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Evaluation of BRTS Service Quality Using User Preference

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Abstract

India is one of the world's fastest developing countries, with increased urbanization contributing to a rise in vehicle population in metropolitan areas. This scenario exacerbates several traffic issues such as congestion, air pollution, and decreased safety, necessitating a change in commuters from private to public transportation. In light of this, public transportation's efficacy and service quality must be improved in order to give a superior alternative to private transportation. Operators of public transportation, on the other hand, are curious in whatever aspect of service quality attracts passengers. Estimating service quality and the impact of qualities on service become more crucial in this area. As a result, the focus of this research is on the technique for estimating service quality based on user preferences and the measuring influence of factors on service quality. The Rajkot city (Gujarat) bus rapid transit system was chosen to meet the main objectives. In this system, operator amenities, safety, convenience, comfort, and service reliability are influencing characteristics on service quality. A questionnaire was developed with this in mind, and a survey was performed. Each stop along the BRTS (Bus rapid transit system) circuit used to collect data aggregating about 650 samples from BRTS users. The service attributes considered as Frequency, Punctuality of the bus, Speed and Proximity of the stops from O/D. Fare, cleanliness of the vehicle, Space, Information, Safety, Courtesy, and Accessibility. To assess service quality rating and identify impacting parameters, Structural equation modeling also known as route analysis approach, is utilized. The structural link between observable variables and their associated latent variables is examined in this technique. The goodness of indicators proposed by several writers verified this concept. Latent or hidden variables are simply explained by their associated observed variable in this study. The present Transit system's service quality is between Good and Excellent, according to an examination of data obtained from a survey of Rajkot BRTS. Apart from a few variables, users are quite satisfied with the service quality of BRTS.

Keywords: Quality survey, Rajkot BRTS, SEM (structural equation modeling), public transportation, transit service indicator

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INTRODUCTION

Background

Due to increased urbanization and rising travel demand in India, a dependable, effective, and safe mass transportation system is necessary. Mass transit or public transportation is defined as "the movement of people within an urban region utilizing group travel technology such as buses and trains." The difficulty of transportation increases as the world's population rises [1]. This led to the creation of a new transit system that can offer people with safe, quick, pleasant, and convenient transportation. As a result, BRTS (Bus rapid transit system) has been established, which includes integrated routes, closed and high-quality stops, low-floor buses, an intelligent transport system, and other advanced characteristics. In comparison with other modes, BRTS is the most cost-effective as indicated by Tindale Oliver and Associates in the year 2009.

Literature Review

In past years, research has been done in the area of public transportation, travel behavior of commuters, Evaluation of Service Quality by many scientists and academicians. Research findings related to this study is listed below in brief.

Service Quality of Transit System

Service Quality of transit system basically depends on series of attributes describing the Transit service. Many scholars tried to define relationship between quality of service and its attributes.

Liping Fu et al. (2007) differentiate between Service quality attributes and Service quantity attributes. Then they unveiled the Transit Service Indicator (TSI), a new performance metric that can be utilized as a thorough evaluation tool for a transit system's level of service quality. Compared with current transit performance indices, the proposed TSI integrates a range of performance parameters of various types, such as service headway, service hours, route coverage, and numerous trip duration components (walk, wait, transfer, and ride). When it comes to service quality, they also eliminated fare [2].

Litman Todd and colleagues came to the conclusion that there are a variety of measures to enhance the quality of transit service, including fewer crowds, more frequent service, nicer waiting places, and better user information. The current assessment methods for transportation often overvalue qualitative elements like comfort, ease, and reliability while undervaluing quantitative factors like speed and cost. As a result, cost-effective transit enhancement techniques are missed and underestimated, resulting in a lack of investment in improving transit service quality, making transport less appealing in comparison to driving.

