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Heterogeneity in perception of service quality attributes of bus transit across various user categories- A case of Kolkata

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Abstract

Existence of heterogeneity in the perception of bus service attributes across various socio-economic groups and travel habits is an established fact, and research continues to harp upon the need to consider these differences in opinion while planning transit services. Studies highlight that various user groups based on their socio-economic characteristics, travel habits and experience of similar service, prioritize service attributes differently, which eventually reflects on their overall satisfaction with the service. Indeed, a good quality service with lower customer deflection rates makes more profit than fare hike strategies. However, most of these studies on heterogeneity in user perception of public transit services across user groups is limited to the developed countries. User perception studies on bus services in developing countries acknowledge the difference in perception, but a detailed analysis of the determinants that influence a user's overall level of satisfaction is yet to be undertaken. This study uses a principal component analysis and confirmatory factor analysis to understand if there actually exist any differences in perception about bus service attributes for various user groups. The study analyses users' perception of bus service attributes for various user categories. The categorization takes into account the differences in both socio-economic characteristics and travel habits of users.

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Keywords: Heterogenous user perception; User groups; Bus service quality attributes; Confirmatory factor analysis

1. Introduction

Market research continuously emphasizes that service quality is the key driver of an enterprise's increased income and their ability to retain customer loyalty. Zeithaml, Berry & Parasuraman (1996) observes that reducing customer deflection rates is more beneficial to an enterprises sustenance than strategies like cost reduction. The same applies upon public transport services. Though the primary goal of any public transit service is to meet the mobility demand for all, especially the lower economic strata and encourage mode shift amongst the choice riders, the latter can only

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be accomplished by increasing user satisfaction of service attributes and improving the public image of the service. Indeed, a positive perception is correlated with higher customer retention and attraction of potential users which eventually leads to increasing returns (Das & Pandit, 2013; Guirao, Garcia-Pastor & Lopez-Lambas, 2016; Pandit & Das, 2013).

Previous research has identified that different user groups perceive service parameters differently depending on their socio-economic background, geographical context, user habits, etc. (Das & Pandit, 2013), and it is important to consider the service priorities of various user groups while undertaking service decisions (Bhat et al., 2005; Bonsall et al., 2005; Cirillo et al., 2011; dell'Olio et al., 2011; Golob et al., 1972). Golob et al. (1972) highlights the need to consider the differences in perception of various socio-economic groups while designing a system. Abenoza et al. (2017) highlights the differences in determinants of travel satisfaction and their overall effect on the business of transport service in their study on public transport services in Sweden. However, most of these studies are limited to developed countries. The current study tries to analyse the differences that might probably occur in the determinants of satisfaction for overall public bus service for various user groups. The study focuses on both socio-economic and public transport usage characteristics of respondents to undertake this analysis.

This current study is divided into seven sections. The first sections discuss the need for the study, the second focuses on literature review of various behavioural studies focused on service quality of public transportation services from a user perspective. The third section discusses the current study framework and the detailed methodology. Section four presents an overview of the study area and data collections. The fifth and the sixth presents the results of the study and analyses the same respectively. The seventh section concludes on the limitations of the study.

2. Research background

Existing literature highlights the differences in perception and priorities amongst various individuals based on their age, sex, income, trip characteristics, urban environment, traffic characteristics, mode choice, route usage, etc. Not only user priorities but factors that influence a user's decision often varies across demographic sub-groups. Zeithaml et al. (1993) acknowledges that a customer's perception is affected by their behavioural intention and experiences. Differences in travel habits leads to differences in perceptions of service quality among users (de Ona et al., 2013). Users' expectation and perception of a service varies over time based on relevant information, daily experience, and experience of similar services.

In the field of transportation, user satisfaction for service quality is often investigated using either the stated importance approach or the derived importance approach. In the stated importance approach the user directly states their preference, while in the derived importance approach, a relationship is established between the user's level of satisfaction for various individual service quality attributes and their overall satisfaction. de Ona and de Ona (2015) and Rashid and Pandit (2017) argues that the derived approach provides more precise results than the stated importance approach. They argue that users tend to highlight every service as important even though they have no influence on their overall satisfaction. This can create confusion and poor allocation of limited resources. This disadvantage of the stated importance approach is of paramount concern in developing countries where users lack awareness and knowledge of a system. This research applies derived importance approach to identify attributes that are of higher importance to users in their overall satisfaction of a bus service.

Relative importance of service quality in the field of transportation is usually measured using regression analysis (Dell' Olio et al., 2010; Karen & Schofield, 2007; Iseki & Taylor, 2010; Ismail et al., 2012; Tyrinopoulos & Aifadopoulou, 2008; Tyrinopoulos and Antoniou, 2008), Principal Component Analysis (PCA) (Lai & Chen, 2011), Confirmatory Factor Analysis (CFA) (Morton, Caulfield & Anable, 2016; Yu & Lee, 2011) and Structural Equation Modelling (de Ona, et al., 2013; de Ona, Machado & de Ina, 2015; Eboli & Mazzulla, 2007; Shen, Xiao & Wang, 2016).

de Ona et al. (2013) opines that SEM is an appropriate measure in describing user's perception of various service attributes because of its consideration of latent aspects of a service that takes into consideration the complex phenomenon of user behaviour than regression methods. Shen, Xiao & Xin (2016) uses PLS estimation method in SEM for better estimation of latent factor scores in their study of user's perception of urban rail transit in China. Rashid & Pandit (2017) in their analysis of users' perception of household toilet structures has used a combination of PCA, CFA and regression analysis to establish a relationship between various household toilet service attributes and

overall satisfaction and analyze the differences in perception of service quality among various socio-economic sub-groups. This study adopts a similar approach to understand the differences in perception of bus service quality for various socio-economic categories and travel habits. However, the study is limited to the use of PCA and CFA to analyze heterogeneity in user perception.

