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An assessment towards identifying improvement needs of urban bus stop infrastructure: Knowledge gained from Bhubaneswar

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Abstract

The article presents a work on assessment of urban bus stop infrastructure in Bhubaneswar, and identifies improvement needs of the same as per bus passengers' requirement and satisfaction. The work proposes a rationally appealing assessment framework, which uses perceived information of bus passengers on various infrastructural items collected in the scales of their importance and satisfaction level. In wake of this assessment, the key-factors are first determined using exploratory factor analysis (EFA) on the stated importance ratings of an array of items, and then those key-factors are ordered using Relative to an Identified Distribution Integral Transformation (RIDIT) analysis on stated satisfaction ratings of the same survey items. The assessment framework takes an attempt to exploit the strength of these two types of data, while preparing the policy framework for improvement. The ordering of key-factors is carried out for two types of bus commuter such as captive users and choice riders. The work documents new evidences in terms of improvement requirement of bus stop infrastructure in mid-sized urban areas of emerging economies like India.

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Keywords: urban bus stop infrastructure; importance and satisfaction data types; exploratory factor analysis; ranking method; policy implication

1. Introduction

Urban areas in India have experienced a sharp economic growth in the past two decades, which has finally led to a rapid growth of vehicle usage on urban roads. It causes a vehicle-centric urban mobility environment, which has finally triggered a number of transport related problems. Such problems have made transportation policy makers to realize the importance of public transport system (Luk, 2003; Badami and Haider, 2007) in improving urban mobility. In majority of Indian cities, bus transportation is often treated as a predominant public transport (Maitra and Sadhukhan, 2013a and b) service. But, the success of bus transport service depends not only on urban transportation network being served by it and its service quality; but also to a great extent on service condition of facilities (Hamby and Thompson,

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2006) provided at urban bus stops. An urban local bus stop facility poses as a key link between the access/egress leg of a bus passenger and the journey in a city bus. Some former studies (Iseki and Taylor, 2010; Morton et al., 2016) highlighted the importance of bus stop improvements towards overall success of urban bus service.

Over the years, city bus service in urban India has experienced a gradual decrease in ridership (Srinivasan and Rogers, 2005). In such situation, the Government of India has taken several initiatives and missions such as National Urban Transport Policy (NUTP 2006 and 2014), Jawaharlal Nehru National Urban Renewal Mission (JnNURM), Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and SMART Cities mission etc. to improve the patronage in urban bus service. In line with this, city bus service was introduced in Bhubaneswar city, India in 2010 under JnNURM (Jawaharlal Nehru National Urban Renewal Mission) as a measure to improve urban mobility through capacity management. Until the year 2010, the city's public transport needs primarily used to be catered by shared-auto service. Shared-auto is a para-transit mode having carrying capacity of about 4-6 passengers. In spite of newly introduced city bus service, the patronage observed in bus service was found not high enough. The report of the CoE-CEPT (2014) indicated that on a typical week day, the city bus service catered to about 35,000 – 40,000 passengers; whereas the shared auto service catered to as high as 1.6 lakh passengers. This implies that about 4 to 5 times more transit passengers are served by shared-autos than that by city bus service. One of the primary reasons for such skewed distribution of ridership between shared-auto and city bus service may be attributed to longer waiting time (IIT Bhubaneswar Unpublished Report, 2015; Basu and Banik, 2015) at bus stops. A relatively longer waiting time at bus stops often poses as a burden to bus passengers. This fact was even highlighted in some of the previous studies (Kittelson and Associates, 2003; Mishalani et al., 2006). They identified that an appropriate improvement in infrastructural facilities could reduce the burden of waiting at urban local bus stops. Some other researchers (Iseki and Taylor, 2009; Litman, 2015) also mentioned that there was a positive correlation between improvement of infrastructural facilities at bus stops and bus patronage. The above fact clarifies that a significant passenger demand could be served by city bus service, if burden for waiting time at urban bus stops can be improved as per bus passengers' infrastructure requirement and satisfaction.

Therefore, the primary objective of the present study is to carry out a rational assessment towards identification of infrastructural improvement needs of local bus stops in Bhubaneswar city as per bus passengers' requirement and satisfaction. In this work, an attempt has been undertaken to propose a rationally appealing assessment framework, which uses perceived information of bus passengers on various infrastructural attributes collected in the scales of their importance and satisfaction level. The assessment framework takes an attempt to exploit the strength of these perceived data types, while preparing the policy framework for improving of bus stop infrastructural facility. In order to satisfy the objective, key-factors of an urban bus stop infrastructure are determined first, and then an assessment of them is carried out by ordering as per their improvement needs. While achieving this, the key-factors are determined using the stated importance ratings as given by bus passengers; and then those key-factors are ordered using the stated satisfaction ratings as given by the same bus passengers. Needless to mention, the perception towards satisfaction level of the identified key-factors may not remain same across different user groups. Therefore, the current investigation considers two types of bus passenger such as captive bus users and choice riders. The captive bus users are those, who only undertake urban local bus service; whereas choice riders are those, who have alternative travel mode options other than local bus service for their reported trip purpose.