Samet Guner et al. (2018) offer a beneficial and practical technique for bus transit operators to monitor and enhance the quality of their services. It is suggested to use a two-stage multi-criteria decision-making process. The initial phase makes use of the Analytic Hierarchy Process [3]. Utilizing the Order Preference by Similarity to Ideal Solution Technique, the second step, the proposed approach offers a thorough performance analysis by factoring user preferences and a variety of evaluation factors into the analysis. The most significant service quality characteristics are identified through analysis from the perspectives of the users: methods to estimate Service quality.

Liping Fu et al. (2007) attempted to gauge service quality (TSI), using a novel indicator called the Transit Service Index. The TSI systematizes the integration of a number of performance characteristics (such as service frequency, hours of operation, route coverage, and trip time components). It recognizes the necessity of using a demand-based LOS metric to take into consideration the effects of both supply and demand. The investigation was limited, though, because it was thought that travel time was the most crucial element [2].

Garrido et al. (2014) developed a novel method for assessing the quality of service in public transportation systems (ANN), using artificial neural networks. ANN analysis is an effective technique because of its excellent prediction skills and the lack of a pre-defined model that it uses. This study advances knowledge of the various variables that affect the level of service quality in the transportation system, either more or less. This study helps us understand which elements are more important to passengers' assessments of service quality and which ones are less significant [4].

Ona et al. (2013) [5] demonstrated that SEM methodology is powerful tool which can be used to find out which are the latent aspect that describing the quality of service The resultant model structure gives useful information for determining which parts of the service are most likely to influence travelers when they utilize it. This data can assist transportation managers in developing new strategies and investment plans to continuously increase passenger satisfaction and, as a result, system utilization. The insights can also be used by transport operators to recruit new customers and maintain existing ones.

Alavifar and colleagues compared and contrasted the first and second multivariate methods, concluding that structural equation modeling, as a second-generation representative, is more applicable and practical in current research problems due to some of its capabilities, such as having more flexible assumptions, reducing measurement error with CFA, having a more appealing interface and more visual, and testing the total model rather than individual coefficients.

Need of Study

A public transportation system's success is based on how many users it can draw in and retain. Since it is generally known that better levels of service quality resulted in higher levels of passenger satisfaction and increased system utilization, the quality of service becomes a crucial issue as a result. A set of characteristics that define a service determines the quality of the service. Berry et al. (1990) [6] and several other authors concurred that "customers are the sole assessors of service quality." As a result, if service quality is assessed from the perspective of the consumer, the quality of the transportation system is based on how users perceive each component.

Objectives of Study

- Research the existing state of BRTS Rajkot and determine how people in the study region travel.
- To create a model of service quality parameters from which overall service quality and satisfaction can be calculated based on user preferences [7].
- To determine the importance and weighting of various characteristics of service that most influence passengers' decision to utilize the service.

Scope of Study

The scope of the present study is given as below

- The study area for evaluation service quality parameters is India's Exploding city Rajkot.
- This Study mainly focus on Quality attributes of existing BRT system of City.

Problem Definition

According to information got from administrator of Rajkot Rajpath Ltd., they saw a decrease in BRTS ridership and were interested in learning why? Existing BRTS have certain concerns with service quality, and by resolving these issues, the quality may be enhanced, which will boost ridership. As a result, the service quality parameters must be defined.

Study Area Selection

Urban and Sub-urban area of Rajkot city on which blue corridor is operating was selected as study area. Based on literature appropriate questionnaire was designed.

- Rajkot, an important Urban Centre located in Saurashtra region, is fast emerging as a center of trade and commerce serving the state in general and the region in particular.
- Rajkot city is spread over 170 sq. kms. and having population of 1.28 million (As per census 2011). The population growth rate is noted 4% per annum, which is comparatively higher than Indian city of similar size [8].

Data Analysis

Collected data was extracted in SPSS and its plug-in AMOS.

METHODOLOGY

Structure Equation Modeling for Service Quality Evaluation

The statistical modeling approach known as "structure equation modeling" (SEM) is highly broad and is frequently employed in the study of behavior. It may be seen as a mixture of route analysis, regression analysis, and factor analysis [9].

