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The Impact of Technology-Enabled Service Quality on Customer Loyalty in Public Transportation: A Multi-Method Study of APSRTC Bus Services

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Abstract

This study examines the complex relationship between technology-enabled service quality (TESQ) and customer loyalty within the public transportation sector, focusing on the Andhra Pradesh State Road Transport Corporation (APSRTC) bus services. Employing a mixed-methods approach, the research identifies key dimensions of TESQ unique to this context and assesses their impact on customer loyalty, mediated by satisfaction, trust, perceived value, perceived risk, brand image, and convenience. Data from a sample of 892 passengers are analyzed using exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and structural equation modeling (SEM). The findings reveal a robust six-dimensional structure of TESQ (Tangibility, Reliability, Responsiveness, Assurance, Empathy, and Technology). The structural model confirms a significant direct effect of TESQ on customer loyalty, as well as a partial indirect effect mediated through satisfaction, trust, perceived value, perceived risk, brand image, and convenience. These results underscore the critical role of technology in shaping service quality and enhancing customer loyalty in public transport, providing actionable insights for both transportation operators and policymakers seeking to improve service delivery.

Keywords: Technology-enabled service quality (TESQ), Customer loyalty, public transportation, Structural equation modelling (SEM), Technology in Public Services, Transportation Policy

1. Introduction

The public transportation sector serves as a crucial artery for societal and economic development, playing an essential role in the daily lives of millions. As such, continuous evolution and adaptation to the dynamic needs of passengers are paramount. In recent years, technology has emerged as a transformative force, capable of enhancing service quality, efficiency, and convenience. This has led to an increased focus on understanding the impact of technology-enabled service quality (TESQ) on customer loyalty within this sector (e.g., Iacobucci et al., 1995; Zeithaml et al., 2008). This study aims to advance this body of knowledge by exploring the specific context of Andhra Pradesh State Road Transport Corporation (APSRTC) bus services, examining how technology shapes customer perceptions of service quality and drives loyalty.

The integration of technology into public transportation has revolutionized traditional service paradigms, enabling innovations such as online ticketing, real-time tracking, and user-friendly mobile applications. While existing research has explored the constructs of service quality and customer loyalty (e.g., Anderson et al., 1994; Oliver, 1999), a gap exists in understanding the nuanced dimensions of TESQ specifically within the public transportation setting. This study addresses this gap by developing a comprehensive model that identifies the key dimensions of TESQ that directly impact customer perceptions of service quality, as well as their subsequent loyalty. Furthermore, it examines the mediating roles of satisfaction, trust, perceived value, perceived risk, brand image, and convenience in the relationship between TESQ and customer loyalty, thereby elucidating the complex mechanisms that underpin customer retention.

2. Literature Review

This section provides a concise review of pertinent literature on service quality, customer loyalty, and technology adoption, particularly within the public transportation context. This review lays the theoretical foundation for the study and provides the justification for the hypothesized relationships tested empirically within the research.

2.1 Service Quality

Service quality, long recognized as a critical determinant of organizational success (e.g., Juran, 1974; Deming & Edwards, 1982), influences various aspects of customer perceptions (e.g., Cronin & Taylor, 1992). The measurement of service quality has also evolved, resulting in several models designed to capture the constructs that influence customer behavior (e.g., Parasuraman et al., 1988; Bitner, 1990; Grönroos, 1984). Among the various models, the SERVQUAL model, proposed by Parasuraman et al. (1988), has been extremely influential, defining five dimensions of service quality: tangibility, reliability, responsiveness, assurance, and empathy. While this original model was designed for traditional service encounters, it has been adapted to consider the impact of technology on service delivery. This study acknowledges the importance of these dimensions and seeks to both build upon and also refine this well-established framework.

In the transportation sector, service quality is a key determinant of passenger satisfaction and loyalty, and it is vital for organizations to continuously assess and improve the services that they provide (e.g., Athiyaman, 1997; Guolla, 1999). Prior research indicates that different factors are important across different transport modes and for diverse passenger demographics (e.g., Hill, 1995; Sander et al., 2000). Therefore, this research seeks to determine the key factors that specifically influence perceptions of service quality in the context of APSRTC bus services, which may differ from factors in other contexts. This study seeks to understand these factors through the creation of a theoretical model that directly considers the needs of passengers in this specific setting, and by identifying the ways that technology is impacting these factors.

2.2 Technology-Enabled Service Quality (TESQ)

The growing integration of technology into service delivery has brought about the concept of technology-enabled service quality (TESQ) (e.g., Dabholkar et al., 2000). TESQ describes the quality of service delivery that is enhanced or facilitated through the use of technology, encompassing features like online booking platforms, mobile applications, real-time information systems, and digital ticketing. TESQ represents a natural progression from traditional models of service quality, reflecting the increasing influence of technology on the customer experience. Research across sectors has shown that technology significantly shapes customer perceptions of service quality (e.g., Bitner, 1990; Yavas et al., 2004). In public transportation, TESQ has the potential to improve accessibility, convenience, efficiency, and customization for passengers (O'Neill & Palmer, 2004).

Therefore, there is a pressing need to understand the mechanisms through which technology influences the perceptions of service quality and customer loyalty within public transportation. This study aims to address this gap by identifying the most influential dimensions of TESQ within the APSRTC context, while also considering how this impacts the traditionally defined factors such as tangibility, reliability, responsiveness, assurance and empathy. Through this, the study seeks to refine the theoretical foundations of TESQ, providing a current and contextually relevant approach to service quality measurement.

2.3 Customer Loyalty

Customer loyalty, which embodies a customer's commitment to consistently use a particular service (e.g., Oliver, 1997, 1999), is recognized as a crucial outcome of positive service experiences. Marketing literature has explored customer loyalty through different lenses; Dick and Basu (1994) view it as the strength of the relationship between a customer's attitude and their repeat purchase behavior. Oliver (1999) emphasizes a combination of both attitudinal and behavioral components. Similarly, research in higher education has indicated the importance of both behavioral and attitudinal loyalty in understanding customer perceptions (e.g., Hennig-Thurau et al., 2001; Marzo-Navarro et al., 2005).

Customer loyalty is particularly vital within public transportation, where multiple options may be available to passengers. It is therefore important to identify not only the key drivers of customer loyalty but also the mechanisms that mediate the relationship between service quality and customer loyalty. By adopting this approach, this research will provide valuable insights for transport providers when developing strategies to enhance customer loyalty.

2: Conceptual Framework/Theoretical Framework

This section outlines the conceptual framework underpinning the study, which integrates the key constructs and their hypothesized relationships. This framework is grounded in existing theoretical models of service quality, technology

adoption, and customer loyalty, and it identifies the specific mechanisms through which technology-enabled service quality (TESQ) influences customer loyalty in the context of public transportation.