2. Design of survey instrument and database development

As mentioned, the study area is the geographical area of Bhubaneswar city, where city bus transport service is in operation. The work identifies an array of items relating to city bus infrastructure through systematic literature review, which are likely to be perceived by bus passengers waiting at urban local bus stops in Bhubaneswar. A survey item consists of a statement describing a typical urban local bus stop infrastructure, which could belong to either of any of the six major infrastructure categories such as bus stop location and its surroundings, bus stop shelter, safety and security, bus stop amenities, access path to bus stop, and built-environment. These categories are summarized based on review of works as reported in established literatures (Loukaitou-Sideris et al., 2001; Kittleson and Associates, Inc. et al., 2003; Washburn and Kirschner, 2006; Caulfield and O'Mahony, 2009; Iseki and Taylor, 2009; Iseki and Taylor, 2010), and then a thorough discussion with various bus passengers. In this study, a total of 37 survey items (as given in Table 1) are finally shortlisted.

Table 1. List of survey items under six major categories

SL #	Major Categories of Survey Items and Statements
Your Current Bus Stop and its Surrounding Area	
1	The bus stop is located at a safe-distance from the nearby intersection or median opening such that through moving traffic remains unaffected and bus-commuters' boarding and alighting experience becomes safe and comfortable
2	Crosswalk facility exists nearby for conveniently accessing bus stop located other side of the road
3	The presence of road-markings or reflector around the bus stop
4	Low height of kerb at bus stop is required to conveniently access bus footboard
5	Presence of kerb-ramp facility at the bus stop for convenient access to bus footboard
6	Presence of safety measures and speed regulatory signs surrounding of the bus stop
7	Presence of way-finding sign-board to bus stop
8	Appropriate placement of way-finding sign-board for making it visible
9	Prohibition of vehicle-parking around the bus stop
10	Cleanliness around the bus stop
Bus Stop Shelter	
11	Presence of bus stop shelter is required at bus stop
12	Adequate room is available at bus stop shelter for accommodating all waiting bus passengers inside
13	Presence of adequate number of seating facility
14	Material of seating facility makes your seating experience comfortable
15	Dimensions of seating facility provides comfortable seating experience
16	Sufficient width of sidewalk facility/pedestrian right-of-way is required at bus stop shelter for providing unobstructed movement of through moving pedestrians
17	Presence of informatory display board of operational bus route number and their schedule
Safety and Security at Bus Stop	
18	Presence of proper lighting facility at the bus stop
19	Presence of surveillance system (such as CCTV/Security Camera) to ensure better security measures at bus stop
20	Presence of civic volunteers for assisting old and disabled, children at bus stop
21	Safety of the waiting bus commuters from through moving traffic at the bus stop zone
Bus Stop Amenities	
22	Presence of public awareness messages and knowledge based messages at the bus stop shelter
23	Presence of public kiosks (such as newspaper stands, information desk etc.) adjacent to bus stop
24	Presence of drinking water facility and refreshment stall adjacent to bus stop
25	Presence of first-aid facility at bus stop for medical emergency
26	Presence of public restrooms nearby of a bus stop
27	Presence of public telephones or other emergency facility at bus stop
Access Path to Bus Stop	
28	Presence of dedicated sidewalk facility to access bus stop
29	Sidewalk is required to have sufficient width
30	Surface condition of sidewalk facility
31	Presence of ramp facility at crosswalks to conveniently access sidewalk facility
32	The guard-rail facility is required on sidewalk accessing bus stop
33	Presence of lighting facility on access path
Built-environment around Bus Stop	

34	Visual attractiveness of greenery landscaping in the neighborhood of bus stop
35	Absence of obstructions due to road-side construction activity, trees/post and other encroachments near bus stop
36	Movement of pedestrian is observed in the neighborhood of bus stop
37	Presence of convenience services such as retail shops/banks/post offices/clinics around bus stop

A paper-based survey instrument is designed to collect responses from bus passengers, who usually undertake walk mode to access city bus service. The questionnaire included two parts. In the first part, respondents' socio-economic and trip- related information are collected; whereas in the second part, respondents' perception towards various survey items are recorded on importance and satisfaction scale. The current study uses a 7-point Likert type ordinal scale. The rating points (1-7) of the Likert scale are classified as extremely unimportant (1), unimportant (2), moderately unimportant (3), neither important nor unimportant (4), moderately important (5), important (6), and extremely important (7). Similarly, the satisfaction ratings are classified as extremely dissatisfied (1), dissatisfied (2), moderately dissatisfied (3), neither satisfied nor dissatisfied (4), moderately satisfied (5), satisfied (6), and extremely satisfied (7). A paper-pencil based face-to-face interview was carried out at various bus stop locations across the city of Bhubaneswar between December, 2017 and February, 2018. The survey was conducted at 55 major and semi-major bus stop locations across the city, which encompass various types of urban form such as residential and other economic activity areas like workplace, business, shopping etc. During data collection, survey respondents were initially requested to provide their socio-economic and trip information. Then, they were briefed about various elements of a typical modern urban bus stop. In order to collect such travel behavior data, bus passengers were intercepted randomly by a survey enumerator. The survey experience indicated that in order to obtain complete travel behavioral information from a bus passenger (who agrees to participate in the behavioral study), about 20 to 30 minutes time was needed. Over course of the survey administration, around 1700 bus users were intercepted with a request to participate in the survey, out of which only 1250 passengers finally agreed to participate. However, due to inconsistency and some incompleteness in filling out of some questionnaires, only 1071 responses were finally used for analysis. Out of the total 1071 respondents, 578 respondents were found to be taken from captive bus users and 493 from choice riders.