Data Collection

The core component of every study is gathering data. At each of the 18 bus stops in Rajkot BRTS, a questionnaire survey approach will be used. The operator provided the initial statistics on ridership (RRL).

Preparation of Questionnaires

The most crucial need for conducting a questionnaire survey is to develop a valid questionnaire. Based on the literature analysis and the objectives of the study, a questionnaire was developed. The design questionnaire consists of three sections. The initial investigation revealed the commuter's pattern of travel (from where to where, how often do you use BRTS). A rating system for metrics relating to service quality was part of the second component. The last portion included questions about socioeconomic variables (gender, age, education, etc.).

Sample size determination

For any Public transportation system evaluation, an adequate sample size is required [10].

Cochran (1963) provides the following formula for determining representative sample size

$$n_0 = Z^2 * p * \frac{1\text{-}p}{e^2}$$

Where,

n_0 = sample size required

Z= (1.96 for 95% confidence interval)

p = response distribution (usual 0.5 used for normally distributed responses) c = amount of uncertainty (usual 0.04 represent tolerance of +/4)

So, from above equation, n_0 = 600.25

Actual sample size$n = \frac{n_0}{1+\frac{n0-1}{N}}$

Where n_0 is initial sample size N = population size

In this study actual sample size can be calculated from above equation. The initial sample size was600.25 and population of Rajkot city is taken as 1286000 [11]. So actual sample size can be found is 600.22 = 601

Moreover, for structure equation modeling:

Minimum sample size should be 200 suggested by Ding, Velicer, and Harlow (1995) [4].

Or

An adequate sample, according to Kline (2005) [13], would consist of 10 to 20 people for each calculated parameter. There are 21 parameters in all in this study,

Sample size required = 20 × 21 = 420 observations.

Sample size distribution done on bases of passenger generation rate on each of 18 stations, which is shown in following bar chart. Sample collected as per distribution of generation rate of each station.

KMO Test for Sampling Adequacy

The Kaiser–Meyer–Olkin (KMO) test, developed by Kaiser in 1977, is a measurement of sample adequacy that ranges from 0 to 1, with results closer to 1 being preferable. KMO values must be more than or equal to 0.5 in order for a sample to be considered adequate. Here, 661 sample numbers underwent the KMO test.

Here, $KMO = 0.692$, which indicates that the sample is adequate, and we may proceed with the Further Analysis [14].

Preliminary Analysis of Socioeconomic and Travel

The preliminary analysis was performed after data was coded by users' responses about their socioeconomic and travel behaviors. Respondent gender, age, education, trip purpose, how often they use BRTS, their previous mode of transportation, whether they have a subsidized pass or not, and their overall service rating were all collected.

Model Development for Estimation of Service Quality Rating

Following preliminary data analysis (Table 1), the acquired data should be carefully analyzed in order to reliably estimate elaborated service ratings, and certain additional characteristics or parameters should be noted. The relationship between such criteria and their relationship with service quality rating should be determined in a methodical manner after utilizing some statistical methods. For this exercise, following service parameter defined and has been recorded [2].

Table 1. Coding of Questionnaire.

S.N.	Description	Measurement Scale
1	Gender of respondent	1. Male 2. Female
2	Age	Direct response
3	Education	1. Primary or less 2. Secondary 3. Graduation or more
4	Trip purpose	1. Work 2. Educational 3. Shopping 4. Other
5	How often do you use BRTS (Bus rapid transit system)? [15]	1. Daily 2. 2-3 times in week 3. Weekly 4. Occasionally
6	Former mode of transport?	1. Auto rickshaw 2. Car 3. 2-W 4. Cycle 5. City-bus 6. Others
7	Do you have subsidized pass?	1. YES 2. NO
8	Overall service rating?	1. Poor 2. Satisfactory 3. Good 4. Excellent

Path Diagram for Model

Path diagram shows a conceptual relationship of observed variables and latent variables (Table 2). For present study concept diagram is shown in Figure 1.