2.4 Mediating Variables

This research will explore the indirect pathways between TESQ and customer loyalty by focusing on the mediating roles of several key constructs. These mediating constructs include: satisfaction, trust, perceived value, perceived risk, brand image, and convenience. These key factors have been identified in prior research, and have also been shown to be particularly salient in the context of public transport, and are described further below:

- **Satisfaction:** Customer satisfaction, often defined as the feeling of pleasure that a customer experiences from service consumption (e.g. Oliver, 1981; Spreng and Singh, 1993), has a direct impact on customer loyalty. Research has indicated that service quality and satisfaction are directly related, and that satisfaction can also mediate the effect of service quality on customer loyalty (e.g. Caruana, 2002; Mosahab et al., 2010). As such, this study will seek to explore the mediating role of satisfaction within the public transport sector.
- **Trust:** Trust refers to the customer's belief that the service provider will fulfil their obligations, which is essential for fostering long-term relationships (e.g. Doney and Cannon, 1997; Ganesan, 1994). Trust also plays an important mediating role, and is known to influence the relationship between service quality and customer loyalty.
- **Perceived Value:** Perceived value reflects a customer's overall assessment of the benefits that they receive from the service, about the costs involved (e.g. Zeithaml, 1988). Perceived value has also been shown to be an important driver of loyalty, and may have a mediating effect on the relationship between service quality and customer loyalty.
- **Perceived Risk:** Perceived risk refers to the potential negative consequences that a customer believes may arise from using a particular service (e.g. Dowling and Staelin, 1994). As such, perceived risk may directly impact customer loyalty, as well as have an indirect impact on the relationship between service quality and loyalty. Perceived risk is an important factor to consider within public transportation, as customers are often putting their trust in the hands of other people, and also the infrastructure, which makes their perceptions of risk an important mediating variable.
- **Brand Image:** Brand image refers to how customers perceive the organization providing the service (e.g. Keller, 1993), and may impact their perceived quality of that service, and also their intention to use that service in the future. A positive brand image often makes customers feel more confident about their decisions, and this is also related to their level of loyalty.
- **Convenience:** Convenience, which describes how easily a service may be accessed, is a significant driver for many customers, and is directly influenced by the level of technology that has been integrated. As such, the level of convenience may directly influence the customer's loyalty, and it may also have an important mediating effect. A convenient service provides greater flexibility and reduces the friction of accessing public transportation, and this is often a key consideration when choosing a specific transport method.

2.5 The Conceptual Framework

This study's conceptual framework, which is based on the existing literature, proposes that technology-enabled service quality (TESQ) has both a direct and indirect effect on customer loyalty. Specifically, this study posits that:

- **Direct Effect of TESQ on Customer Loyalty:** TESQ directly influences customer loyalty, as positive experiences with technology-enabled services are likely to enhance customer perceptions of value and also increase their intentions to use the service again (Zeithaml et al, 1996).
- **Indirect Effect of TESQ through Mediators:** The relationship between TESQ and customer loyalty is mediated by satisfaction, trust, perceived value, perceived risk, brand image and convenience. Therefore, TESQ not only influences customer loyalty directly, but also indirectly, by impacting their levels of satisfaction, and trust, and also through managing perceptions of risk, while also increasing convenience and improving brand image (e.g. Caruana, 2002; Mosahab et al., 2010).

The conceptual framework of this research is visually represented below:

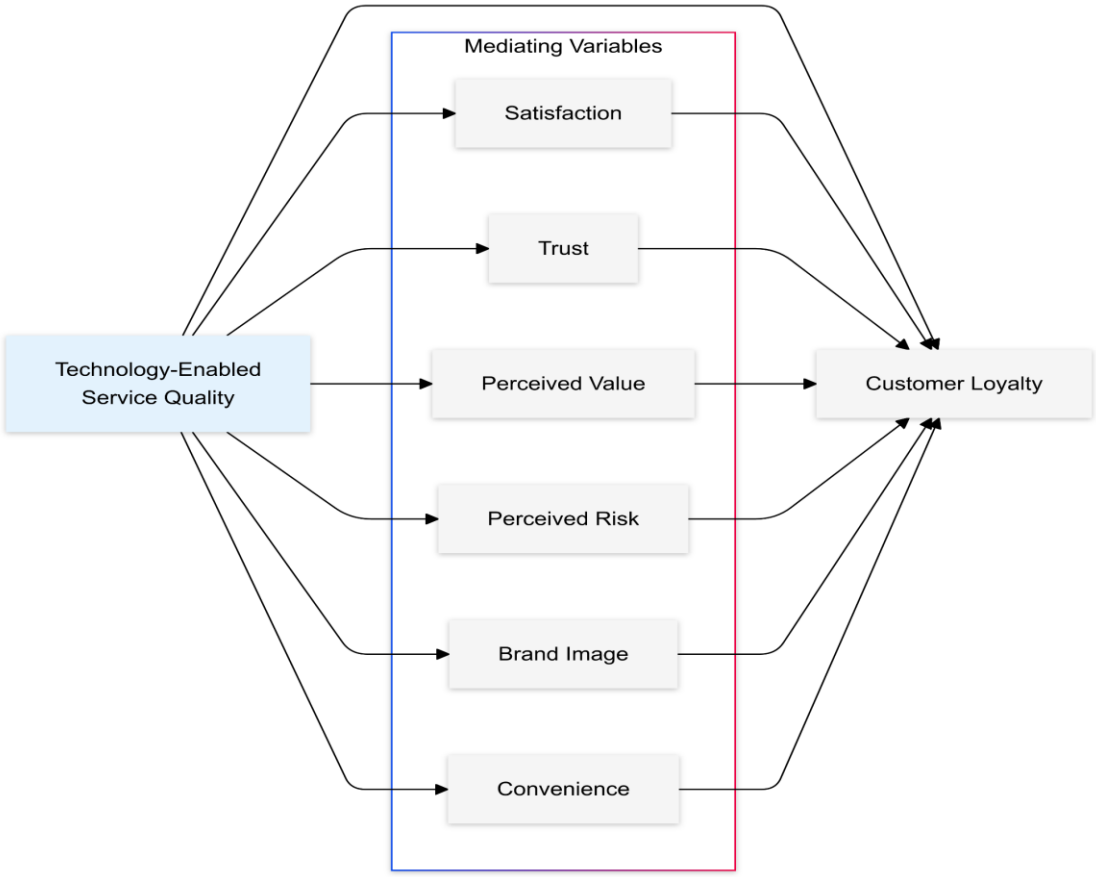


Figure 2.1 Conceptual Framework

This framework emphasizes the complex interplay between technological innovation and customer perceptions. It suggests that organizations should prioritize the strategic implementation of technology that enhances not only the functional aspects of service delivery but also the psychological factors that shape customer loyalty. In this context, this research aims to explore the mechanisms that underpin customer perceptions and also to demonstrate how they mediate the relationship between TESQ and customer loyalty. Therefore, this provides an approach that focuses on both the practical and perceptual elements, which are vital for understanding the complexities of the relationship between technology and service quality.

This model provides a basis for the development of specific hypotheses, which are outlined below.

2.6 Hypotheses

Based on the proposed conceptual framework, the following hypotheses will be tested in this research:

Direct Effects of Technology-Enabled Service Quality (TESQ):

- **H7:** Technology-enabled service quality has a significant positive effect on customer satisfaction.
- **H8:** Technology-enabled service quality has a significant positive effect on perceived value.
- **H9:** Technology-enabled service quality has a significant positive effect on trust.
- **H10:** Technology-enabled service quality has a significant positive effect on customer loyalty.
- **H11:** Technology-enabled service quality has a significant positive effect on perceived risk.
- **H12:** Technology-enabled service quality has a significant positive effect on brand image.
- **H13:** Technology-enabled service quality has a significant positive effect on convenience.

Mediating Effects:

- **H2a:** Satisfaction partially mediates the relationship between technology-enabled service quality and customer loyalty.

- **H2b:** Trust partially mediates the relationship between technology-enabled service quality and customer loyalty.
- **H2c:** Perceived value partially mediates the relationship between technology-enabled service quality and customer loyalty.
- **H2d:** Perceived risk partially mediates the relationship between technology-enabled service quality and customer loyalty.
- **H2e:** Brand image partially mediates the relationship between technology-enabled service quality and customer loyalty.
- **H2f:** Convenience partially mediates the relationship between technology-enabled service quality and customer loyalty.