3. Assessment framework of user perception data

In the first step, determination of key-factors for the urban local bus stop infrastructure is carried out using exploratory factor analysis (EFA); and then in second step, the key-factors are assessed by ordering them as per bus passengers' satisfaction ratings using ranking method called as Relative to an Identified Distribution Integral Transformation (RIDIT). The rank order is prepared in such a way that key-factors ranked with lower values and thereby all survey items belonging to those key-factors are appeared to be poorly rated by bus passengers in terms of satisfaction, and therefore they may be identified as priority areas of intervention for improvement. In this study, the key-factors are first generated using bus passengers' perceived information on importance level of various survey items. Subsequently, the preparation of rank order of the key-factors is done using bus passengers' perceived information on satisfaction level of the generated key-factors, which are evaluated using perceived satisfaction level of various survey items belonging to key-factors.

As said, a bus passengers' perception (in scale of importance and satisfaction) on six major categories of urban bus stop infrastructure was collected on 37 survey items. However, intuition and thorough inspection of these survey items suggest that there could be a possibility of the existence of multi-dimensional correlation among these survey items. Therefore, a reduction in the dimension of dataset is required to be done as a priori. In this aspect, an Exploratory Factor Analysis (EFA) is employed in order to remove the redundancy due to presence of the correlated survey items. In EFA, the derived key-factors remain highly uncorrelated with each other; while the survey items belonging to a key-factor remain highly correlated. The EFA analysis is carried out by following theoretical guidelines as demonstrated in Hair et al. (2012). The derived key-factors are supposed to be true indicators of the scientific major infrastructure categories of a typical bus stop as desired by city bus passengers in Bhubaneswar.

In the second step, the derived key-factors are assessed by ordering them as per their relative service condition using a ranking method. The indicator of the service condition of key-factors are taken as their perceived satisfaction scores. Any ranking method is a Multi-Criteria Decision Making (MCDM) tool, which searches for the best (or worst) alternative among a set of feasible alternatives. With reference to the current study, the generated key-factors are considered as alternatives; whereas their factor scores (or the Likert scale points) are considered as decision criteria. In this study, the factor scores are estimated from raw satisfaction score matrix of the survey items (as referred in Eqn. 1). Survey items loaded onto a key-factor are considered for estimating the factor score of that particular key-factor. The item loadings (refer Eqn 2.) are considered as weights. The procedure for calculating the factor score is illustrated below.

Let the raw satisfaction score matrix be denoted by R. Therefore,

$$R = \left[r_{ij}\right]_{i\times j} \text{where } i = 1,2,\dots, number\ of\ respondents,\ j = 1,2,\dots, number\ of\ items \quad (1)$$

Again, let the item loading matrix be denoted by L. Therefore

$$L = \left[l_{jk}\right]_{j\times k} \text{ where } j = 1,2,\dots, number\ of\ items, k = 1,2,\dots, number\ of\ factors \quad (2)$$

In the above matrix, the item loading of any survey item within a factor is set to zero, if that item is not loaded onto that factor as a result of EFA. This is done to ensure that the weighted mean is taken only for those survey items, which are loaded onto a particular factor. After that, the factor score is estimated as the weighted mean of raw scores of the survey items loaded onto that factor. The weighted mean technique (Winters et al., 2011) is employed to ensure that an estimated score of a key-factor remains bounded by the same scale (i.e., 1 to 7) as that of Likert scale considered in the study. Such estimated scores of key-factors can be considered as criteria for RIDIT analysis. The factor score matrix F, can be calculated as follows

$$F = [f_{ik}]_{i\times k} = \left[r_{ij}\right]_{i\times j} \times \left[l_{jk}\right]_{j\times k} \quad (3)$$

The factor scores are then scaled and the scaled factor score matrix F' is estimated as follows

$$F' = \left[f'_{ik}\right]_{i\times k} = \left[\frac{f_{ik}}{\sum_i l_{jk}}\right]_{i\times k} \quad (4)$$

As mentioned before, any ranking method requires to a decision matrix as an input. With reference to the present study, the form of decision matrix M becomes

$$M_d = \left[d_{ij}\right]_{\mathrm{i\times j}}\ where\ i = number\ of\ factors, j = 1,2,\dots,7\ Likert\ Scale\ points \quad (5)$$

In the above equation, d_{ij} is the frequency of occurrence of j^{th} Likert Scale point for the i^{th} key-factor. The decision matrix forms the basic input in any ranking method. The following sub-sections now briefly describe the procedure for deriving rank order of derived key-factors using RIDIT analysis.

3.1. Procedure for deriving rank order using RIDIT

Relative to an Identified Distribution Integral Transformation or RIDIT analysis was proposed by Bross (1958), which has widely been used in preparing relative ranking of alternatives. It is a "distribution free" analysis that makes no assumption about distribution of the population under study. In this work, it is employed to order derived key-factors in terms of their relative service condition as represented by their mean RIDIT scores. A RIDIT-score is interpreted as odds ratio (sometimes called as probability) of an alternative (i.e. a derived key-factor) being more important than the other alternatives (Flora 1974). In this study, the key-factors having mean RIDIT scores higher than 0.50 indicate that they have higher odds of being perceived as more important than the other key-factors having mean RIDIT scores less than 0.50. The key-factors are then ranked in descending order of their RIDIT scores. Therefore, in line with this study, the steps to be followed for ranking of key-factors using RIDIT analysis is illustrated with the help of the following steps.