3. Broad research framework

The first step in this research was to identify the relevant service quality attributes. Based on extensive literature review, expert opinions, pilot survey of bus users and the researchers' judgement, a list of 26 quantitative and qualitative bus service attributes has been identified for study (refer to Table 1). The attributes range from quantitative service attributes like bus stop proximity, service hours, waiting time at bus stop, headway between buses, on-time performance of service, boarding and alighting time, delay in total journey time, number of transfers, transfer distance, transfer waiting time, crowding at bus stop, crowding inside buses and fare amount/ travel cost, to qualitative service attributes like quality of pedestrian infrastructure, quality of para-transit service, quality of feeder service, bus stop design, bus design, safety and security of the system, quality of driving practice, quality of customer service, availability of route and network information at bus stops and inside buses, availability of real time information on arrival and departure of buses, and disruption in services, ease in fare calculation and ease in payment of fare .The service attributes bus stop design, bus design and safety and security of the system are considered as important bus service attributes and must be detailed out. Factors like permanent and semi-permanent structure in case of bus stops, or provision of air conditioned or non-air conditioned buses and provision of safety and security at access and egress ends, within the bus stop and within buses all play a major role in influencing a user's overall satisfaction. However, for this study they have been considered as a single attribute because of the respondents' ease in rating.

Table 1. Identified bus service quality attributes and their description

Sl. No.	Service Quality Attribute	Definitions	References
1.	Bus stop proximity	Perceived time taken by a user to walk from one's origin/ destination to the nearest bus stop.	Das & Pandit, 2015; Eboli & Mazzulla, 2011; Garrido & Ortuzar, 1994; MoUD & CEPT, 2013; NCTR, 2012; TCRP, 2003
2.	Quality pedestrian infrastructure	Provision of good quality, clean, walkable, wide footpaths	Bromley, Matthews & Thomas, 2010; NCTR, 2010; UTTIPEC, 2010
3.	Quality para-transit services	Provision of quality para-transit services that act as a feeder and helps in connecting ones origin/ destination to the nearest bus stop.	
4.	Feeder services	Availability of reliable feeder services like smaller sized buses connecting the user's origin/ destination to the nearest bus stop.	Lei & Church, 2010; Levinson et al., 2002
5.	Service hours	Perceived daily hours of bus service on an average working day.	Das & Pandit, 2015; Eboli & Mazzulla, 2011; TCRP, 2003
6.	Waiting time at the bus stop	Perceived time spent by a user at the bus stop before boarding a bus.	Das & Pandit, 2015; Eboli & Mazzulla, 2011; Golob et al., 1972
7.	Headway of service	Refers to the perceived time interval between two consecutive buses.	Das & Pandit, 2015
8.	On-time performance of service	Passenger's perception of buses adhering to scheduled arrival and departure timings based on past experience.	Das & Pandit, 2015
9.	Boarding-alighting time	Refers to the perceived amount of time a bus should stop at a bus stop even when there are no passengers waiting at the bus stop.	
10.	Delay in total travel time	Refers to the perceived delay in journey time in comparison to other modes	Das & Pandit, 2015; Garrido & Ortuzar, 1994; Golob et al., 1972
11.	Number of transfers	Total number of change in modes that a user undertakes to reach ones destination.	Andaleeb, Haq & Ahmed, 2007; Das & Pandit, 2015; Guo & Wilson, 2011
12.	Transfer distance	Perceived time that a user takes to walk from one mode to the other.	Guo & Wilson, 2011; TfL, 2009
13.	Transfer waiting time	Perceived time that a user spends for waiting while changing from one mode to the other.	Guo & Wilson, 2011; TfL, 2009

Sl. No.	Service Quality Attribute	Definitions	References
14.	Crowding level inside the bus stop	Perceived average occupancy inside the bus stop (average number of passengers standing or seating inside the bus stop in terms of its total capacity).	
15.	Crowding level inside the bus	Perceived average occupancy inside the bus (average number of passengers standing or seating inside the bus in terms of its total capacity).	Das & Pandit, 2015; Eboli & Mazzulla, 2007; Garido & Ortuzar, 1994; TCRP, 2003
16.	Route and network information	Provision of route and network information inside buses, at bus stops through information pylons, and through websites and mobile applications.	Ben-Elia & Shiftan, 2010; Das, 2013; Eboli & Mazzulla, 2016; Lei & Church, 2010; Guo, 2011, TfL, 2016 Ben-Elia & Shiftan, 2010; Das, 2013; Eboli & Mazzulla, 2016; Lei & Church, 2010; Guo, 2011, TfL, 2016
17.	Arrival and departure information	Provision of real time information on arrival and departure of buses through VMS at bus stops, through websites and mobile applications, and real time information on arrival of next bus stop inside buses.	Ben-Elia & Shiftan, 2010; Lei & Church, 2010; Guo, 2011, TfL, 2016; TCRP, 2003 Ben-Elia & Shiftan, 2010; Lei & Church, 2010; Guo, 2011, TfL, 2016; TCRP, 2003
18.	Real time information on emergencies	Provision of real time information on delay, disruption in service and incidences at bus stops and inside buses.	TfL, 2016 TfL, 2016
19.	Fare amount	Perceived amount a commuter spends while undertaking a public transit trip.	Eboli & Mazzulla, 2007, 2011; Garrido & Ortuzar, 1994; TCRP, 2003
20.	Fare structure	Refers to the various ways by which a fare is charged: i. Flat fare- fare is same irrespective of the distance travelled ii. Distance based fare- fare increases as distance increases iii. Zone-based fare- city is divided into concentric zones where fare within each zone is same irrespective of the distance travelled within the zone but fare increases as one travels from one zone to the other, based on the distance traversed	Vuchic, 2006 Vuchic, 2006
21.	Convenience in payment of fare	Refers to the users perception of convenience while paying the fare in terms of point at which fare is being paid, mode of payment, ease in fare calculation.	Das, 2013; Eboli & Mazzulla, 2011; Golob et al., 1972; TCRP, 2003 Das, 2013; Eboli & Mazzulla, 2011; Golob et al., 1972; TCRP, 2003
22.	Bus stop design	Refers to the user's perception of the over-all design features and quality of the bus stops	Das, 2013; Eboli & Mazulla, 2007; Iseki & Taylor, 2010, Phadke, 2013; UTTIPEC, 2010
23.	Bus design	Refers to the user's perception of the over-all design features and quality of buses	Das & Pandit, 2016; GIZ, 2007; Golob et al., 1972; MoUD, 2008; NCTR, 2012; TCRP, 2003
24.	Safety and security	Refers to the user's perception of the over-all safety and security of the bus service system	Das, 2013; Garrido & Ortuzar, 1994; GIZ, 2007; Phadke, 2013; Roberts, 2013; TfL, 2009

