cities with diverse geographies, systems of government and service availability

in case of women. To the best of the authors' knowledge, almost insignificant research on customer satisfaction in public transportation in a developing country like India has been reported which emphasizes exclusively on women's perception of public transport service quality. This paper is an attempt to fill this research gap and analyse the women's perceptions of public transport service quality in context of two cities of Delhi and Lucknow with diverse geographies, systems of government and transit service quality. In both cities, a customer satisfaction survey format was used to interview about 500 female passengers who were travelling. In public transport system such as buses and metro systems. In order to prioritize women's service attributes, structural equation modelling (SEM) and importance-performance analysis (IPA) are used.

2. METHODOLOGY

SEM technique has been applied to group the variables as well as to identify the relationship between latent variables and observed variables. Measurement model is determined to check the relation between latent variables and observed variables with Cronbach's alpha co-efficient to explain the consistency of the variable on factors. Estimation of model is done to check the weighted least square about effectiveness of the variable on factors. Goodness of Fit indices is checked by measuring degree of freedom (DF), comparative fit indices (CFI), and route mean square error of approximation (RMSEA) is carried out to proceed with comparison of latent and observed variable, or else to start again with EFA to develop a relation to check the validity of the model. Figure 1 shows the SEM modelling technique.

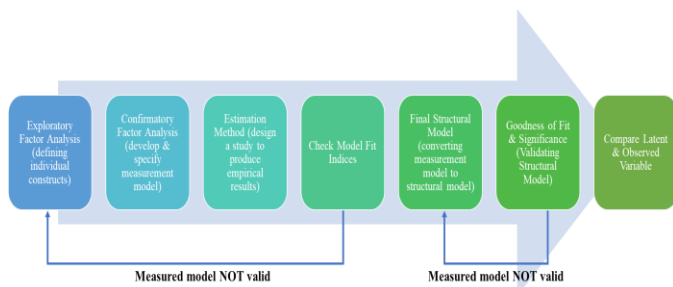


Fig -1: Structural Equation Model Technique

In order to understand the importance of each attribute and to categorize them according to their level of importance as perceived by women public transport user from the survey, an IPA analysis was done to the trade-off of two components: the performance of providing a service/product (x-axis) and the importance of that service/product (y-axis), which create a coordinate system and can be represented in four quadrants, each of which enjoins a strategic approach. Quadrants are categorized according to their level of importance & performance as follows:

- High importance – high performance: That is one of the service's main strengths, and the attributes assigned to this area should continue to perform well.
- High importance – low performance: This area contains the service's biggest flaws and requires quick attention for improvement.
- Low importance – high performance: Excessive resources have been allocated to service attributes in this quadrant that may be used elsewhere.
- Low importance – low performance: Minor flaws are located in this area and do not necessitate quick attention.

3. DATA COLLECTION & ANALYSIS

In the current study, primary surveys were conducted via personal interviews at a number of public transportation stations, with data collected via personal interviews in the case cities of Delhi and Lucknow. The goal of the survey was to assess women's daily travel patterns. The survey included approximately 350 samples, with 56 percent women in Delhi (196) and 44 percent women in Lucknow (154), who were interviewed in 2021 and 2022 in and at metro stations. The questionnaire is divided into three sections: 1) service attributes, 2) trip characteristics, and 3) personal attributes. Respondents rated each service attribute on a Five-point Likert scale (5 = very satisfied, 1 = very dissatisfied). Figure 2 depicts the descriptive statistics of the user interviewees' socio-demographic and trip characteristics. There are significant differences between Delhi and Lucknow in terms of having a driver's licence, access mode, egress mode, and trip purposes. In the sample, the proportion of Delhi women without a driver's licence was less than 10%, while it was more than 30% for Lucknow women. Women in Lucknow chose walking for access and egress mode more than women in Delhi, indicating that women in Lucknow walk more than women in Delhi and make more non-work trips.