Step 1: The first step is to select a population as a reference data set, which is comprised of the total responses of a survey (i.e. the total number of respondents multiplied by the total number of survey items being asked for rating).

Step 2: In this step the following decision matrix, M_d is estimated as explained before.

$$M_d = \begin{pmatrix} d_{11} & \cdots & d_{1j} \\ d_{21} & \cdots & d_{2j} \\ d_{31} & \cdots & d_{3j} \\ \vdots & \ddots & \vdots \\ d_{i1} & \cdots & d_{ij} \end{pmatrix} \quad (6)$$

where, d_{ij} is the frequency of the i^{th} Likert scale point as recorded for the j^{th} key-factor.

Step 3: The cumulative score for each category of response (here factor score) is calculated using the following equation

$$d_j = \sum_{i=1}^{n} d_{ij} \ \forall \ n \ number \ of \ factors \quad (7)$$

Step 4: The mid-point scores (D_j) for each of the key-factors is calculated as follows

$$D_j = \frac{1}{2} d_j \ if \ j = 1 \quad (8)$$

$$D_j = \frac{1}{2} d_j + \sum_{k=1}^{j} d_k \ \forall \ j = 2, \dots, n \quad (9)$$

Step 5: The RIDIT value for each of the key-factors is then computed using

$$R_j = \frac{d_j}{N} \quad (10)$$

Here, N= total number of responses from the Likert scale survey, (i.e. the total number of survey respondents multiplied by the total number of survey items being asked for rating).

Step 6: The RIDIT value matrix is then computed with normalized RIDIT values r_{ij}, where r_{ij} is normalized over the whole population of responses as shown below

$$r_{ij} = \frac{R_j \times \pi_{ij}}{\pi_i} \quad (11)$$

$$\pi_i = \sum_{k=1}^{n} \pi_{ij} \quad (12)$$

In the above set of equations, $\pi_{ij} = \text{total number of respondents}$.

Step 7: The mean RIDIT score for each alternative key-factor is then calculated as follows

$$\rho_i = \sum_{j=1}^{j} r_{ij} \ , \forall \ i \ \text{number of city key} - \text{factors} \quad (13)$$

Step 8: In this step, a statistical parameter called Kruskal-Wallis statistics is computed in order to test the hypothesis whether the derived RIDIT scores are significantly deviating from 0.50. This test-statistics is computed as follows

$$W = 12 \sum_{i=1}^{i} \pi_i (\rho_i - 0.5)^2 \quad (14)$$

Step 9: The city bus stops are then ranked in descending order of their RIDIT scores. This means that a city bus stop with higher mean RIDIT score has more probability of being in worse condition than the other city bus stops.

Therefore, the current work follows a two-step evaluation process, where the key-factors of a typical bus stop infrastructure are extracted using EFA using importance ratings, and then they are ordered according to their relative satisfaction level using satisfaction ratings by RIDIT analysis. The overall framework for this current assessment is illustrated using flow-chart as shown in Fig. 1.