The second step involves the evaluation of users' perceived level of satisfaction. Three types of data were collected from each respondent. The questionnaire first noted the socio-economic information about the interviewee. The trip characteristics and the public transport characteristics of a respondent was collected in the second section of the questionnaire. The third section collected information on the user's perceived level of satisfaction for various quantitative and qualitative bus service attributes. The users were asked to state their perceived level of satisfaction on a Likert scale of 1 to 5 where 1 represented 'Very poor' and 5 represented 'Very good' for various bus quantitative and qualitative bus service attributes. After cleaning the data to remove missing data, PCA was applied on the satisfaction data for all respondents. This step was then repeated on the satisfaction data for various user categories to analyze any heterogeneity in perception. In the second step of analysis, CFA was applied on both the overall data and the categorized user satisfaction data to validate the PCA results, and obtain latent factors that govern the user's perception of various service quality attributes. This step also facilitates in drawing a relation between the various service attributes and the overall satisfaction for bus service. CFA is a multivariate technique that is useful in understanding the transit attitude of the users (de Ona et al., 2013). The model fit is tested using goodness of fit index (GFI), aggregate goodness of fit index (AGFI), parsimony fit index (PNFI), comparative fit index (CFI), root mean square error of approximation (RMSEA) and root mean residual (RMR).

4. Study area and data collection

The user perception survey conducted as part of this research was limited to the city of Kolkata, India. As per Census 2011, Kolkata is the largest megapolis in eastern India covering an area of 1480 sq. kms. with a population of 44,96,694. A north-south, east-west pattern is prevalent in the city's road structure. Multiple public transit modes like public bus, tram, metro rail, sub-urban rail and ferry services, along with fixed route para-transit services, app based cab services and private cab services, cater to the transit needs of the city (refer to Figure 1). Bus services are operated by both public and private operators. Due to the availability of abundant public transit mode choices, usage of private vehicles is comparatively lesser in Kolkata in comparison to other metropolitan cities of India. The urban public bus system serves approximately 54% of the total passenger travel demand of the city (Wilbur Smith Associates, 2008). The bus system is however plagued with issues like that of unreliable service, crowding, lack of maintenance, rash driving, etc. Recently, an 18 km segregated BRT service has been proposed along the Eastern Metropolitan Bypass (EM Bypass) corridor in Kolkata. This study focuses specifically upon the bus routes that ply along the EM Bypass. A total of 57 public bus routes operated by WBTC ply along this corridor, of which 25 bus routes have a minimum of 50 percent of their entire route length lying on the EM bypass corridor. These 25 routes and 15 household locations lying along EM Bypass were selected for on-board bus user and potential user survey respectively.

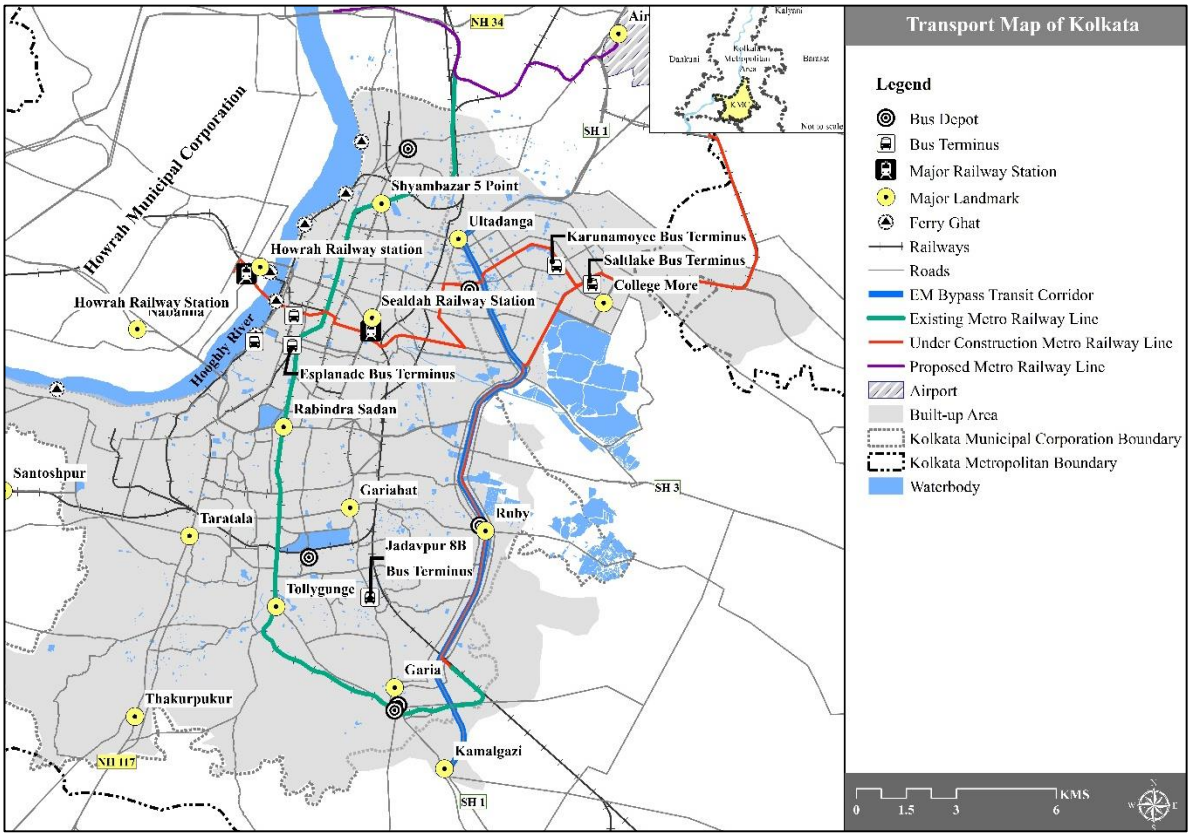

Figure 1. Transport map of Kolkata

A total of 411 complete samples were collected. The socio-economic categorisation of the sample is listed in Table 2. The users are categorised on the basis of gender, age, income of the respondents, bus user type, frequency of bus usage and vehicle ownership. The user categorisation based on age is classified as those that are less than 30 years of age representing the young adults, those that belong to the middle age group from 30- 59 years and the elderly user groups consisting of users belonging to the age 60 years and above. Captive bus users are those who do not have any alternative mode of mobility but to depend on bus services and walking as their major mode of transport. Users