These hypotheses will be empirically tested using data collected from APSRTC bus passengers in Andhra Pradesh, and the findings will help to further the theoretical framework of service quality and also to offer practical recommendations to transport providers and policymakers.

3. Methodology

This section details the research design, data collection methods, and statistical techniques employed to investigate the relationship between technology-enabled service quality (TESQ) and customer loyalty in the context of APSRTC bus services. This mixed-methods approach combined qualitative and quantitative data to develop and test a comprehensive model.

3.1 Research Design

This study adopted a mixed-methods research design, incorporating both qualitative and quantitative research techniques. This approach is particularly effective for studying complex social phenomena, as it allows for a more in-depth and holistic understanding than a single method can achieve (e.g., Creswell & Plano Clark, 2017). The integration of qualitative and quantitative methods provides a more robust and comprehensive analysis of the research problem by addressing both the "what" and the "why" questions.

The research process was divided into three main phases:

- **Phase 1: Exploratory Qualitative Research:** This initial phase used focus group discussions with APSRTC passengers to identify the key dimensions of TESQ specific to the public transport context, and to develop suitable survey items that reflect those dimensions. This qualitative phase was essential for capturing nuanced perceptions and ensuring the relevance of the study to the specific context of APSRTC bus services.
- **Phase 2: Exploratory Factor Analysis (EFA):** The second phase involved a pilot study, followed by Exploratory Factor Analysis (EFA) to uncover the underlying dimensions of TESQ and to purify the research instrument. The EFA enabled the development of a reliable and valid scale that reflected the key components of the theoretical model, as well as ensuring the content validity of the instrument.
- **Phase 3: Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM):** The final phase used data from a separate sample to perform confirmatory factor analysis (CFA), to test the fit of the measurement model, and to finally test the hypotheses using Structural Equation Modeling (SEM). This approach also involved an analysis of the mediating effects of satisfaction, trust, perceived value, perceived risk, brand image, and convenience. The confirmatory approach, using CFA and SEM, allowed for a robust assessment of the structural model and also enabled the hypothesized relationships to be evaluated empirically.

3.2 Sample

The study employed a purposive sampling technique to select participants from multiple bus depots across Andhra Pradesh. This technique was used, because it enabled the researchers to deliberately include different types of passengers, who may have different levels of familiarity with technology and also to ensure an adequate representation of different passenger groups.

- **Focus Groups (Phase 1):** Participants were recruited from multiple APSRTC depots in key districts, with an equal representation of male and female passengers, and also representation from all key age groups. These focus groups provided a broad range of perspectives and helped ensure the richness and diversity of information that was collected during the focus group stage.
- **EFA (Phase 2):** For the pilot study, a sample of 250 long-distance travellers from 25 depots across the state was used, and this sample was used to refine the survey instrument. In addition, a total sample of 446 responses (n1 =

446) was obtained from a separate set of depots for the main EFA analysis. This ensured that there was a good sample size for identifying the underlying dimensions of TESQ.

- **CFA & SEM (Phase 3):** A separate sample of 446 respondents (n2 = 446) from other depots within the state was used for confirmatory factor analysis and structural equation modeling, thereby ensuring a degree of independence between the exploratory and the confirmatory phases of analysis.

The total sample size used for testing the main hypotheses was n = 892 (n1 + n2), which has been shown to meet the minimum requirements for robust statistical analysis, and all ethical considerations were carefully followed, including assurances of anonymity and confidentiality.

3.3 Data Collection

Data collection involved several methods to ensure rigour and validity:

- **Focus Group Discussions:** The focus group discussions were conducted at strategic locations across the state and all discussions were audio-recorded and transcribed for analysis. This rich qualitative data was used to identify recurring themes related to passenger experiences and was an important foundation for the development of the survey instrument.
- **Pilot Study:** After the initial survey items were developed, the survey instrument was tested using a sample of 250 passengers. All participants were provided with a paper-based survey instrument, which was completed in person. This allowed for the usability and the reliability of the measurement items to be checked before full data collection.
- **Survey Administration:** Following the refinement of the survey, data were collected using a paper-based survey instrument, and all surveys were completed in person, with the help of the research team. All participants were fully informed about the objectives of the study, and also of the assurances of anonymity and confidentiality.

The survey instrument was structured into two parts:

- **Part A:** A series of Likert-scale questions (7-point scale) were designed to measure passenger perceptions of TESQ, satisfaction, trust, perceived value, perceived risk, brand image, convenience, and customer loyalty. This part was essential for testing the study's hypotheses.
- **Part B:** A range of demographic variables were collected to profile the respondents and to examine potential moderators, which also helped to provide additional context to the interpretation of the data. The section also contained an open-ended question to enable the collection of additional qualitative information which provided greater insight into the passenger's experiences.

3.4 Measures

The development of the survey instrument was iterative, using a multi-step approach based on established methods, as well as both a review of relevant literature and also the insights that were gained from the focus group discussions. The key constructs used in this study were measured using the following validated items:

- **Technology-Enabled Service Quality (TESQ):** Measured using a 32-item scale, which captures the six underlying dimensions of tangibility, reliability, responsiveness, assurance, empathy, and technology-enabled service. These items sought to measure the unique dimensions of service quality that were influenced by the integration of technology.
- **Satisfaction:** Measured using a 5-item scale, which reflects the passenger's overall contentment with the service. This scale captures the overall emotional response of the customers to the service.
- **Trust:** Measured using a 6-item scale, reflecting the passenger's reliance on the service provider. This scale captures the degree of confidence and reliance that passengers have on the service provider and their operations.
- **Perceived Value:** Measured using a 5-item scale, which measures the overall perceptions of the benefit that customers receive from using the service.
- **Perceived Risk:** Measured using a 6-item scale, which assessed the potential negative outcomes that a passenger may perceive when they use the service. This scale was designed to assess the level of perceived risk, discomfort and inconvenience that may come from using the APSRTC service.
- **Brand Image:** Measured using a 5-item scale, reflecting the passenger's perceptions of the overall reputation of the provider.

- **Convenience:** Measured using a 6-item scale, capturing the perceived ease of using the bus service and how flexible and accessible it was to customers.
- **Customer Loyalty:** Measured using a 7-item scale, reflecting passengers' behavioral intentions and attitudinal attachment to the service.

All items were measured using a 7-point Likert scale, which ranged from 1 (strongly disagree) to 7 (strongly agree).

3.5 Statistical Analysis

The collected data was analysed using a combination of appropriate statistical techniques:

- **Descriptive Statistics:** Means, standard deviations, frequencies, and percentages were calculated to summarize the demographic profiles of the respondents, which was important for understanding the different customer groups.
- **Exploratory Factor Analysis (EFA):** Principal component analysis (PCA) with varimax rotation was used to identify the underlying dimensions of TESQ, using the n1 = 446 samples, which helped to identify the relationships between the data and to define the key factors that were being measured.
- **Confirmatory Factor Analysis (CFA):** Using the second sample (n2=446), confirmatory factor analysis (CFA) using Structural Equation Modeling (SEM) was conducted in AMOS to validate the measurement model that was developed by the EFA, and also to determine the fit of the measurement items. This step was important for confirming that the identified factors were valid and reliable.
- **Structural Equation Modeling (SEM):** To test the hypothesized relationships between TESQ and customer loyalty, as well as the mediating variables, structural equation modeling (SEM) with path analysis was performed using AMOS. Model fit was evaluated using commonly accepted fit indices, and the structural model was used to determine the direct relationships between key constructs.
- **Parallel Mediation Analysis:** The PROCESS macro for SPSS, as proposed by Hayes (2013) was used to test the mediating effects of satisfaction, trust, perceived value, perceived risk, brand image and convenience, while also considering the direct effect of TESQ on loyalty. This approach was essential for understanding the mechanisms through which TESQ influences customer loyalty.