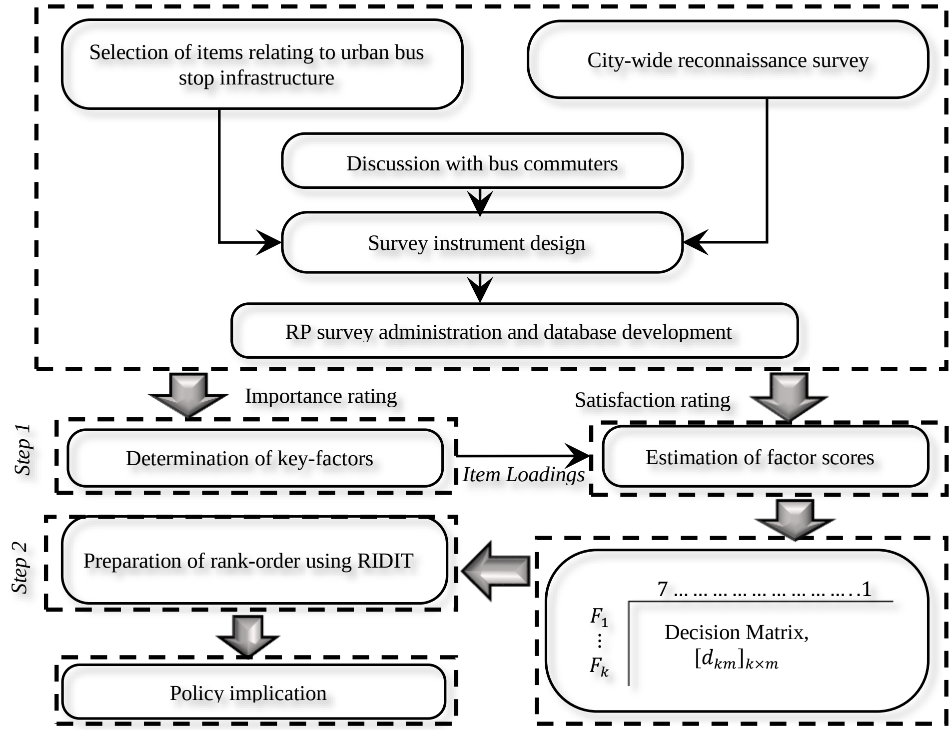

Figure 1. A framework for assessment of bus stop infrastructure

4. Analysis, results and discussion

In order to employ the EFA, the dataset should first be checked for its compatibility for the EFA. Several tests need to be carried out for this purpose. One simple and preliminary test is the determination of sample to variable ratio. The accepted range for sample to variable ratio could vary (Hair et al. 2012) between 3:1 and 20:1. The sample size for this study is 1071, and the number of variables is 37. Therefore, the sample to variable ratio for this study is found to be suitable for EFA. This ratio is a kind of test for adequacy of the number of samples in relation to the number of variables considered in the study, so that factor analysis can be employed. This measure of adequacy has further been validated with the help of determination of a robust estimator called Kaiser-Meyer-Olkin (KMO) measure for sampling adequacy. The threshold KMO value is 0.5 as per Tabachnick et al. (2007). In another test, an initial assumption is made that the correlation matrix of the raw data is not an identity matrix, which may statistically be referred to as the null hypothesis (H_0). The significance of this hypothesis is that, if the matrix is not an identity matrix, then there exists some degree of correlation between the dissimilar survey items. This means that these correlated items may be clubbed together, and the dataset can be reduced into simpler form. The acceptance or the rejection of H_0 depends on the statistical significance of the approximate chi-squared value as calculated from the Bartlett's Test of sphericity.

In order to extract latent factors from the survey responses, the Weighted Least Squares Means and Variance Adjusted (WLSMV) estimator has been used. The extracted factors are not mutually uncorrelated. However, the objective of this study is to find distinct uncorrelated factors. Mathematically, it may be explained that the resultant factors should have the maximum variance among them. The procedure followed in order to achieve the same is Varimax rotation. The Varimax rotation is a type of orthogonal rotation, which maximises the variance among extracted factors. The method of steepest descent iterations have been used to obtain the uncorrelated key-factors with the maximum variance among them. The convergence criteria is set at 5×10^{-5}. The results of the factor analysis has been validated using some further statistical tests. One such test parameter is called the Cronbach's Alpha, which measures the internal consistency of the extracted key-factors, or more specifically to mention that how a set of survey items are closely related as a group. The index is basically a measure of the reliability, and value of 0.70 or higher is considered acceptable (UCLA Statistical Consultant Group). The Kaiser criterion of extracting factors with Eigen value more than unity is usually followed in literature. However, this restriction may be relaxed in some cases according to some literature (Jolliffe, 1972) in order to obtain easily interpretable factors. The threshold value in such cases is taken as 0.7. Another easily observable test criteria is the cumulative variance of the dataset, which is adequately explained by the extracted key-factors. The cumulative variance explained as a measure that the fewer number of key-factors can sufficiently represent the whole dataset. Usually, 60% cumulative variance is set as the minimum threshold (Bartholomew, 2008). The goodness-of-fit criteria for the factor analysis model can be estimated from the Root Mean Square Error of Approximation (RMSEA) and the Root Mean Square Residual values. The maximum thresholds for these parameters are found to be 0.06 and 0.08 respectively (Muthén and Muthén, 1998).

The EFA on the survey responses reveals a total of 7 key-factors (as shown inTable 2) namely bus stop shelter, bus stop amenities, access path, markings and informatory signs, safety at bus stop, lighting and security, and bus stop location. A key-factor has been named keeping in mind the characteristics of survey items with the highest loadings within a particular key-factor (Hair et al., 2012). The adequacy of the extracted key-factors in describing the pedestrian perception is evident from the 70.44% (more than 60%, Bartholomew, (2008)) cumulative variance explained by them. The KMO measure of sampling adequacy is used as a test parameter to verify, whether adequate number of responses exist in comparison to the number of survey items. It is observed that the KMO value of 0.882 is acceptable, when compared to the threshold (0.5) provided by Tabachnick et al. (2007). The approximate chi-squared value from the Bartlett's Test of Sphericity is found as 8969.52, which is highly significant (significance <0.0005) and thereby accepting the null hypothesis. Besides, in order to measure internal consistency of the extracted factors, Cronbach's alpha index is calculated. It is observed that all extracted key-factors are found to be consistent. In process of the extraction of key-factors, the survey items with loadings of less than 0.3 have not been considered.

Table 2 Extracted key-factors from EFA

Key-factors determined	Eigen value	Variance explained	Cumulative variance explained	Brief description of items	Factor loadings	Cronbach 's Alpha
Bus Stop Shelter	11.035	29.82%	29.82%	Presence of bus stop shelter	0.721	0.892
				Adequate room at bus stop shelter	0.678	
				Material of seating facility at bus stop	0.590	
				Dimension of seating facility	0.582	
				Adequate number of seating facility	0.511	
				Sufficient width of sidewalk at bus stop	0.380	
Bus Stop Amenities	4.085	11.04%	40.86%	Drinking water facility	0.677	0.868
				Presence of public kiosk	0.531	
				Public restroom at bus stop	0.405	
				First-aid facility at bus stop	0.394	
				Presence of convenient services	0.323	
Access Path	3.000	8.11%	48.97%	Sufficient width on sidewalk	0.619	0.835
				Dedicated sidewalk on access path	0.563	
				Absence of obstruction on sidewalk	0.429	
				Visual attractiveness of greenery landscaping	0.358	
				Presence of ramp on access path	0.333	
	2.468	6.67%	55.64%	Presence of road markings and reflector	0.575	0.928