belonging to low income group and lower middle income group with no access to private vehicles are categorised under this group, while choice riders belong to high middle income group and high income group with access to private vehicles. Low income respondents have monthly income of less than Rs. 10,000, respondents belonging to middle income group have a monthly income varying between Rs. 10,000- Rs. 50,000, and respondents with monthly income more than Rs. 50,000 are categorised as high income group (1 USD= Rs. 69.46). Users who use bus service less than once a week are considered as irregular users while users who uses buses daily to weekly are considered as regular users.

Table 2. Socio-economic characteristics of respondents

Socio-economic groups	Percentage of respondents	Socio-economic Groups	Percentage of respondents
Total sample size	**411**		
Gender of respondents		**Type of bus user**	
Male	64	Choice	34
Female	36	Captive	66
Age of respondents		**Income of respondents**	
<30 years	29	Low income	22
30- 59 years	58	Middle income	65
≥60 years	13	High income	13
Vehicle ownership of respondents		**Frequency of bus usage**	
Vehicle owner	33	Regular	84
Vehicle non-owner	67	Irregular	16

5. Results

It is to be noted that although the attributes proximity to bus stop, quality of feeder service and safety of the system were initially taken into consideration because of their importance and overall influence in user's choice, both PCA and CFA results showed low factor loading and significant cross loadings. As a result, these attributes have been removed during analysis of the models. The socio-economic user categories of elderly population (more than equal to 60 years) and the high income group (monthly income of 'more than Rs. 50,000') has also been omitted from analysis because of insufficient sample size.

5.1. Exploratory factor analysis

The users' perceived quality of satisfaction data was initially analyzed using exploratory factor analysis (EFA). In EFA, factors are extracted using PCA. The EFA for service quality attributes was conducted on both the overall data as well as categorized user data. Initially, a base model was developed using EFA considering all the attributes. However, the final model was defined by attributes with factor loadings of 0.4 and more, total variance explained (TVE) and satisfactory internal consistency. Internal consistency was measured using Cronbach's alpha (α) and mean of inter-correlation of items (MIC). The identified attributes are distinct and no significant cross loading of attributes occur on multiple constructs. The results for the overall model show that the attributes can be grouped into eight factor groupings namely transit information, transfer convenience, service operation, fare system, transit personnel, crowdedness and comfort, access infrastructure and others (refer to Table 3). The attributes in the eighth factor group do not explain any particular service characteristic and is thus named as others. This factor however has high attribute loadings inspite of having low internal inconsistency.

Table 3. Exploratory factor analysis for bus service attributes for all users

Attributes	1	2	3	4	5	6	7	8
Transit information (TVE: 12.60%; α: 0.971; MIC:0.918)								
Real time arrival and departure information	0.964							
Route network information	0.957							
Real time service disruption information	0.950							
Service operation (TVE: 11.48%; α: 0.769; MIC:0.397)								
Headway		0.840						
On- time performance		0.730						
Waiting time		0.716						
Delay in journey time		0.458						
Boarding and alighting time		0.447						
Transfer convenience (TVE: 10.87%; α: 0.839; MIC:0.636)								
Transfer distance			0.867					
Route directness			0.836					
Transfer waiting time			0.749					
Fare system (TVE: 10.63%; α: 0.872; MIC:0.696)								
Ease in fare calculation				0.906				
Fare amount				0.900				
Ease in fare payment				0.852				
Access Infrastructure (TVE: 7.56%; α: 0.736; MIC:0.585)								
Quality pedestrian infrastructure					0.842			
Quality para-transit services					0.828			
Transit personnel (TVE: 7.46%; α: 0.787; MIC: 0.649)								
Customer service						0.899		
Driving practice						0.830		
Crowdedness (TVE: 6.99%; α: 0.669; MIC:0.505)								
Crowding at bus stop							0.794	
Crowding inside a bus							0.787	
Others (TVE: 6.52%; α: 0.492; MIC:0.246)								
Bus stop design								0.695
Bus design								0.622
Service hour								0.613

KMO: 0.782; Bartlett's test of sphericity: 4916.147; p-value: 0.000

The factor groupings extracted for various socio-economic categories are listed in Table 4. Factors that are part of the same factor group in a user category is represented with similar symbol. For example, for the user category male, bus service attributes quality of pedestrian infrastructure, quality of para-transit services and route directness are part of the same factor grouping and are thus represented with the symbol ●. Attributes which had factor loadings less than 0.4 have been left blank and were omitted from factor extraction for the particular user group.

It has been observed in Table 4 that the factor groupings for most user categories is similar to that of the overall users. There are mostly eight factor groupings similar to the overall EFA results- accessibility infrastructure, service operation, transfer convenience, crowdedness, transit personnel, transit information, fare system and others. However, except for the socio-economic groups female, respondents aged less than 30 years and captive riders, bus service attributes like route directness, transfer waiting time, transfer distance, crowding at bus stop and crowding inside buses are grouped together. This grouping sometimes also features the attribute bus design. Factor groupings for bus service attributes like quality of pedestrian infrastructure, quality of paratransit infrastructure, waiting time, headway, on-time performance, driving practice, customer service, route network and service information, real time information on arrival and departure of buses, real time information on disruption of services, fare amount, ease in fare calculation and ease in fare payment is similar.