4. Results

This section presents the findings of the data analysis, following the methodological approach described in the previous section. It begins with a detailed description of the demographic profile of the respondents, then presents the findings from the instrument development process, and continues with the results of the exploratory and confirmatory factor analyses, before finally discussing the findings of the structural equation modelling and mediation analysis.

4.1 Demographic Profile of Respondents

The demographic profile of the 892 participants in this study reveals a diverse range of APSRTC bus passengers, encompassing a near-equal distribution of genders (58.2% male, 41.8% female), a strong representation of young and middle-aged individuals (with the majority falling between the 21-40 age categories, though all age ranges were represented), a significant proportion of married respondents (77.2%), varied family sizes (with most reporting 3-4 or 5-6 members), and a wide range of educational backgrounds (with the most common responses being a 'degree,' an 'INTER' qualification, and a post-graduate qualification, though a significant proportion also had an SSC level of education), and also diverse occupations and income levels. The sample was also shown to include passengers who used the service for different lengths of time, with various purposes of travel, and with a wide variety of motivations, including a "safe and comfortable journey," "fewer fares," "loyalty," "no other alternative" and "easy accessibility." This diverse sample provides a robust foundation for further analysis, ensuring that the findings reflect a wide range of customer perspectives and usage patterns within the APSRTC bus service.

4.2 Development of the Theoretical Model

This section will explore the development of the theoretical model, beginning with the instrument development process, followed by the analysis of descriptive statistics, testing for reliability, and the exploratory factor analysis (EFA) used to establish the theoretical model.

4.2.1 Instrument Development

The development of the instrument was undertaken using a process informed by established procedures, drawing on insights from various research studies within the service quality domain (Churchill, 1979; Flynn & Pearcy, 2001; Hinkin, 1998). The initial item generation phase was informed by a thorough literature review, focusing on service quality,

technology adoption, and customer loyalty, particularly within the transportation sector. This review was combined with insights from focus group interviews with APSRTC users, which allowed the identification of specific dimensions of service quality, which are important within the context of technology-integrated public transportation.

The initial item pool consisted of 124 items, which were refined to 91 items based on their suitability and relevance to the research constructs. Expert consultation helped to refine the items, and the final survey was structured into two parts: Part A (124 items designed to measure TESQ, passenger satisfaction, and passenger loyalty) and Part B (14 items to capture detailed demographic profiles). All items in Part A were measured using a 7-point Likert scale.

A pilot study was also undertaken, and data was collected from 250 long-distance travellers from 25 strategically selected depots. This involved a careful analysis of the survey responses, which helped to ensure that the measurement instrument was valid, reliable and appropriate for the study's context.

4.2.2 Descriptive Statistics, Reliability, and Item Purification

Preliminary analysis of the data was conducted using item statistics and included means and standard deviations, as well as the calculation of Cronbach's alpha. The standard deviations for all but three items were less than 2.0, suggesting a shared perception among respondents. The overall Cronbach's alpha for the scale was .898, demonstrating strong internal consistency among the items. This was then further refined by the removal of four items with low item-total correlations ($r < .40$), which increased the overall reliability of the scale further.

4.2.3 Exploratory Factor Analysis (EFA)

The exploratory factor analysis (EFA) was undertaken to examine the underlying structure and inter-relationships among the items. The appropriateness of the sample was tested using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, and Bartlett's test of sphericity, which were both significant, confirming that the data was suitable for this form of analysis.

Principal component analysis (PCA) with varimax rotation was used because it was appropriate for this form of analysis and helped to ensure the interpretability of the factors. To determine the number of factors to extract, a combination of Kaiser's criterion, the scree plot test, and a priori considerations was used, which resulted in the retention of six factors. The six factors were named as follows: 1) Tangibility, 2) Reliability, 3) Responsiveness, 4) Assurance, 5) Empathy, and 6) Technology. The six-factor model accounted for 61.67% of the total variance, which was considered to be acceptable.

The results of the EFA are summarized in Table 4.2 below:

Table 4.2: (EFA) Exploratory Factor Analysis Results

Rotated Component Matrix[a]						
	Component					
	1	2	3	4	5	6
Digital ticketing provided by the bus service is straightforward and efficient.	.785					
The bus service's technology reduces the time needed for booking.	.779					
The real-time tracking feature of the bus service is accurate and helpful.	.756					
The mobile app provided by the bus service is user-friendly.	.747					
The integration of various technology features (e.g., online payment, real-time updates) meets my expectations.	.740					
Online booking through the bus service's platform is convenient.	.730					
The Buses maintain reliable service even during peak hours or festival seasons.		.773				
The bus service is dependable in terms of frequency.		.764				
The buses are generally punctual.		.759				
The buses operate consistently according to the published timetable.		.742				
The bus service provides accurate information regarding schedules and routes.		.719				
I can rely on the bus service to be available when needed.		.716				

I feel safe and secure while using the bus service.			.793			
I feel confident that my personal and payment information is secure when booking tickets online or through the app.			.782			
I trust the competence of the bus drivers and staff.			.767			
The bus service is reliable in terms of safety measures.			.760			
The bus service operates with high standards of professionalism.			.760			
Bus stops are clean and well-equipped.				.767		
The bus service provides comfortable seating arrangements.				.764		
Information boards and signage are clear and informative.				.760		
The bus service offers convenient facilities (e.g., restrooms, refreshments).				.758		
The buses are well-maintained and in good condition.				.738		
The bus service treats all passengers fairly and equally.					.773	
Bus drivers show consideration for passenger comfort by driving smoothly and avoiding sudden brakes.					.768	
Staff members demonstrate concern and understanding towards passengers.					.768	
Bus conductors show patience when passengers take time to find their fare or ticket.					.740	
Staff members are courteous and respectful in their interactions.					.712	
The bus service handles unexpected situations effectively.						.768
The bus service adjusts schedules promptly when needed.						.758
The staff members promptly respond to passenger's queries or complaints.						.753
Staff members are attentive to the needs of passengers.						.750
Staff members are quick to assist passengers during boarding.						.725
Eigenvalue	7.698	2.811	2.506	2.432	2.179	2.11
Variance%	11.512	11.285	9.948	9.699	9.647	9.586
Cumulative % of Variance Explained	11.512	22.797	32.745	42.444	52.092	61.678
Cronbach's Alpha	.847	.865	.837	.856	.839	.870
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.						
a. Rotation converged in 6 iterations.						

This analysis has shown that the original list of 32 measurement items could be effectively grouped into six underlying factors, which are both internally consistent and also demonstrate a good fit for the model. The next stage of analysis will seek to further test and validate this model, prior to testing the structural relationships that were outlined in the conceptual framework.

4.3 Development of Measurement Model

This section focuses on the development and validation of the measurement model, using Confirmatory Factor Analysis (CFA). This stage was designed to build upon the findings of the EFA, to test the structure of the identified factors, and also to assess the validity and reliability of the measurement items.

4.3.1 Confirmatory Factor Analysis (CFA)

To further validate the theoretical model derived from the EFA, confirmatory factor analysis (CFA) was conducted using a separate sample (n2 = 446). This analysis was performed to assess the measurement properties of each factor and confirm the underlying factor structure identified earlier. The analytical approach involved Structural Equation Modeling (SEM), utilizing AMOS (Analysis of Moment Structures) version 22.0 software. The CFA process was undertaken in two stages:

first, individual first-order CFA models were developed for each of the six factors, and then the results of this were used to construct a second-order model that integrated all of the factors under a broader concept of service quality.