Markings and Informatory Sign				Informatory display board of bus route number and schedule	0.433	
				Way-finding sign-board to bus stop	0.432	
				Placement of way-finding signboard to bus stop	0.376	
Safety at Bus Stop	2.356	6.37%	62.01%	Safety measures and speed regulatory signs	0.780	0.781
				Prohibition of vehicle parking at bus stops	0.641	
				Safety of the waiting bus commuters from through moving traffic	0.556	
				Guard-rail facility	0.449	
				Low height of kerb at bus stop	0.374	
				Presence of kerb-ramp facility	0.333	
Lighting and Security	1.903	5.14%	67.15%	Presence of proper lighting facility at bus stop	0.654	0.602
				Presence of lighting facility on access path	0.618	
				Presence of surveillance system	0.417	
				Presence of civic volunteers	0.315	
Bus Stop Location	1.217	3.29%	70.44%	Safe-distance from the nearby intersection or median opening	0.678	0.594
				Crosswalk facility exists nearby	0.644	
				Movement of pedestrian is observed in the neighborhood	0.429	
				Cleanliness around the bus stop	0.359	

*KMO measure of sampling adequacy=0.882, Bartlett's Test of Sphericity: Approx. Chi-square=8969.52, significance <0.000
*Factor loadings<0.3 are not considered

4.1 Procedure for deriving rank order using RIDIT

As mentioned, the assessment of key-factors is carried out using RIDIT analysis. The assessment of derived key-factors is separately done for two types of bus passenger such as captive bus users and choice riders. The criteria used for ordering of the key-factors is called factor scores. It is estimated using (as per Eqn.4) raw satisfaction scores of the survey items, where the loading of a survey item is considered as weight in the aforementioned equation.

Table 3. Ordering of key-factors for captive bus users using RIDIT

Key-factors	Satisfaction score of key-factors in range of Likert scale: Extremely Satisfied (7)	(6)	(5)	(4)	(3)	(2)	Extremely Dissatisfied (1)	Mean RIDIT value	Rank-Order	Kruskal-Wallis (W)
Bus Stop Shelter	0	0.007	0.212	0.298	0.088	0.002	0	0.608	2	69.7931
Bus Stop Amenities	0	0	0.071	0.629	0.029	0.000	0	0.730	1	317.9701
Access Path	0.001	0.037	0.170	0.158	0.104	0.011	0	0.481	4	2.2534
Markings and Informatory Sign	0.002	0.054	0.153	0.126	0.043	0.005	0	0.383	6	81.9336
Safety at Bus Stop	0.001	0.052	0.183	0.129	0.031	0.009	0	0.404	5	55.5615
Lighting and Security	0	0.031	0.189	0.202	0.085	0.009	0	0.516	3	1.5358
Bus Stop Location	0.002	0.059	0.143	0.118	0.049	0.009	0	0.379	7	88.7066

Kruskal-Wallis (W) =617.754; critical chi-squared χ (7-1) =12.59 at 0.05 significance level, indicating perception scores for all the factors are statistically different.

Table 3 shows the rank order of 7 key-factors representing an infrastructure requirements of an urban bus stop facility for captive bus users. The rank order is prepared in such a way that key-factors ranked with lower values are comparatively poorly satisfied by bus passengers, and therefore they deserve priority for improvement. The Kruskal-

Wallis (W) value 661.95 is found to be significantly higher than the critical chi-squared value with degrees of freedom at 6 [$\chi 2(7-1)=12.59$] at 0.05 significance level. This indicates that captive bus users' satisfaction level towards all 7 key-factors are found to be statistically different. It may be observed from Table 3 that mean RIDIT value of the key-factor called bus stop amenities is the highest (i.e. 0.73>0.50) among others indicating a highest probability for being in worst service condition. This suggests that captive users require immediate intervention for improvement of bus stop amenities. In similar manner, RIDIT score of key-factors such as bus stop shelter (i.e. 0.608>0.50) and lighting and security at bus stop (i.e. 0.516~0.50) are found to be estimated more than or closer to 0.5 indicating a requirement by captive users for intervention. The RIDIT scores of other key-factors are less than 0.5, which imply that captive users are perceiving them relatively in better service condition.

Table 4. Ordering of key-factors for choice riders using RIDIT

Key-factors	Satisfaction score of key-factors in range of Likert scale: Extremely Satisfied (7)	(6)	(5)	(4)	(3)	(2)	Extremely Dissatisfied (1)	Mean RIDIT value	Rank-Order	Kruskal-Wallis (W)
Bus Stop Shelter	0	0	0.026	0.678	0.070	0	0	0.774	1	453.380
Bus Stop Amenities	0	0.009	0.214	0.242	0.057	0.008	0	0.530	3	5.534
Access Path	0	0.032	0.222	0.094	0	0	0	0.348	7	138.744
Markings and Informatory Sign	0.001	0.035	0.139	0.127	0.045	0.006	0	0.352	5	131.590
Safety at Bus Stop	0	0.013	0.194	0.262	0.051	0	0	0.522	4	2.938
Lighting and Security	0	0	0.182	0.367	0.072	0	0	0.622	2	89.739
Bus Stop Location	0	0.031	0.229	0.090	0.002	0	0	0.352	6	132.406

Kruskal-Wallis (W) =954.331; critical chi-squared χ (7-1) =12.59 at 0.05 significance level, indicating perception scores for all the factors are statistically different.