Here *Amenities*, *Comfort*, *Safety*, *Accessibility*, *Reliability*, *Convenience*, *Security*, *Courtesy* are Latent variables. And *Overall Rating* is exogenous observed variable which is dependent on latent variable.

Table 2. Service quality parameters and their latent variables.

S.N.	Parameter	Latent variable	Coding
1	In terms of Smart Payment	Amenities	Am1
2	In terms of Wi-Fi availability		Am2
3	In terms of availability of Change-coins		Am3
4	Availability of Newspaper		Am4
5	Behavior of Staff at Ticket counter	Courtesy	Cr1
6	Behavior of other staff		Cr2
7	Availability of Seats	Comfort	Cm1
8	Cleanliness in Bus and at Station		Cm2
9	A.C. in Bus		Cm3
10	In terms of Automatic door system	Safety	Sf1
11	In terms of Driving skill of driver		Sf2
12	In terms of Bus stop location	Accessibility	Ac1
13	Easiness in Road-crossing		Ac2
14	Availability of feeder service		AC3
15	Arrival of Bus in time	Reliability	RL1
16	Availability of Bus in peak hour		RL2
17	Availability of timetable	Convenience	Cnv1
18	Alert-sound of forthcoming station in Bus		Cnv2
19	Convenience in BRTS with respect to Auto rickshaw		Cnv3
20	Personal security from theft	Security	Sc1
21	Security from mob and threat		Sc2

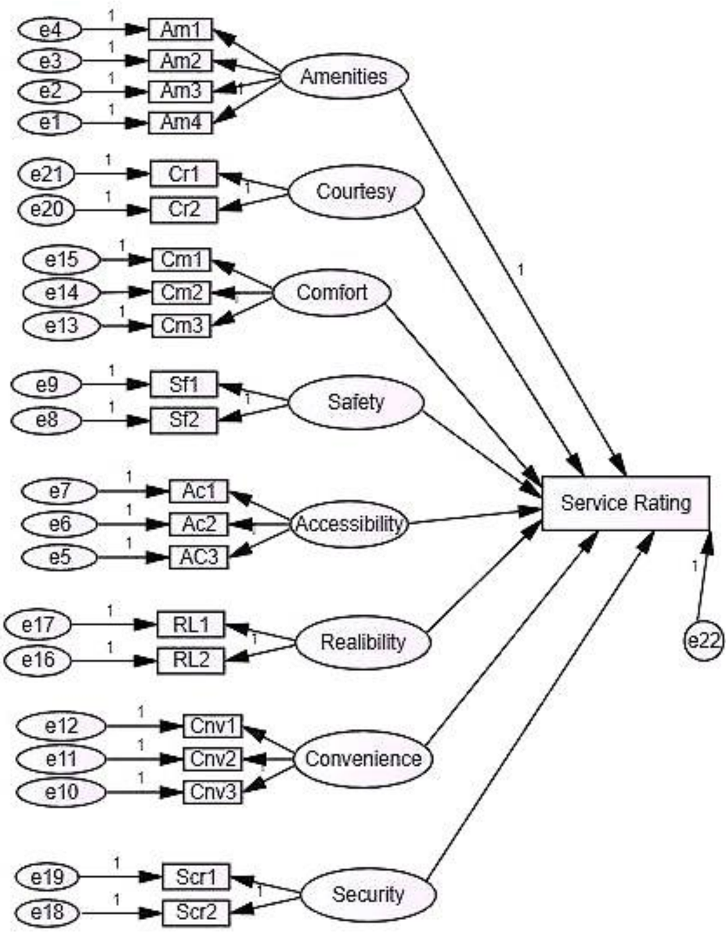

Figure 1. Path diagram of model.

RESULT AND DISCUSSIONS

In this study, Structure equation modeling was applied to estimate Service Quality rating based on user perception. By considering total 21 observed variables and 8 latent variables. These 8 latent unobserved variables all together are representing the observed variable of Rating (Table 3). The regression weights were obtained by solving equations. The model calibrated by using Amos package. The model results are reported in Tables 4 and 5.