4.3.2 Preliminary Analysis of the Data

Before conducting confirmatory factor analysis (CFA) and subsequent modeling, a preliminary analysis of the data was undertaken. This initial step involved assessing the assumptions of normality and linearity, crucial preconditions for the application of Structural Equation Modeling (SEM). Specifically, tests for univariate and multivariate normality, as well as scatterplots for assessing linearity, were examined to ensure the data met the requirements of the statistical techniques.

- **Assessment of Normality:** Normality was assessed using skewness and kurtosis values. Data were considered to be normally distributed when both skewness and kurtosis values fell within an acceptable range of ± 1 and did not exceed three times their standard error. The results indicated that all variables met the criteria for normality, which allowed for this to be treated as an appropriate dataset.
- **Testing of Data Linearity:** Linearity was assessed by using ANOVA, testing whether there is a significant linear relationship between each independent variable and the dependent variable. The results indicated a statistically significant linear relationship at a significance level of $p < 0.05$ between all independent variables and the dependent variable, thus satisfying the assumption of linearity.
- **Outliers Assessment:** The analysis of outliers was undertaken through a variety of techniques: Univariate outliers were assessed using box plots and by carefully examining extreme values. Additionally, to address the possibility of unengaged respondents, attention check questions were used. Multivariate outliers were identified using Mahalanobis distance (D^2) calculated in AMOS. This analysis showed that there were no significant univariate or multivariate outliers and that it was appropriate to continue with CFA.

4.3.3 First-Order CFA Models

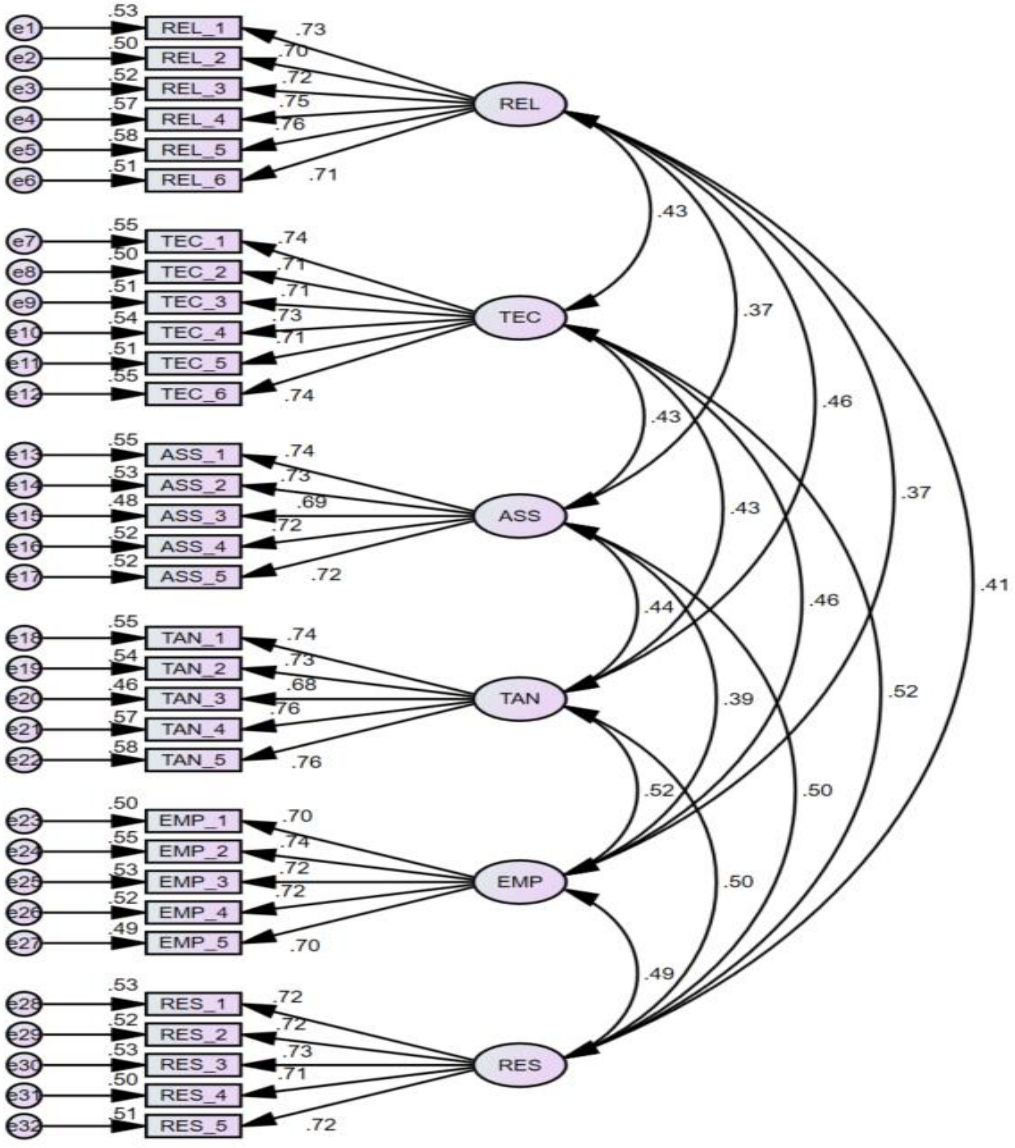
To confirm the unidimensionality of each latent construct and to evaluate their measurement properties, a first-order confirmatory factor analysis (CFA) was conducted for each of the six factors derived from the EFA. These are as follows:

- **CFA of Tangibility:** The tangibility dimension, which pertains to the physical attributes of the service, was measured by five variables. The Average Variance Extracted (AVE) and Construct Reliability (CR) values were 0.538 and 0.853, respectively, which met the required thresholds, demonstrating good convergent validity and reliability. The model fit indices ($\chi^2 = 3.742$, df = 2, GFI = .997, AGFI = .990, CFI = 1.000, TLI = 1.003, NFI = .996, IFI = 1.00, RMR = .026, SRMR = .013, RMSEA = .0000, and PCLOSE = .918), also indicated a good fit.
- **CFA of Reliability:** The reliability dimension, which pertains to the consistency and dependability of the service, was measured by six variables. The AVE and CR values were 0.533 and 0.872, respectively, which demonstrates that this factor met the required criteria. The model fit indices ($\chi^2 = 9.956$, df = 9, GFI = .993, AGFI = .983, CFI = 0.999, TLI = 0.999, NFI = .991, IFI = .999, RMR = .037, SRMR = .018, RMSEA = .015, and PCLOSE = .901) indicated a good fit for the CFA model of the reliability dimension.
- **CFA of Responsiveness:** The responsiveness dimension, which pertains to the willingness and ability of the service to assist and adapt to passenger needs, was measured by five variables. The AVE and CR values were 0.519 and 0.843, respectively, indicating good convergent validity and reliability. The model fit indices ($\chi^2 = 4.250$, df = 5, GFI = .996, AGFI = .988, CFI = 1.000, TLI = 1.002, NFI = .995, IFI = 1.001, RMR = .031, SRMR = .015, RMSEA = .000, and PCLOSE = .891) also indicated a good model fit.
- **CFA of Assurance:** The assurance dimension, which pertains to the feelings of safety, security, and competence associated with the service, was measured by five variables. The AVE and CR values were 0.519 and 0.844, respectively. The model fit indices ($\chi^2 = 4.597$, df = 5, GFI = .996, AGFI = .988, CFI = 1.000, TLI = 1.001, NFI = .994, IFI = 1.001, RMR = .031, SRMR = .015, RMSEA = .0000, and PCLOSE = .871) also indicated a good fit.
- **CFA of Empathy:** The empathy dimension, which pertains to the caring, individualized attention, and understanding provided by the service, was measured by five variables. The AVE and CR values were 0.515 and 0.842, respectively. The model fit indices ($\chi^2 = 8.375$, df = 5, GFI = .992, AGFI = .997, CFI = .996, TLI = .991,

NFI = .990, IFI = .996, RMR = .042, SRMR = .021, RMSEA = .039, and PCLOSE = .596) also indicated a good model fit.