On the other hand, Table 4 shows the rank order of 7 key-factors for captive riders. The order of rank is also prepared in the same way as it was done for captive bus users. The Kruskal-Wallis (W) value 954.331, which is significantly higher than the critical chi-squared value with degrees of freedom as 6 [$\chi 2(7-1)=12.59$] at 0.05 significance level. This indicates that choice riders' satisfaction level towards all 7 key-factors are found to be statistically different. It is evident from Table 4 that choice riders are dis-satisfied of the key-factor bus stop shelter (RIDIT score 0.774>0.50) among other key-factors, and thereby requiring immediate intervention. Apart from this lighting and security at bus stop (RIDIT score 0.622>0.50) and bus stop amenities (RIDIT score 0.53>0.50) are also perceived to be in relatively poorer service condition. It may need to be noted that these 3 key-factors were also poorly satisfied by captive city bus users as well. However, the service condition of safety at bus stop (RIDIT score 0.522>0.50) is solely perceived to be in dis-satisfaction level by the choice riders. All other key-factors having a mean RIDIT value of less than 0.50 imply that immediate intervention for them is not sought by choice riders. Therefore, it may be concluded that both captive and choice riders together identify that bus stop shelter, bus stop amenities and lighting and security are three major key-factors, where policy maker should look into for intervention. Additionally, the choice riders also identify the condition of safety at bus stop also requires improvement.

5.0 Policy implication

The overall results of rank-order (as shown in Table 5) for the key-factors of captive bus users and choice riders clearly show that the requirement for improvement of bus stop infrastructure poses different for these different user groups. But, both of them have expressed their serious concern in terms of current service condition for three major key-factors such as bus stop shelter, bus stop amenities, and lighting and security. In this regard, an immediate intervention is needed by improving infrastructural facilities such as building of a new bus shelter, if it does not exist at scheduled bus stop, enhancing inside room and seating capacity within of a bus stop, and making seating facility spacious enough to provide a comfortable seating experience, etc. In this aspect, it is pertinent to highlight that some previous studies (Lusk, 2002; Yavuz et al., 2007) also highlighted the importance of bus stop shelters with seating facility, which could be visible from surroundings in order to keep positive interaction between waiting of bus passengers and bus service.

Table 5. Comparison of rank-orders for key-factors between captive and choice riders

	Rank-orders from RIDIT analysis	
Key-factors	Captive users	Choice riders
BusStopShelter	2	1
BusStopAmenities	1	3
AccessPath	4	7
Marking&Info	6	5
SafetyBusStop	5	4
Lighting&Security	3	2
BusStopLocation	7	6

All of these survey items belonging to key-factor bus stop shelter are having relatively higher factor loading (i.e., >0.50). In addition, bus passengers are also expecting presence of bus stop amenities such as nearby drinking water facility and public kiosk. These two survey items are found with relatively higher factor loading among all other survey items within the key-factor called bus stop amenities. The consideration of these services are also suggested in in the work of Vuchic (2002) and Tyrinopoulos and Antoniou, (2008) for design of urban bus stop infrastructure considering public demand and expectation. The expectation of the city bus passengers also suggest requirement of the proper illumination and enhanced security system (i.e. survey items under key-factor “Lighting and Security” having factor loadings >0.50) inside of a bus stop such as presence of CCTV. In this aspect, it may also be suggested to provide the same within the bus stop facility and also on access-path to bus stops. The choice riders are specifically concerned about key-factor safety at bus stop. In this aspect, it is suggested to provide safety and speed regulatory signs near bus stops, arrangement for prohibition of vehicle parking near bus stops and providing low-height kerbs for passengers to conveniently access the bus footboards. All of these survey items are also found having factor loading greater than 0.5.

6.0 Conclusion

Waiting at bus stop for bus passengers becomes a burden, when existing infrastructural facilities at bus stop remain in poor service condition and/or does not suit as per expectation of bus passengers. It was also realized through previous studies that a rational improvement of bus stop infrastructural facility is pertinent not only to reduce the burden for waiting but also to augment bus patronage. In line with this experience, the current study takes an attempt to identify intervention areas for improving existing urban bus stop infrastructure facilities in Bhubaneswar as per bus passengers’ requirement and satisfaction. In this work, an attempt has been undertaken to propose a rationally appealing assessment framework, which uses perceived information of bus passengers on various infrastructural attributes collected in the scales of their importance and satisfaction. The assessment framework takes an attempt to exploit the strength of these perceived data types, while preparing the policy framework for improving of bus stop infrastructure in Bhubaneswar.

In order to meet the major objective, at first key-factors for bus stop infrastructure are determined, and then an assessment of them is carried out by ordering as per their improvement needs. In wake of this assessment, the key-factors are determined using exploratory factor analysis (EFA) on the stated importance ratings of an array of survey items, and then those key-factors are ordered using Relative to an Identified Distribution Integral Transformation (RIDIT) analysis on stated satisfaction ratings of same survey items. The study is carried out for two types of bus passengers such as captive bus users and choice riders, as requirement and perception of each individual group is expected to be different. The work identifies 7 key-factors such as bus stop shelter, amenities, access-path, marking and informatory sign, safety at bus stop, lighting and security, and location of bus stop. Among all these, derived key-factors both the captive bus users and choice riders have expressed their concern for bus stop shelter, bus stop amenities and lighting and security, as their satisfaction level appear to be relatively poorer than others. However, safety at bus stop is found as major concern for choice riders and require immediate intervention. The work documents a fresh experience about bus passengers need in terms of improving urban bus stop infrastructure in developing countries and archives new findings and evidences with reference to urban India.