Table 3. Measurement result of observed and latent variables.

Observed variables	Latent variables	Regression weights	Std. regression weights
Am1	Amenities	0.094	0.05
Am2	Amenities	0.322	0.12
Am3	Amenities	0.511	0.15
Am4	Amenities	1	0.47
Cr1	Courtesy	0.838	0.54
Cr2	Courtesy	1	0.68
Cm1	Comfort	0.411	0.13
Cm2	Comfort	1.07	0.56
Cm3	Comfort	1	0.42
Sf1	Safety	0.9	0.60
Sf2	Safety	1	0.57
Ac1	Accessibility	0.104	0.06
Ac2	Accessibility	1.103	0.42
AC3	Accessibility	1	0.39
RL1	Reliability	0.835	0.49
RL2	Reliability	1	0.53
Cnv1	Convenience	1.195	0.64
Cnv2	Convenience	0.137	0.04
Cnv3	Convenience	1	0.47
Sc1	Security	0.97	0.55
Sc2	Security	1	0.49

Table 4. Measurement result of service quality and latent variables.

S.N.	Latent exogenous variables	Observed endogenous	Regression weights
1	Amenities	Service quality	0.06
2	Courtesy	Service quality	0.04
3	Comfort	Service quality	0.07
4	Safety	Service quality	0.13
5	Accessibility	Service quality	0.06
6	Reliability	Service quality	0.10
7	Convenience	Service quality	0.37
8	Security	Service quality	0.25

Table 5. Indices of goodness of fit.

S.N.	Description	Observed value	Permissible value	Acceptable level
1	Chi-Square/degrees of freedom	2.717	≤3.00	Tabled χ^2 Value
2	Goodness of fit (GFI)	0.940	>0.90	0 (no fit) to 1 (perfect fit)
3	Adjusted goodness of fit (AGFI)	0.913	>0.90	0 (no fit) to 1 (perfect fit)
4	Comparative fit index (CFI)	0.835	>0.90	Researchers define level
5	Root mean square residual (RMR)	0.031	<0.10	0.05 to 0.08
6	Root mean square Error (RMSEA)	0.051	<0.06 or <0.08	0 (no fit) to 1 (perfect fit)

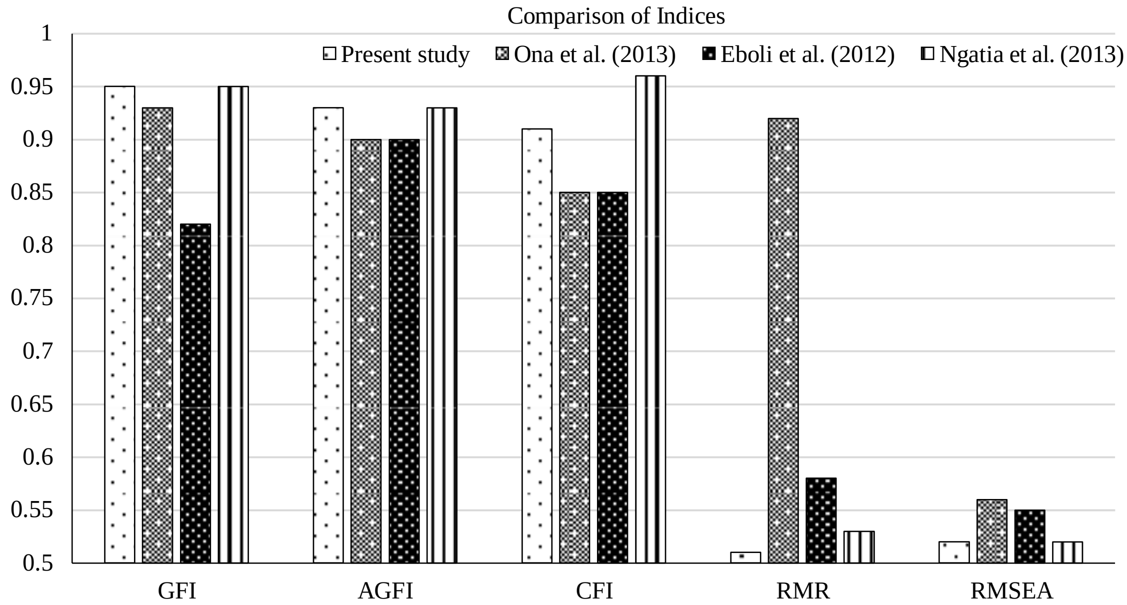

Figure 2. Comparison of fit indices.