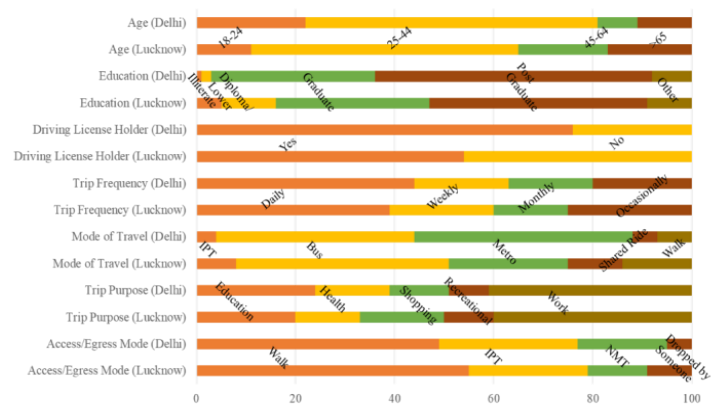


Fig -2: Descriptive Statistics for women in Delhi and Lucknow

The mean and standard deviation for each attribute for women in Delhi and Lucknow is shown in Table 1. Women were more satisfied with station cleanliness, travel card usage, and ticket purchase and recharging in both cities, whereas waiting time, seat availability, and crowd at stations made them less satisfied.

Table -1: Mean and standard deviation for each attribute for women in Delhi and Lucknow

Service attributes	Mean		Standard deviation	
	Delhi	Lucknow	Delhi	Lucknow
Cleanliness at station	4.65	4.19	0.79	0.56
Fare Collection	4.18	3.89	0.80	0.69
Ticket purchasing or recharging	4.49	4.31	1.13	0.83
Cleanliness within system	4.31	4.32	1.15	0.89
Information at station	3.84	4.04	1.07	1.09
Security at station	3.89	3.91	1.01	0.84
Staff behavior	3.99	4.01	1.13	1.06
Safety at station	4.01	4.04	1.01	1.60
Travel time	3.57	3.77	1.11	0.89
Access time	3.59	3.82	1.54	1.19
Information on board	3.85	3.94	1.11	1.08
Security on board	3.31	3.42	1.01	1.08
Egress time	3.87	3.93	1.14	0.99
Comfort within system	3.73	3.91	1.31	1.26
Transfer time	3.99	3.41	1.08	1.02
Crowd at platform	3.04	3.12	1.48	1.39
Waiting time	3.81	3.99	1.12	1.37
Seat availability	2.74	2.99	1.56	1.59
Crowd within system	2.98	3.07	1.62	1.49
Current trip experience	3.65	3.97	0.96	0.92

Fig -1: Modal Split of Working and Non-working women in case cities

3. APPLICATION OF STRUCTURAL EQUATION MODEL (SEM)

Structure Equation Modelling (SEM) technique is used to assess the perception of women related to service quality of public transport system in both the case cities of Delhi and Lucknow. As part of this technique first Exploratory Factor Analysis (EFA) was done on the data base, which enabled identification of primary attributes to construct the Structural Equation Model and the latent variables. Cronbach's alpha value was checked for reliability, and it was found to be acceptable for all the identified latent variables. Following that, Confirmatory Factor Analysis (CFA) examined structures to see if the loading factors were greater than 0.4 (variables with factor loadings less than 0.4 should be removed from the structure) and if the composite reliability (CR) was greater than 0.6. CFA confirmed the following five latent variables- comfort, cleanliness, protection, service quality and availability of information to be the determinants for the further analysis of the samples. To check the reliability and validity of attributes to be considered in the model for both the cities, CFA was done so as to apply the basic structure to both the case cities sample separately. It was observed that the factor loading of fare collection and ticket purchase or recharge system for women in Lucknow were less than 0.4 and thus was removed. Other travel pattern attributes for both the case cities of Delhi and Lucknow respectively ranged up to 0.4. Table 2 shows the acceptable Composite Reliability (CR) for each latent variable. SEM was performed on both case cities to determine the derived importance for each attribute shown in Figure 3 & 4.