- **CFA of Technology:** The technology-enabled service dimension, which pertains to the effectiveness and user-friendliness of technology in service delivery, was measured by six variables. The AVE and CR values were 0.526 and 0.869, respectively. The model fit indices (χ^2 = 25.008, df = 9, GFI = .982, AGFI = .958, CFI = .985, TLI = .985, NFI = .978, IFI = .985, RMR = .060, SRMR = .028, RMSEA = .063, and PCLOSE = .201) also indicated a good model fit.

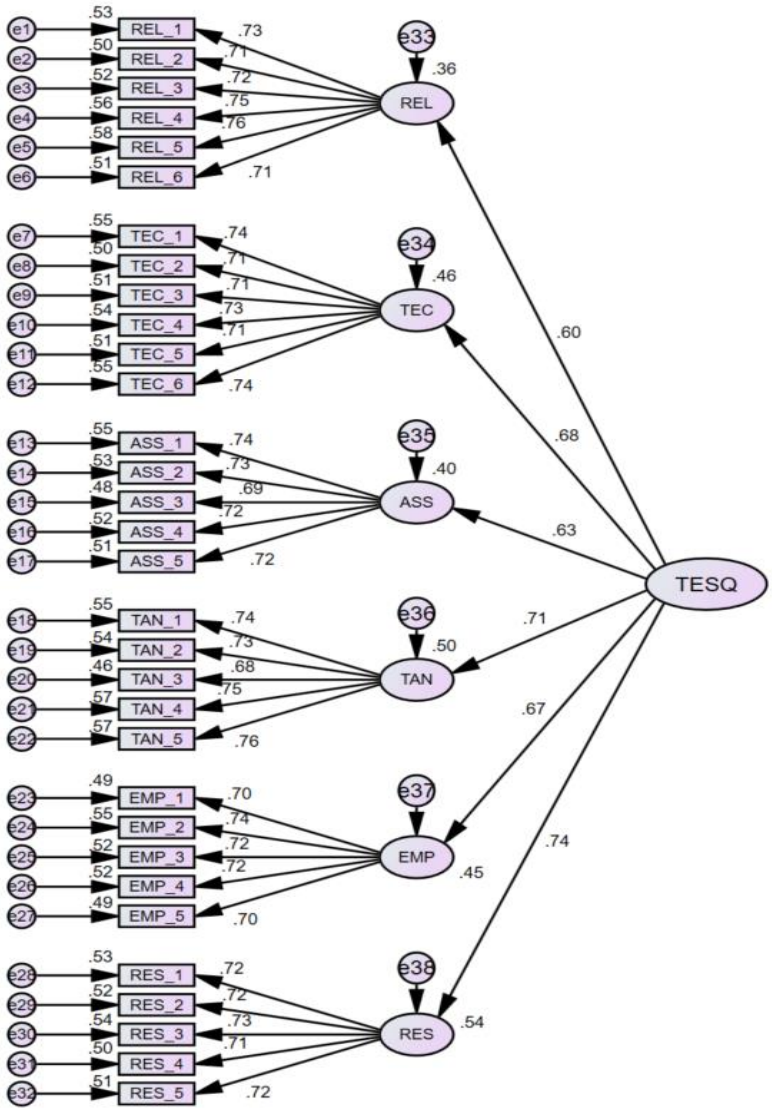
The results of the individual first-order confirmatory factor analysis models, for each of the six factors, have indicated that there is an appropriate level of convergent validity, construct validity and also model fit.



The overall fit of the first-order measurement model, which included all six identified factors and 32 measurement items, was assessed using several fit indices. The results showed that the model achieved a good fit, with a chi-square value of 462.933 and 449 degrees of freedom, a Goodness of Fit Index (GFI) of .940, an Adjusted Goodness of Fit Index (AGFI) of .930, a Comparative Fit Index (CFI) of .998, a Tucker-Lewis Index (TLI) of .997, a Normed Fit Index (NFI) of .929, an Incremental Fit Index (IFI) of .998, a Root Mean Square Residual (RMR) of .075, a Standardized Root Mean Square Residual (SRMR) of .032, a Root Mean Square Error of Approximation (RMSEA) of .008, and a PCLOSE of 1.000

4.3.4 Second-Order Measurement Model

To further investigate the structure of service quality, a second-order measurement model was developed, which assumed that all first-order latent constructs were integrated into a single higher-order latent construct, which represents overall service quality (SQ). The results of this analysis are shown below:



These results show that all six of the first-order factors load well onto the second-order factor of overall service quality, and also that all of the relationships are statistically significant. The model fit indices also support the use of this model, as they meet the required thresholds, as can be seen in Table 4.4.

The second-order measurement model, which integrated all six first-order factors into an overall service quality construct, also demonstrated a good fit. The model fit indices indicated a chi-square value of 473.644 with 458 degrees of freedom, a Goodness of Fit Index (GFI) of .939, an Adjusted Goodness of Fit Index (AGFI) of .930, a Comparative Fit Index (CFI) of 0.997, a Tucker-Lewis Index (TLI) of 0.997, a Normed Fit Index (NFI) of .928, an Incremental Fit Index (IFI) of 0.997, a Root Mean Square Residual (RMR) of .081, a Standardized Root Mean Square Residual (SRMR) of 0.034, a Root Mean Square Error of Approximation (RMSEA) of 0.009, and a PCLOSE of 1.000. These results indicate that the second-order model adequately represents the data, and is, therefore, a good fit.

The results presented above indicate a strong and robust measurement model which is both valid and reliable, and the data is now suitable for further analysis to investigate the hypothesized relationships.

4.3.5 Reliability and Validity Tests

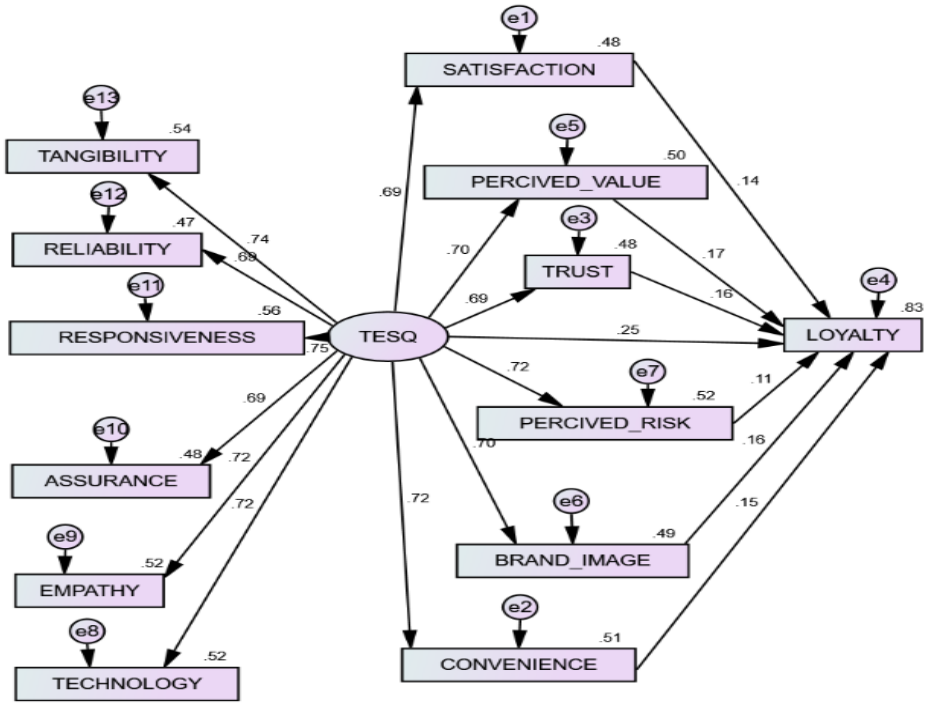
The assessment of the measurement model also involved tests for reliability and validity:

- **Reliability:** The CFA results demonstrated strong evidence of construct reliability, and it was shown that all factor loadings were significant, with critical ratios exceeding 1.96. The AVE and CR values for each construct were also found to meet the recommended thresholds.
- **Face Validity:** The content of the items was assessed during the initial item generation stage, which involved the development of items based on a comprehensive analysis of the literature, and subsequent reviews by experts in service quality and logistics.
- **Convergent Validity:** Convergent validity was supported by statistically significant factor loadings and also by the AVE values, which were all above the recommended threshold of 0.50, and which confirmed that items were measuring the same construct.
- **Discriminant Validity:** Discriminant validity was also assessed by evaluating the variance extracted (VE) estimates, which showed that each was greater than the squared inter-construct correlations (SIC).
- **Nomological Validity:** Nomological validity was assessed by analyzing the Pearson product-moment correlations between the constructs, which indicated that all relationships were positive and significant.

These results provide strong evidence for both the reliability and validity of the multi-dimensional measurement model, indicating that it is robust and that the measures are well-defined.

4.4 Structural Equation Model

Following the development and validation of the measurement model, a structural equation model (SEM) was developed to empirically test the hypothesized relationships among technology-enabled service quality (TESQ), perceived value, perceived risk, trust, satisfaction, convenience, brand image, and customer loyalty. The SEM analysis was conducted using AMOS 22.0 software.



4.4.1 Model Fit

The structural model was assessed for goodness-of-fit using a range of commonly accepted indices. The results, which are summarized in Table 4.5, indicated that the model provided an acceptable fit to the data. Specifically, the chi-square value

was 183.079 with 59 degrees of freedom, the Goodness of Fit Index (GFI) was .945, the Adjusted Goodness of Fit Index (AGFI) was .915, the Comparative Fit Index (CFI) was .964, the Tucker-Lewis Index (TLI) was .953, the Normed Fit Index (NFI) was .949, the Incremental Fit Index (IFI) was .965, the Root Mean Square Residual (RMR) was .037, the Standardized Root Mean Square Residual (SRMR) was .035, the Root Mean Square Error of Approximation (RMSEA) was .069, and the PCLOSE was .003. These results all fell within commonly accepted thresholds and indicated an acceptable fit for the data (Hair et al., 2019).

These results show that the fit of the data was within acceptable thresholds, as recommended by (Hair et al., 2019), and therefore it was appropriate to test the hypothesised relationships.

4.4.2 Hypotheses Testing of Direct Relationships

The structural model was used to evaluate the hypothesized relationships, and the regression weights and t-values were calculated. The results of the analysis demonstrated that there were significant positive relationships for all of the hypothesized direct effects, and the specific results are shown in Table 4.6.

These results demonstrated the significant direct effects of TESQ on satisfaction, trust, perceived value, perceived risk, brand image and convenience, and also on customer loyalty, therefore supporting all of the hypothesised relationships that have been included in the conceptual framework.

4.4.3 Structural Equation Model (Standardized Regression Coefficients)

The standardized regression coefficients for the structural model are shown below. These demonstrate how strongly the constructs influence each other, and also provide additional insight for the mediating analysis.

The results demonstrated that:

- TESQ had a positive and significant influence on Perceived Value ($\beta = 0.704$, $p<.001$), Perceived Risk ($\beta = 0.718$, $p<.001$), Trust ($\beta = 0.691$, $p<.001$), Satisfaction ($\beta = 0.694$, $p<.001$), Convenience ($\beta = 0.716$, $p<.001$), Brand Image ($\beta = 0.700$, $p<.001$), Tangibility ($\beta = 0.736$, $p<.001$), Reliability ($\beta = 0.687$, $p<.001$), Assurance ($\beta = 0.690$, $p<.001$), Empathy ($\beta = 0.724$, $p<.001$), Responsiveness ($\beta = 0.748$, $p<.001$), and Technology ($\beta = 0.718$).
- Perceived value ($\beta = 0.169$, $p < .001$), Trust ($\beta = 0.161$, $p < .001$), Perceived Risk ($\beta = 0.108$, $p < .001$), Satisfaction ($\beta = 0.142$, $p < .001$), Convenience ($\beta = 0.146$, $p < .001$), and Brand Image ($\beta = 0.156$, $p < .001$) all had a significant and positive effect on customer loyalty.
- Finally, there was also a positive and significant direct effect of TESQ on customer loyalty ($\beta = 0.251$, $p = 0.001$).

4.5 Mediation Analysis

To further explore the pathways between TESQ and customer loyalty, a parallel mediation analysis was conducted. The results of this analysis, which was undertaken using the PROCESS macro for SPSS, demonstrated that the mediating effects of satisfaction, trust, perceived value, perceived risk, brand image, and convenience were all significant. The direct and indirect effects are summarized in Table 4.7. All confidence intervals did not contain zero, which provides further support for the existence of these mediating effects.

Table 4.7: Summary of Parallel Mediation Test Results

Effect	β	SE	t-value	BootLLCI	BootULCI
Total Effect of TESQ on LOYALTY (c)	0.8799	0.0304	28.9381	0.8202	0.9397
Direct Effect of TESQ on LOYALTY (c')	0.1402	0.0437	3.2089	0.0543	0.2261

Indirect Effect of TESQ on LOYALTY through:					
Total Indirect Effect	0.7397	0.0458		0.6479	0.8317
Satisfaction (SATISFAC)	0.1168	0.0207		0.0806	0.1632
Perceived Value (PERCIVED)	0.1352	0.0215		0.0985	0.1840
Trust (TRUST)	0.1289	0.0198		0.0923	0.1710
Perceived Risk (PERCIV_1)	0.1012	0.0198		0.0638	0.1417
Brand Image (BRAND_IM)	0.1292	0.0195		0.0944	0.1713
Convenience (CONVENIE)	0.1283	0.0199		0.0923	0.1711

The specific indirect effects are:

- **Satisfaction**: The results demonstrated a significant mediating effect for satisfaction (β = .1168, BootLLCI = .0806, BootULCI = .1632). Therefore, Hypothesis 2a is supported.
- **Trust**: There was a significant mediating effect through trust (β = .1289, BootLLCI = .0923, BootULCI = .1710), which supports Hypothesis 2b.
- **Perceived Value**: The hypothesized relationship was supported, as there was a significant mediating effect of perceived value (β = .1352, BootLLCI = .0985, BootULCI = .1840). This supports Hypothesis 2c.
- **Perceived Risk**: The mediation effect of perceived risk was also significant (β = .1012, BootLLCI = .0638, BootULCI = .1417), supporting Hypothesis 2d.
- **Brand Image:** The analysis showed a significant mediating effect of brand image (β = .1292, BootLLCI = .0944, BootULCI = .1713), supporting Hypothesis 2e.
- **Convenience**: The mediating effect of convenience was also found to be significant (β = .1283, BootLLCI = .0923, BootULCI = .1711), which supports Hypothesis 2f.