Table 4. Factor groupings obtained from exploratory factor analysis for various user groups

Bus Service Attributes	Gender		Age		Income		User Type		Frequency of Bus Usage		Vehicle Ownership	
	Male	Female	<30 years	30-59 years	LIG	MIG	Captive	Choice	Regular	Irregular	Owner	Non-owner
Quality pedestrian infrastructure	●	●	●	●	●	●	●	●	●	●	●	●
Quality para-transit services	●	●	●	●	●	●	●	●	●	●	●	●
Service hours		$	@	#	#	@	$	#	#	@	#	$
Waiting time	*	*	*	*	*	*	*	*	*	*	*	*
Headway	*	*	*	*	*	*	*	*	*	*	*	*
On- time performance	*	*	*	*	*	*	*	*	*	*	*	*
Boarding and alighting time	*	*	*	*	*	+	*	*	*	*	*	*
Delay in journey time	+	@	@	*	*	@	*	*	*	#	*	
Route directness	●	+	+	+	+	+	+	+	+	+	+	+
Transfer distance	+	+	+	+	+	+	+	+	+	+	+	+
Transfer waiting time	+	+	+	+	+	+	+	+	+	+	+	+
Crowding at bus stop	+	@	@	+	+	+	@		+	*	+	@
Crowding inside a bus	+	@	@	+	+	@	@		+	*	+	@
Driving practice	@	#	#	@	@	#	#	@	@	@	@	#
Customer service	@	#	#	@	@	#	#	@	@	@	@	#
Bus stop design	@	$	●	#	#	@	$	#	#		#	$
Bus design	+	$	@	#	+	@	$	#	#	#	#	$
Route network information	#	©	$	$	$	$	©	$	$	$	$	©
Real time arrival and departure information	#	©	$	$	$	$	©	$	$	$	$	©
Real time service disruption information	#	©	$	$	$	$	©	$	$	$	$	©
Fare amount	$	□	©	©	©	©	□	©	©	©	©	□
Ease in fare calculation	$	□	©	©	©	©	□	©	©	©	©	□
Ease in fare payment	$	□	©	©	©	©	□	©	©	©	©	□

5.2. Confirmatory factor analysis

The results of the EFA is validated through confirmatory factor analysis. The factor groups obtained from EFA is initially considered as the benchmark model. In case, the benchmark model does not have acceptable goodness of fit

indices, then a new model has been developed. The benchmark model for all accepted respondents is calculated with eight ξ latent factors. Access infrastructure characterizes quality of pedestrian infrastructure and quality of para-transit infrastructure. Headway, waiting time, on-time performance of the service, boarding-alighting time and delay in total journey time is represented in service operation. Transfer convenience consists of three observed variables characterizing route directness, transfer distance and transfer waiting time. Crowdedness characterizes level of crowding at bus stop and level of crowding inside a bus. Transit personnel consists of driving practice and quality of customer service. Transit information is explained by three observed variables namely provision of route, network and service information, real time information on arrival and departure of services and, real time information on disruption of services. Fare system comprises of fare amount, ease in fare calculation and ease in fare payment (refer to Figure 2). Finally, the latent parameter others comprise of three observed variables bus stop design, bus design and service hours of the system. The model has absolute fit indices GFI and AGFI values, slightly lower than the recommended value of 0.9 (GFI- 0.898; AGFI- 0.861). The RMSEA value is in the range of an acceptable fit model (RMSEA- 0.062). The values of incremental fit indices are closer to 0.9 (NFI- 0.892; CFI- 0.930).