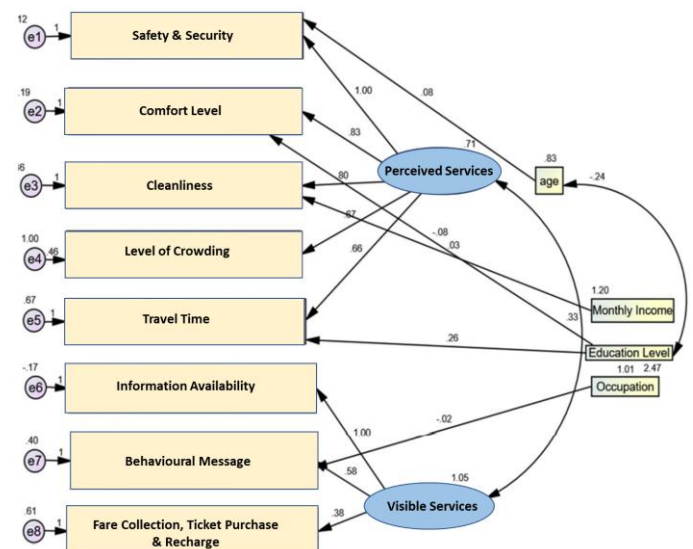


Fig -3: SEM Model for Delhi Metro users

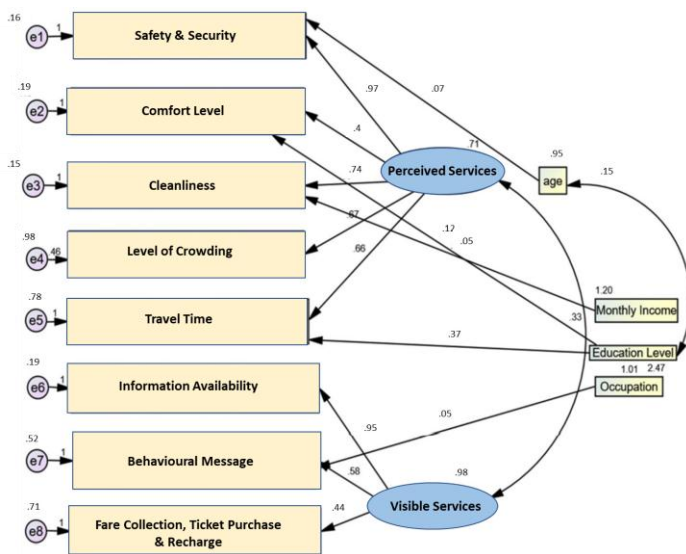


Fig -4: SEM Model for Lucknow Metro users

Table -2: Results of CFA and SEM

Service quality attributes	Composite Reliability (CR)	Factor loading		Derived importance	
		Delhi	Lucknow	Delhi	Lucknow
Comfort	0.73				
Crowd within system		0.74	0.78	0.48	0.47
Crowd at platform		0.73	0.76	0.35	0.53
Seat availability		0.76	0.75	0.44	0.46
Comfort within system		0.61	0.66	0.31	0.34
Cleanliness	0.81				
Cleanliness at station		0.79	0.56	0.41	0.31
Cleanliness within system		0.72	0.82	0.44	0.33
Protection	0.79				
Security on board		0.74	0.85	0.48	0.51
Security at station		0.77	0.84	0.49	0.47
Safety at station		0.71	0.53	0.44	0.31
Safety on board		0.64	0.56	0.39	0.35
Service Quality	0.74				
Access time		0.42	0.42	0.30	0.23
Fare Collection		0.53	0.32	0.32	-

Ticket purchasing or recharging		0.53	0.35	0.34	-
Ticket presenting		0.56	0.43	0.31	0.25
Waiting time		0.41	0.49	0.35	0.37
Travel time		0.46	0.58	0.33	0.35
Egress time		0.52	0.42	0.35	0.24
Staff behavior		0.49	0.45	0.31	0.32
Information Availability	0.72				
Information on board		0.84	0.76	0.39	0.29
Information at station		0.67	0.72	0.27	0.31
Fit indices	CMIN/DF	GFI	RMS EA	CFI	TLI
Delhi	2.48	0.87	0.061	0.84	0.85
Lucknow	2.21	0.88	0.059	0.87	0.86

From Table 2 it can be observed that attributes which were categorized under comfort consisting of crowd within the system, crowd at station and comfort within the system were found to be more important for women in Lucknow. A study on inter-urban bus found that attributes such as seat availability and comfort within the system for which woman found them to be more significant (12). It was observed that crowding at the platform and within the system is another significant attribute related to comfort in transit that can affect women's perception about public transport system in present case study. Visible services include discipline and cleanliness within the system. Cleanliness at the station were more significant for women public transport users in Delhi while this attribute was not that important for women in Lucknow.

The results show that women in Delhi have a high level of concern about safety at metro stations whereas, women in Lucknow placed less emphasis on metro station safety is due to passenger density at metro stations which also impacts the level of surveillance and management within the transit system. Access time and egress time were more significant for women in Delhi while travel time and waiting time were more significant for Lucknow women. This study demonstrates that women pay more attention to the amount of time they spend in the metro system from entrance of station to exit out of station. Women in Delhi, on the other hand, pay more attention to the amount of time they spend outside metro during access or egress stages. Fare collection, ticket purchase and recharging system were

important attributes for women in Delhi as compared to city of Lucknow. On the other hand, ticket purchasing and recharging were one of service attributes with least priority for women in Lucknow. Table 2 shows the model fit indices for both models; CMIN/DF less than 5 and RMSEA less than 0.08 which indicate a good fit (90 percent confidence interval). GFI, CFI, and TLI bound by 1 indicates perfect fit. The model fits well in both case cities of Delhi and Lucknow.