The results showed that the total effect of TESQ on customer loyalty was significant (β = 0.8799, $p < .001$), and the direct effect was also shown to be significant (β = 0.1402, p = .0014), indicating partial mediation of these pathways. This indicates that while TESQ has a direct effect on customer loyalty, its influence is also enhanced by its effect on satisfaction, trust, perceived value, perceived risk, brand image, and convenience.

5. Discussion

This section provides a comprehensive discussion of the research findings, interpreting them within the context of the theoretical framework and research objectives. The discussion is structured to emphasize both the theoretical contributions and the practical implications of the study, while also acknowledging its limitations and suggesting future research directions.

5.1 Theoretical Implications

The findings of this study offer significant theoretical contributions to the fields of service quality, technology adoption, and customer loyalty within the public transportation sector.

- **A Multi-Dimensional Model of TESQ**: This research has successfully developed and validated a multi-dimensional model of Technology-Enabled Service Quality (TESQ) that integrates both traditional dimensions of service quality with contemporary technological components. This model, comprised of six distinct factors (Tangibility, Reliability, Responsiveness, Assurance, Empathy, and Technology), extends and refines the existing

understanding of service quality. This study has shown that the traditional dimensions of service quality are still important, but need to be considered in conjunction with technology. Therefore, this provides a more comprehensive framework that can be used to understand customer perceptions of service quality in the context of technologically advanced organizations.

- **Empirical Confirmation of Direct and Mediated Effects**: This study has empirically demonstrated that TESQ has a significant direct positive effect on customer loyalty, which is further enhanced by several mediating constructs (satisfaction, trust, perceived value, perceived risk, brand image and convenience). The significant direct effect of TESQ on customer loyalty reinforces the importance of technological innovation in enhancing customer experiences and also in fostering long-term relationships. By integrating the mediating factors, this approach has shown that customer loyalty is not determined solely by perceptions of technology but is also influenced by more complex relationships with the service itself.
- **Elaboration of Mediating Mechanisms:** This research has identified specific pathways through which TESQ influences customer loyalty, and has shown that it operates through various mediating factors. This highlights the need for service providers to focus on improving both the functional aspects of service, as well as the overall customer experience. This finding is particularly important for developing a more detailed understanding of the constructs that shape customer perceptions and shows how different aspects of service delivery interact to create loyalty, and also a strong customer base.
- **Integrated Theoretical Framework**: By exploring these complex and interrelated mechanisms, this study contributes to the integration of different theoretical perspectives, and creates a holistic framework which captures how technology, service quality, and customer perceptions interact to shape loyalty. By doing this, this study demonstrates the importance of considering both the direct and indirect effects of TESQ on customer loyalty and shows that service providers should aim to develop integrated approaches that consider all elements of the customer experience, rather than relying on one single variable.

5.2 Practical Implications

The findings of this research have several important practical implications for public transport providers, as well as for policymakers:

- **Strategic Investment in Technology:** Public transport providers must prioritize strategic investments in user-friendly, efficient, and reliable technologies. This should include both hardware and software solutions, as well as focus on how these technological tools can also create a positive perception of the overall service. This may involve using mobile apps, websites or digital information boards. All investments should be strategic and should aim to focus on what will benefit the customer the most.
- **Enhance the Overall Customer Experience:** Technology should not be seen as a solution on its own but must be designed to improve the overall customer experience. This includes considering the usability of technology, as well as how it can be used to make the service more reliable and to also communicate more effectively with customers. This may also involve the provision of clear information about routes, times, and safety.
- **Build Trust and Confidence:** Transportation providers must prioritize building trust with their passengers by ensuring that services are consistently reliable, safe, and professionally delivered. This should be approached holistically and may involve a variety of actions, such as using highly trained staff and using up-to-date technologies.
- **Develop a Strong Brand Image:** A positive brand image is a valuable asset, and also has a significant impact on customer loyalty. Therefore, transportation providers should consider how to improve their brand, by improving all aspects of their service and by communicating this to the customer base effectively.
- **Focus on Convenience:** Public transport providers must seek to ensure that their services are as convenient and accessible as possible, and they should seek to provide an efficient and easy way for customers to use the service. This will include the development of easy-to-use booking systems, as well as clear information about routes and timetables.
- **Manage Customer Perceptions of Risk:** Transportation providers should be proactive in addressing customer safety concerns and managing perceptions of risk. This will involve showing that the transport provider is taking safety seriously, and this will help to improve the overall trust that passengers have in the service.

5.3 Limitations and Future Research Directions

This study, like all research, has some limitations that present opportunities for further research.

- **Geographic Specificity:** The data for this study was collected in Andhra Pradesh, which may limit the generalizability of the findings to other contexts. Future studies could explore the transferability of this model to other regions and cultures, and should also consider the unique needs and expectations of different passenger groups.
- **Cross-Sectional Design:** The use of a cross-sectional approach limits the ability to determine causal relationships or to investigate changes over time. Therefore, longitudinal studies may be beneficial, as they will help to explore how these variables change over time and also allow researchers to more fully understand the relationships between them.
- **Limited Scope of Mediating Variables**: While the study explored key mediating variables, there may be other relevant factors (e.g. customer engagement, perceived ease of use, or social influence) that may affect the relationships between TESQ and customer loyalty, and that could be considered in future research.
- **Qualitative Perspectives:** While focus groups were used in the initial stage of the research, future studies may benefit from additional qualitative investigations to gather deeper insights into customer experiences and to provide a richer understanding of the user perspective. This approach may help to identify new factors or also to explore aspects that could be more difficult to measure through quantitative approaches alone.

6. Conclusion

This study has provided a comprehensive investigation into the impact of technology-enabled service quality (TESQ) on customer loyalty within the public transportation sector, focusing specifically on APSRTC bus services. Through the rigorous development of a multi-dimensional model of TESQ, this study has empirically demonstrated that TESQ has a significant direct effect on customer loyalty, and also that this relationship is further enhanced through the mediating roles of satisfaction, trust, perceived value, perceived risk, brand image, and convenience.

The findings of this research have several notable theoretical contributions. First, this study extends the traditional models of service quality to better reflect how technology is now a key factor when considering customer perceptions of service, and also by creating a bespoke model that is specific to the public transportation context. Second, it empirically demonstrates the validity of the hypothesized relationships between TESQ and customer loyalty, and also that this relationship is not direct, but is instead partially mediated by several key constructs, which helps to show the complex interplay of these variables in determining customer loyalty. Finally, it also provides insight into the specific mechanisms that underpin customer loyalty, and how technology can be strategically used to manage both direct and indirect influences on customer retention and user satisfaction.

From a practical perspective, the findings of this research emphasize the importance for transportation providers and policymakers to prioritize investments in technologies that are user-friendly, reliable, and also enhance the overall customer experience. This also highlights the need for transport providers to manage not only perceptions of quality but also the risks and the perceived value that is associated with using the service. This research also shows that to enhance customer loyalty, it is vital for organisations to build trust and confidence, to focus on their brand image, and also to focus on convenience. The recommendations that have been developed from this research provide actionable strategies for transport providers to adopt a customer-centric approach that is designed to increase both customer satisfaction and also long-term loyalty.

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