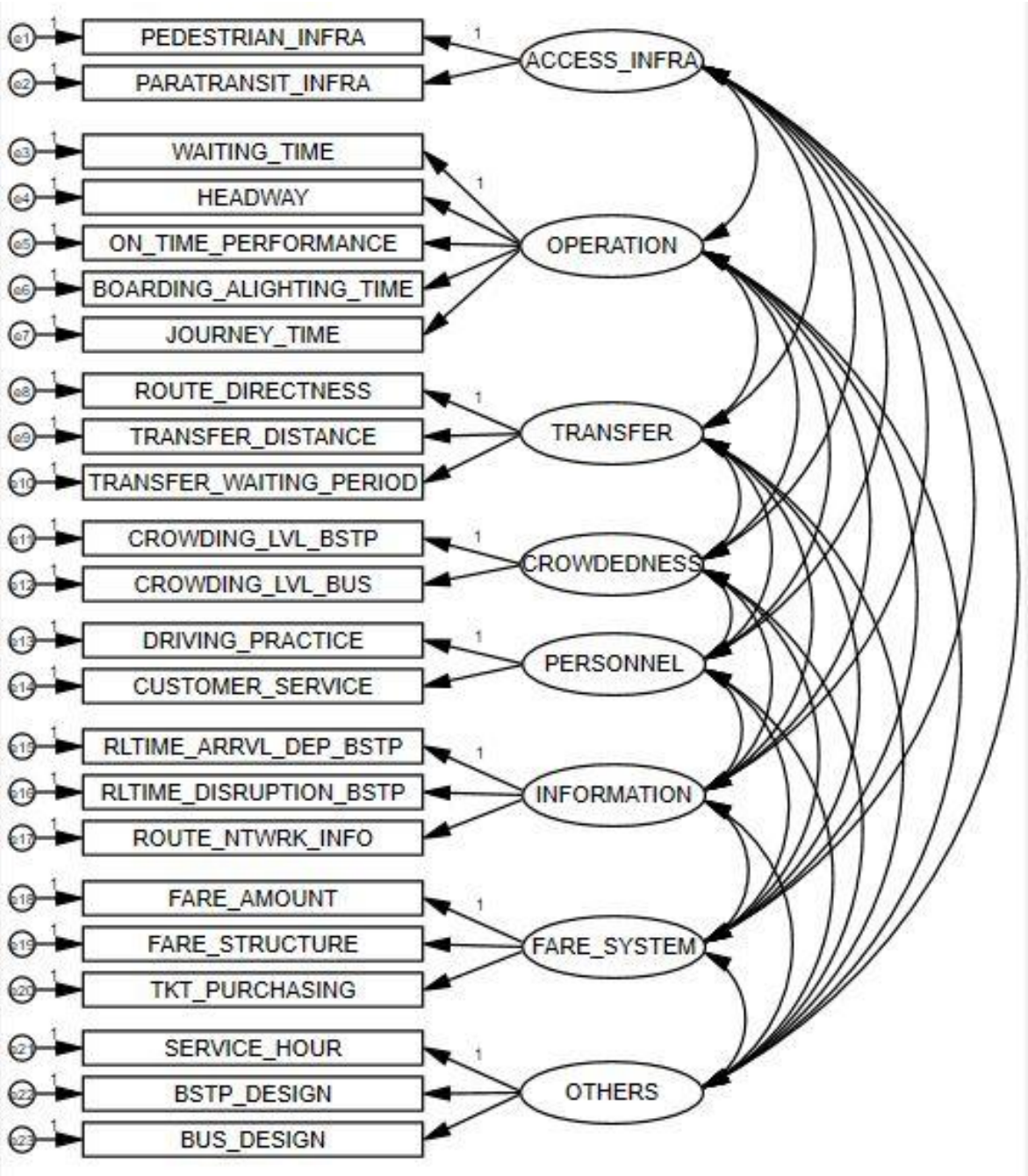

Figure 2. CFA benchmark model structure for bus service quality attributes for all users

In Model 2, the attributes quality of pedestrian infrastructure, quality of para-transit infrastructure, waiting time, delay in total journey time, bus stop design and bus design has been removed as the error terms of these attributes covary and removal of these attributes lead to an increased model fitness. The observed variable service hour is grouped under the latent construct service hours. The fit indices in this second model are better, with higher values of GFI (0.939), AGFI (0.911), NFI (0.944) and CFI (0.970), and lower values of RMSEA (0.051). In addition, by considering the lower values of RMR (0.028), we can retain the model as better than the benchmark model. The

model has six ξ latent exogenous variables namely service operation, transfer convenience, crowdedness, transit personnel, transit information and fare system. The results of Model 2 are listed in Table 5. All the observed parameters assume a value statistically different from zero at a good level of significance ($P < 0.05$). Most of the standard regression weights are all reasonably high, except for the parameters service hours and boarding-alighting time. These have standard regression weights of less than 0.5.

Analysis of the relationship between the latent exogenous variables and the observed variables reveal that headway of service (0.652) and on-time performance of the service (0.797), best describe service operation. Similarly, transfer convenience is best explained by route directness (0.768), transfer distance (0.833) and transfer waiting time (0.794). The crowding level at bus stop (0.711) and crowding level inside a bus (0.711) have equally strong relationship with crowdedness. The same occurs with transit information where the three observed variables information on arrival and departure (0.973), information on disruption in services (0.940) and route and network information (0.96) have equally strong relationship with the latent variable. Customer service (0.992) has the strongest relationship with transit personnel in comparison to driving practice (0.654). Fare amount value (0.864) and ease in calculation of fare (0.863) have stronger relationship with fare system than ease in payment of fare (0.778).

Table 5. Results of Model 2 for confirmatory factor analysis for all bus survey respondents

Observed Variables	**Latent Variables**	**RW**	**SE**	**P**	**SRW**
Service hours	Service operation	1.000			0.421
Headway		1.874	0.262	0.000	0.652
On-time performance		2.579	0.359	0.000	**0.797**
Boarding and alighting time		1.427	0.228	0.000	0.497
Route directness	Transfer convenience	1.000			0.768
Transfer distance		1.049	0.065	0.000	**0.833**
Transfer waiting time		1.080	0.073	0.000	0.794
Crowding level at bus stop	Crowdedness	1.000			0.711
Crowding level inside buses		1.107	0.157	0.000	0.711
Driving practice	Transit personnel	1.000			0.654
Customer service		1.570	0.278	0.000	**0.992**
Real time information on arrival and departure of buses	Transit information	1.000			**0.973**
Real time information on disruption in services		0.993	0.022	0.000	0.940
Route network information		0.995	0.019	0.000	0.961
Fare amount	Fare	1.000			**0.864**
Ease in fare calculation		1.121	0.058	0.000	0.863
Ease in fare payment		0.956	0.055	0.000	0.778