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References

Badami, M.G. and Haider, M., (2007). An analysis of public bus transit performance in Indian cities. Transportation Research Part A: Policy and Practice, 41(10), pp.961-981.

Bartholomew, D. J., Steele, F., Galbraith, J., Moustaki, I., (2008). Analysis of multivariate social science data. CRC press.

Basu, D. and Banik, AD., (2015) Valuing travel attributes of public transport as perceived by commuters in Bhubaneswar. In Proceedings of The 3rd Conference of Transportation Research Group (CTRG) of India, Kolkata, India: Paper ID 725.

Bross, I.D.J., (1958). How to use RIDIT analysis. Biometrics 14(1), pp.18-38.

Caulfield, B., and O'Mahony, M. (2009). A stated preference analysis of real-time public transit stop information. Journal of Public Transportation, 12(3), pp.1.

Flora, J.D., 1974. A note on RIDIT analysis. Technical report distributed to Motor Vehicle Manufacturers Association on behalf of Highway Safety Research Institute, The University of Michigan, Ann Arbor, Michigan.

Hair, J., Anderson, R., Tatham, R., Black, W.C., (2012). Multivariate Data Analysis. Prentice-Hall Inc., New Jersey.

Hamby, B., and Thompson, K. (2006). New toolkit provides practical tools to build better bus stops. Institute of Transportation Engineers. ITE Journal, 76(9), pp.22.

Iseki, H. and Taylor, B.D., (2009). Not all transfers are created equal: Towards a framework relating transfer connectivity to travel behaviour. Transport Reviews, 29(6), pp.777-800.

Iseki, H. and Taylor, B.D., (2010). Style versus service? An analysis of user perceptions of transit stops and stations. Journal of Public Transportation, 13(3), p.2.

Jolliffe, I. T., 1972. Discarding variables in a principal components analysis. I: artificial data. Applied Statistics 21, pp.160–173.

Kittelson & Associates, Inc., Texas Transport Institute, and Transport Consulting Limited. 2003. Transit Capacity and Quality of Service Manual - 2nd Edition. Washington, D.C.: National Academic Press.

Litman, T., (2015). Evaluating public transit benefits and costs. Victoria Transport Policy Institute.

Loukaitou-Sideris, A., Liggett, R., Iseki, H., and Thurlow, W. (2001). Measuring the effects of built environment on bus stop crime. Environment and Planning B: Planning and Design, 28(2), pp.255-280.

Luk, J. Y. K., (2003). Reducing car travel in Australian cities: Review report. Journal of Urban Planning Development, ASCE 129:2(84), pp.84–96.

Lusk, A., (2002). Bus and Bus Stop Designs Related to Perceptions of Crime. U.S. Department of Transportation, Federal Transit Administration, Office of Research, Demonstration and Innovation, Washington, D.C.

Maitra, B., Sadhukhan, S., 2013 a. Public transport in the context of urban mobility in India, SHELTER 14(2), pp.52-56.

Maitra, B., Sadhukhan, S., 2013 b. Urban public transportation system in the context of climate change mitigation: Emerging Issues and research Needs in India, Mitigating Climate Change, A. Khare and T.Beckman (eds.) Springer Environmental Science and Engineering, pp.75-91

Mishalani, R. G., McCord, M. M., and Wirtz, J. (2006). Passenger wait time perceptions at bus stops: Empirical results and impact on evaluating real-time bus arrival information. Journal of Public Transportation, 9(2), pp.5.

Morton, C., Caulfield, B., and Anable, J., (2016). Customer perceptions of quality of service in public transport: Evidence for bus transit in Scotland. Case Studies on Transport Policy, 4(3), pp.199-207.

Muthén, L. K., and Muthén, B. O. (1998). Statistical analysis with latent variables. Mplus User's guide, 2012.

Srinivasan, M., and Rogers, P., (2005). Travel behavior of low-income residents: studying two contrasting locations in the city of Chennai, India. Journal of Transport Geography, 13, pp.265-274.

Tabachnick, B.G., Fidell, L.S., (2007). Using multivariate statistics, Boston. Pearson Education Inc.

Tyrinopoulos, Y., and Antoniou, C., (2008). Public Transit User Satisfaction: Variability and Policy Implication. Transport Policy 15, pp. 260–272

Vuchic, V.R., (2002). Urban public transportation systems. University of Pennsylvania, Philadelphia, PA, USA.

Washburn, S., and Kirschner, D. (2006). Rural freeway level of service based on traveler perception. Transportation Research Record: Journal of the Transportation Research Board, (1988), pp.31-37.

Winters, M., Davidson, G., Kao, D., Teschke, K., 2011. Motivators and deterrents of bicycling: comparing influences on decisions to ride. Transportation 38(1), pp.153-168.

Yavuz, N., Welch, E. and Sriraj, P., (2007). Individual and neighborhood determinants of perceptions of bus and train safety in Chicago, Illinois: Application