From Figure 2, it is observed that present model is comparable with other study models. The value assigned to each exogenous variable were obtained by using estimated weights for each observed variables and corresponding ratings given by users, as given in following formula (Figure 2).

Estimated Service rating = 0.06 (Amenities) + 0.04 (Courtesy) +0.07 (Comfort) + 0.13 (Safety) + 0.06 (Accessibility) + 0.10 (Reliability) + 0.37 (Convenience) + 0.25 (Security)

Where, Latent variables,
Amenities = 0.05 Am1 + 0.12Am2 + 0.15Am3 + 0.47Am4
Courtesy = 0.54Cr1 + 0.68Cr2
Comfort = 0.13Cm1 + 0.56Cm2 + 0.42Cm3
Safety = 0.6Sf1 + 0.47Sf2 Accessibility = 0.06Ac1 + 0.42Ac2 + 0.39Ac3 Reliability = 0.49 Rl1 +0.53 Rl2
Convenience = 0.56 Cnv1 + 0.04Cnv2 + 0.47Cnv3 Security = 0.55 Sc1 + 0.49 Sc2
Using above equation value of service rating can be estimated.

From table, it can be said that model is able to predict service rating this fact realize that developed SEM model for user satisfaction can be utilized to estimate Service quality (Figure 3).

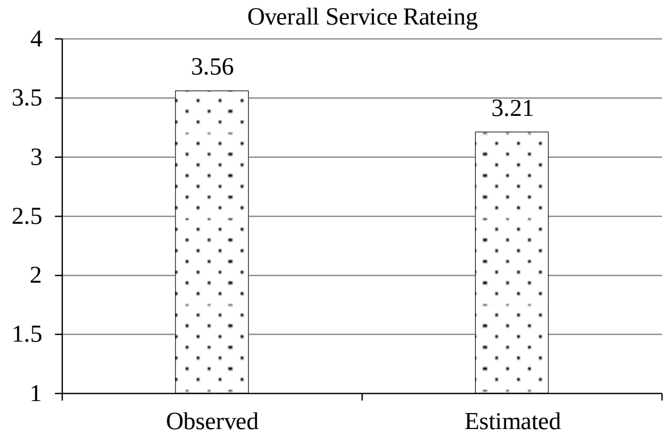

Figure 3. Rating comparison.

CONCLUSION

The present Transit system's service quality is between Good and Excellent, according to an examination of data obtained from a poll of customer preferences on service station I Rajkot BRTS. Apart from a few variables, users are quite satisfied with the service quality of BRTS.

The current study develops service quality rating models based on the data obtained. It has been demonstrated that SEM techniques are suitable for modeling the Service Quality Rating of a specific Transit system.

From Table 4, we can conclude that the regression weights of Convenience and Safety are more, which means people are more satisfied by this latent variable and the regression weights of Amenities, Courtesy, and Accessibility are less and thus by improving the parameters in that latent variable which have less standard regression weights we can increase the service quality of BRTS.

From the perspective of the operators, it is simple to determine which parameters should be improved in order to improve the service quality of this particular transportation system. 3.21 is the estimated total service rating based on regression (out of scale 4). Between excellent and mediocre service, this rating falls somewhere in the centre. That's really close to the Figure of 3.56, showing that the created model correctly predicts outcomes. The current study was only able to examine BRTS along a single route, but it might be extended to explore BRTS over more routes in the future.

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