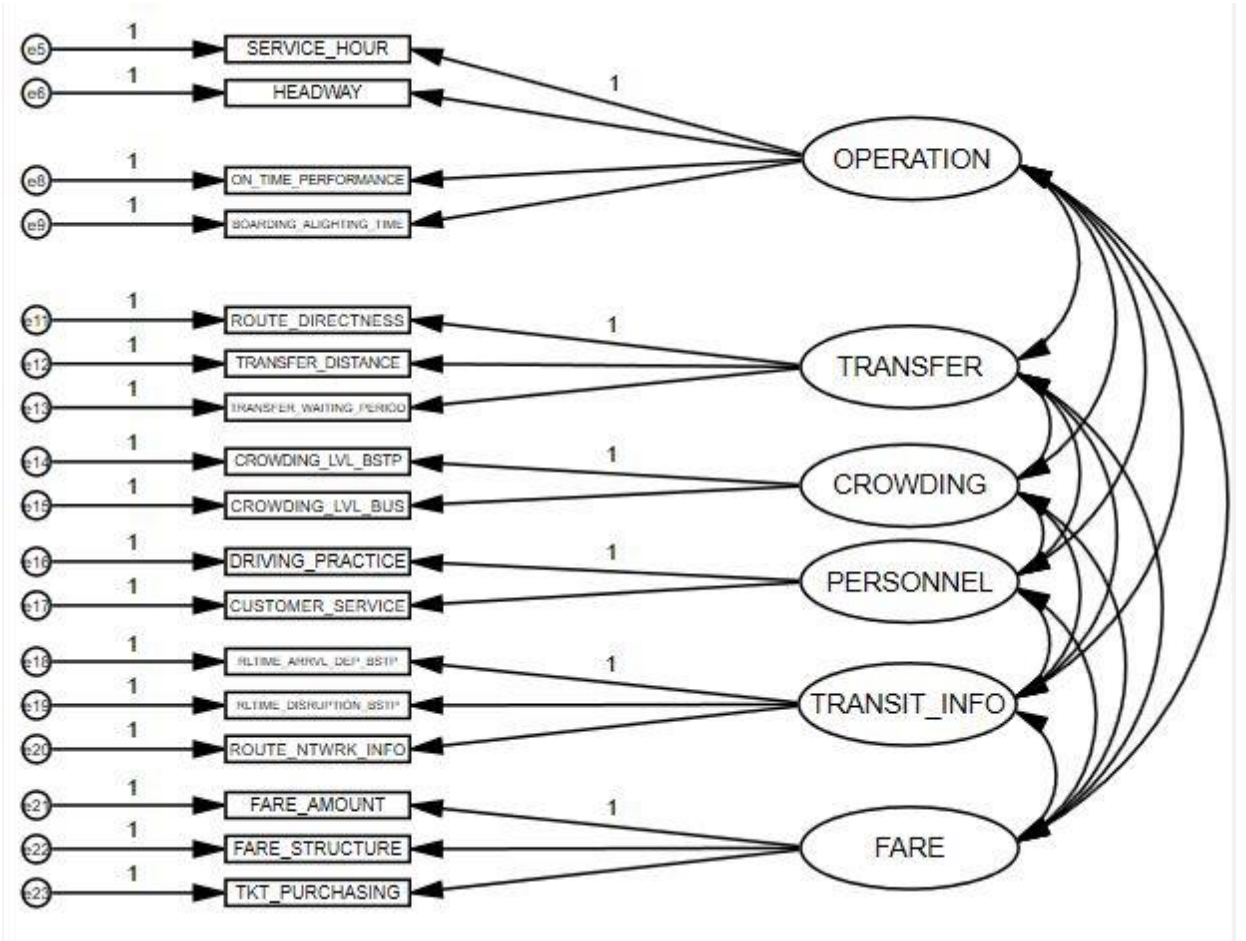

Figure 3. CFA model 2 structure of bus service quality attributes of all bus users

The EFA results for all socio-economic groups has been validated through CFA and the standardised regression weights (SRW) for the best fit model for every user group is listed in Table 6. The table shows that there are typically eight latent parameters- the observed variables quality of pedestrian infrastructure and quality of para-transit service characterises the latent parameter *accessibility*; service hours, waiting time, headway, on-time performance, boarding-alighting time, delay in total journey time is grouped as *service operation*; *transfer conveniences* characterises three attributes- route directness, transfer waiting time and transfer distance; crowding at bus stop and crowding inside buses is part of *crowdedness*; quality of driving and customer service characterises *transit personnel*; route and network information, real time information on arrival and departure of buses and disruption in services can be grouped as *transit information*; and all fare related attributes like fare amount, ease in fare calculation and ease in fare payment characterises one group here named as *fare system*. Unlike in EFA (as observed in Table 4), there are no mixing of service attributes in various factor groups. Accessibility is an influential latent variable only for male users, users between the age group 30- 59 years, middle income groups, choice users, regular bus users and non-owners of private vehicles. Service hours, waiting time at bus stop, headway of service, on-time performance of the service, boarding-alighting time and delay in total journey time influences the service operation perception of a service. The attributes waiting time or on-time performance of the service have the strongest relationship with service operation. The attributes headway, boarding-alighting time and delay in total journey time also have strong relationship with operation across all groups. Transfer convenience is an important latent factor across all socio-economic categories and the attributes route directness, transfer waiting time and transfer distance all have strong relation with transfer convenience. The same applies for transit information and fare system. Crowding at bus stop and inside buses are

important to most user groups except for choice users, irregular bus users and private vehicle owners. The latent parameter transit personnel are of consideration for both young and adults, middle income group, choice user, regular user and non-owners of private vehicles. The parameter customer service and driving practice both a have a strong relation with transit personnel. The parameters bus stop design and bus design characterising service infrastructure are of importance to users of age group 30-59 years and regular users, especially bus design which has a stronger relation to the latent parameter *infrastructure*.

Table 6. SRW values for observed bus service quality attributes for various user groups

Bus Service Attributes	**Gender**		**Age**		**Income**		**User Type**		**Frequency of Bus Usage**		**Vehicle Ownership**	
	Male	**Female**	**<30 years**	**30-59 years**	**LIG**	**MIG**	**Captive**	**Choice**	**Regular**	**Irregular**	**Owner**	**Non-owner**
Accessibility infrastructure												
Quality pedestrian infrastructure	**.739**	-	-	**.866**	-	**.808**	-	.722	**.767**	-	-	**.942**
Quality para-transit services	.663	-	-	.591	-	.639	-	**.789**	.668	-	-	.571
Service operation												
Service hours	-	-	-	.429	.476	-	.348	-	-	.562	-	.424
Waiting time	**.663**	-	-	-	**.863**	-	**.710**	-	-	**.940**	**.992**	-
Headway	-	.633	.618	.609	-	.577	-	.516	.607	.825	.706	.615
On- time performance	.611	**.805**	**.699**	**.790**	.524	**.844**	.624	**.716**	**.731**	.722	.646	**.761**
Boarding and alighting time	.542	.559	.625	.551	-	-	-	.624	.542	-	-	.568
Delay in journey time	.531	.567	.515	.581	-	-	-	-	.591	-	-	.561
Transfer convenience												
Route directness	.738	.771	.801	.747	.784	.735	.750	.738	.744	.767	.738	.759
Transfer distance	**.835**	**.869**	.802	**.850**	**.820**	**.844**	.834	**.899**	**.846**	**.891**	.851	**.836**
Transfer waiting time	.813	.779	**.884**	.784	.816	.807	**.786**	.835	.797	.851	**.887**	.777
Crowdedness												
Crowding at bus stop	.661	.635	**.807**	.573	**.744**	.689	.737	-	.646	-	-	.697
Crowding inside a bus	**.704**	**.880**	.763	**.690**	.737	**.725**	**.768**	-	**.800**	-	-	**.784**
Transit personnel												
Driving practice	-	-	**.767**	.726	-	.718	-	.727	.720	-	-	.704
Customer service	-	-	.706	**.987**	-	**.960**	-	**.918**	**.924**	-	-	**.945**
Transit information												
Route network information	.954	.961	.942	**.966**	**.986**	.951	.959	**.984**	.958	**.944**	.931	.965
Real time arrival and departure information	**.982**	**.972**	**.998**	.965	.916	**.975**	**.978**	.909	**.977**	.742	**.995**	**.973**
Real time service disruption information	.941	.922	.924	.934	.969	.938	.943	.943	.933	.941	.874	.960
Fare system												
Fare amount	.811	**.895**	.750	**.865**	**.940**	.796	**.885**	.730	.822	**.968**	.742	**.879**
Ease in fare calculation	**.874**	.811	**.866**	.856	.844	**.841**	.866	.818	**.846**	.906	.824	.874