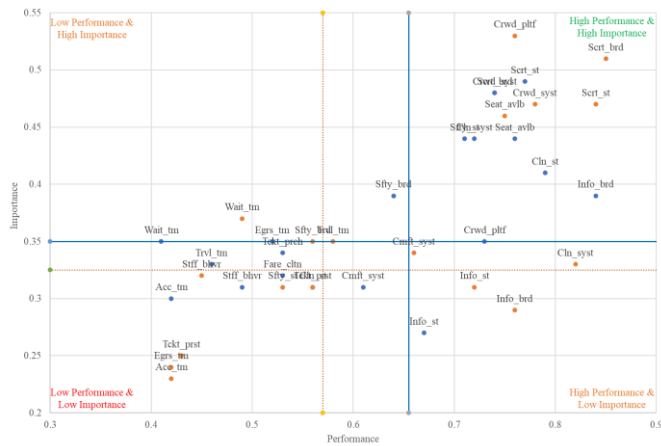


Fig-5: Importance-performance analysis (Delhi and Lucknow)

Figure 4 (Blue color used for women in Delhi and Orange color used for women in Lucknow) presents the location of each service attribute in IPA in order to determine priority for women in Delhi and Lucknow respectively.

From IPA analysis following inferences could be arrived at for four quadrants:

- **High importance – high performance:** attributes like security at the station and within the system, crowd within the system and at the platform cleanliness on-board information for Delhi meaning that their situation should be kept. Security at station, crowd within system and at the platform and seat availability are in this quadrant for women in Lucknow placed at highly important factors with high performance, which should continue to perform well.
- **High importance – low performance:** this quadrant contains waiting time, safety on board and travel time for women in Lucknow. Whereas, attributes like waiting time and egress time while travelling for women in Delhi are placed in this quadrant. These attributes should improve immediately as they are placed as of higher important factors with low performance.
- **Low importance – high performance:** this quadrant includes other attributes like comfort within the system, information availability on board and at the station and cleanliness within the system for women in Lucknow.

For women in Delhi, information availability is the only attribute falling in this quadrant which has high performance but perceived with low importance by users as excessive resources have been allocated to service attributes in this quadrant that may be used elsewhere to improve service quality of metro service.

- **Low importance – low performance:** this quadrant comprises safety at station, travel time, staff behavior, access time and ticket purchase and recharge process while travelling placed in this quadrant for Delhi. Attributes like ticket purchase and recharge process, access and egress time and staff behavior are placed in this quadrant for women of Lucknow. These attributes require do not need any attention.

3. CONCLUSIONS

This research investigates the level of women public transport users various service quality aspects within public transport system in case cities of Delhi and Lucknow. Public transport system comprising of metro and bus was chosen in case cities. Structural Equation Modelling (SEM) was chosen to determine how the importance of each service attribute influenced women's perceptions towards usage of public transportation, and Importance Performance Analysis (IPA) was done to determine which are the attributes that needs to be focused so as to increase the public transport usage of women in these two case cities.

The findings revealed that, while there are some similarities, women perceive things differently according to system availability. Women were more likely to value service aspects that promote user comfort, such as seat availability on board, air conditioning, and level of crowding at the station and on board. According to IPA, these traits require immediate improvement in both the cities, but have a more positive and significant effect on user's opinion. For metro system in both the cities, the behavioural instructions and cleanliness at the station and on-board were significant. Women prioritise station safety significantly more than within transit experience. This study shows that women using metro and earning more pay attention to time spent in the metro system from entry station to exit station, such as waiting time and transit time, also women in Delhi pay attention to time spent in accessing the service, such as access or egress time. Factors in the quadrant of high importance - low performance must be addressed immediately because they affect the service quality of the metro system in the case cities. Waiting and travel time are the most important factors for both cities, which require immediate attention to meet the needs of women who use the metro system. As this study is only limited to metro systems in both the case cities, hence a particular user group was covered in this study with only focus on metro systems.

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