Bus Service Attributes	Gender		Age		Income		User Type		Frequency of Bus Usage		Vehicle Ownership	
	Male	**Female**	**<30 years**	**30-59 years**	**LIG**	**MIG**	**Captive**	**Choice**	**Regular**	**Irregular**	**Owner**	**Non-owner**
Ease in payment of fare	.766	.725	.680	.808	.722	.775	.719	**.836**	.755	.789	**.835**	.717
Infrastructure												
Bus stop design	-	-	-	.349	-	-	-	-	.428	-	-	-
Bus design	-	-	-	**.625**	-	-	-	-	**.706**	-	-	-

6. Analysis

The major goal of this study was to understand the heterogeneity in perception while prioritizing bus service quality attributes for developing countries. The results of this study highlight that irrespective of variation in socio-economic and trip characteristics of individuals, bus service attributes are categorized primarily as accessibility infrastructure, service operation, transfer convenience, crowdedness of the system, quality of transit personnel, quality of transit information, fare system and bus service infrastructure. However, there exists difference in prioritization of service attributes among individual user groups.

Accessibility is an influential latent variable for male users, users between the age group 30- 59 years, middle income groups, choice users, regular bus users and non-owners of private vehicles. These users except for choice users forms the majority as well as the most frequent users of the service. They understand the system better and finds poor accessibility as a major impedance to their mobility needs. The choice riders are usually the users who are more aware of the sustainability of the system and feels that improved accessibility enhances the overall experience of the system.

The attribute service hours grouped under to the latent parameter *service operation* is relevant only for the user groups aged between 30-59 years, LIG, captive riders, irregular bus users and non-owners of private vehicles. The user groups LIG, captive riders and non- owners of vehicles are all highly dependent on bus service for their mobility needs. Service timings play a major role in their trip planning. Most young adults are dependent on bus service for conducting their compulsory trips, while irregular users usually lack knowledge about service timings and thus service hour is an important service attribute. It is to be noted that except for the user group irregular bus users, SRW value for all user groups for the attribute service hour is low, thus referring to the lower influence of the attribute to the overall service operation. The service attribute on-time performance has a strong relation to the latent construct across all user groups. This is similar to the results obtained by Cirilli, Eboli & Mazzulla (2011), de Ona et al., (2015) and Eboli & Mazulla (2012), where they have observed that punctuality of service is the most influential bus service attribute across all user groups. A comparison of the SRW values among user groups reveal that on-time performance has the strongest relation to *service operation* for female users unlike the male users where waiting time has the highest value. This may be related to their inherent nature of trip characteristics. Females tend to trip chain (Roberts, 2013) and thus punctuality of bus service affects their travel plan. Male users on the other hand usually are dependent on public transit to conduct compulsory trips. So, inspite of the fact that on-time performance has a strong relation to the latent parameter, waiting time is the most influential attribute in the factor group. A similar difference in prioritization is observed among regular and irregular users of bus service. Irregular users who are not accustomed to the schedule of the service, finds waiting time as a stronger attribute than regular users who has a stronger relation between on-time performance of the service and *service operation*.

The latent construct *crowdedness* is irrelevant for choice users, irregular users and vehicle owners. All these three groups have access to alternate modes or routes. Crowding was found to be an attribute of low importance in user perception survey in Milan (de Ona et al., 2015) too.

Across all user groups the attributes under transfer convenience, transit information and fare system mirror the results of overall users. Transfer convenience was not a factor of consideration in studies conducted in developed countries. Public transit modes in developing countries lack integration both in terms of service integration and integration with other modes. Thus making it an important factor influencing satisfaction.

The importance of transit information across all users is similar to the findings of de Ona et al. (2015) and Eboli & Mazzulla (2012) where qualitative attributes like route information had higher influence on overall satisfaction. This finding however contrasted the study of Cirillo, Eboli & Mazzulla (2011). Their study observed that most respondents were not interested in transit information.

Fare was splitter variable in the CART methodology used by de Ona et al., (2015). This implies its influence on overall satisfaction. However, in their study fare as travel cost was an important variable while in this current study fare amount is not the most influential attribute though it has a strong relation with the latent construct *fare system*.

Lack of influence of transit personnel on the user's overall satisfaction is a common observation across all studies. Lack of any significant relation to quality of transit personnel among captive and lower income user groups can be attributed to their lack of alternate services.

The latent parameter *transit infrastructure* is of importance only to users who characterize higher usage of bus service. Bus design has stronger relation with the latent construct, for the users of age group 30-59 years and regular users. This is contrast to the study by de Ona et al. (2015) where qualitative attributes related to bus stop design and bus design were found to have high influence on overall satisfaction. However, a detailed study on the bus stop and bus infrastructure needs to be conducted to understand their relation to overall satisfaction of bus service.

7. Conclusion

The present study does have certain limitations which probably might have an influence on the results. The study is limited only to the public bus users of the city of Kolkata and can be a location specific result. The results may vary across various geographic locations. A detailed study on heterogeneity of perception needs to be conducted across geographies. Also, potential users of service must also be considered as user category for analysis.

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