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Riding the Wave: The Growing Preference for Public Transit System among Customers

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ABSTRACT

Public transport is essential for urban mobility, reducing traffic congestion, and minimizing environmental impact. However, inadequate public transport conditions in Karachi have shifted interest towards private vehicles. The Green Line Bus Rapid Transit (BRT) System aims to offer a modern alternative and improve the current situation. This study aims to explore the role of technological developments, best practices, and standard operating procedures (SOPs) in improving service quality and attracting people to public transportation in Karachi. A cross-sectional study and survey were conducted in Karachi to gauge residents' perceptions and expectations of the Green Line BRT System. Data were collected from 450 participants using a non-probability sampling technique. The findings reveal that technological advancements contribute to improved service quality and are considered significant by consumers when evaluating and selecting public transport services. Improved road quality further reinforces this connection. These insights are essential for policymakers and transport authorities to develop strategies that increase the attractiveness of public transportation and ensure sustainable urban mobility. Addressing core issues with modern technological methods can improve public transport systems and inspire further research.

1 Introduction

In recent decades, there has been a substantial and increasing dependence on cars for daily transportation. This has resulted in major environmental consequences, such as the generation of greenhouse gases, as well as negative health impacts, including casualties (Ghaffar et al., 2021). Poor public transport conditions within Karachi have led the public to use private transport to a greater extent. Karachi's transportation issues have worsened over the last few decades.

People choose various transportation modes depending on the trip's intent and duration (Wang & Namgung, 2007). The worst transportation system may lead to multiple issues. Increased mobility issues have resulted from increased active car usage in and around cities in developed countries (Sahito et al., 2020). Many people now rely on Karachi, their cars, and unofficial means of public transportation to get around town. Most Karachi residents regularly use informal public transportation to and from school, college, university, and employment (Brohi et al., 2023). The increasing use of private vehicles and motorbikes has put substantial pressure on urban transportation and policymakers.

2 Literature Review

2.1 Green Buses as Customers' Choice

Green Line, also known as Bus Rapid Transit (BRT), is a project initiated in Karachi by the Government of Pakistan in 2016. The Green Line Bus Rapid Transit (BRT) project is an advanced mass transit system in Karachi that will enhance the city's public transportation infrastructure. In early 2022, Prime Minister Imran Khan opened the initial stage of the project, which spans 21 kilometres and includes 22 stations. Additionally, the government procured 80 diesel hybrid buses from Foton firm, each capable of accommodating 150 passengers. The buses are equipped with surveillance cameras and charging stations designed to be accessible for people with disabilities. The project's objective is to enable the smooth transportation of 135,000 passengers daily, with buses scheduled to arrive at intervals of 10 minutes. The Karachi Green Line BRT system is the inaugural functioning metro bus route under the broader "TransKarachi" project, which is swiftly developing to tackle transportation challenges in the metropolis.

As it has been seen commonly, most people in Karachi city choose private rather than public transportation. Public transport is in such bad condition in the city that almost 60 – 70 % of people use private transport. According to Matas (2004), the declining trend

in public transport ridership can be reversed through an active public transport policy based on low-cost travel passes and, most importantly, improvements in the quality of service offered (Kim et al., 2021, Yaya et al., 2014). The rest either use the public services because they cannot afford the higher cost of private transport or do not own it. An excellent public bus service is essential to support economic growth, the growing population, and the expansion of urban or rural activities (Bachok et al., 2014).

This study examines the core reasons and the impact of those reasons on the public's prime choice so that they should go for public mode. Preferably, public transportation is appreciated in the rest of the world because it reduces the area of people covered on roads and is more eco-friendly than private vehicles. The research investigates the factors influencing public transport as a prime customer choice. There are a wide range of different modes of public transportation. The aim is to understand better how technological advancement and best practices help increase service quality. Technological enhancement means the application and induction of recent technological developments in the transportation sector. Procedures are vital in eliminating health, safety, and environmental risks.

In addition to improving service quality, road structures and availability of transport are the factors that help public transport become a prime choice for customers. Service quality represents the system's overall effectiveness according to the customer's needs. The availability is the ease of access to services for the common public—these play moderating roles for better customer satisfaction levels. Transport stakeholders in Malaysia must ensure the availability of resources to provide effective and efficient public transport systems. These are to maintain the current passenger loads that will eventually increase. (Fahim et al., 2021). Finally, road quality is the reliability of roads, routes, and all the accessories and protocols of a route transit. Service quality attributes influence customer satisfaction and prime choice, while road quality and availability of transport

will help strengthen the relationship. Public transport should become part of a solution for sustainable transport in the future.

The study focuses on the attributes that made public transport a prime choice for customers. The actual service performance of a transit system should be considered from the transit users' perspective. This study checks the impact of technological enhancements and best practices on service quality and customer's prime choices. Technological Enhancements and Best Practice SOPs are our independent variables, and the customer's prime choice will be our dependent variable. Service quality will mediate the effect of the two independent variables on the dependent variables. We also used two moderators', i.e., availability and road quality concerning service quality and customer choice. Our primary purpose is to know the public's requirements and expectations and the key factors that directly impact the customer's transportation mode choice.

2.2 Theoretical Underpinning

This study is underpinned by social safety theory. Human beings aspire to have a safer and happier life. After the pandemic outbreak in 2020, the world has drastically changed its dimensions into some very new concepts. The first thing affected was the social distancing issue, which led to the displacement of almost every individual across the globe. According to social safety theory, "the human brain and immune system are principally designed to keep the body biologically safe, which they do by continually monitoring and responding to environmental, social, physical, and microbial threats (Slavich, 2020). In 1991, Ajzen proposed a theory of planned behavior, intentions, attitudes, and subjective forms that determine behavior. The more people believe in the efficiency and pros of a system, the more likely they are to make it their priority. People who say that public transportation provides excellent service and personal cars hurt the environment have more potential to use public transit (Borhan et al., 2014). In bus

transport systems, the need to continually improve technology and services is high in demand because a customer wants his every day to be better than yesterday. If the customer feels the improvement work is not up to the mark, he will likely skip it. For better customer catchment, you must be well-updated with current scenarios.

2.3 Best Practice SOPs

Standard Operating Procedures (SOPs) are the best and safest practices for routine work or specific assignments in every organization. These practices mainly focus on enhancing the system's overall performance and avoiding maximum risks related to the tasks. SOPs are designed so efficiently that every commoner can understand them and act accordingly. In our context, the best practice SOPs relate to all necessary sets of guidelines for a transport service, which helps maintain proper service quality and system discipline. It is in a documented form and is communicated with all the people related to the system so that each one remains on the same page of the story.

Applying SOPs to any system helps improve its quality. They (SOPs) must be revised continuously to manage the same quality (Bodur, 2018). When all the employees and customers follow rules and regulations, the overall sense of quality is continually improved. The principal aim of developing and following SOPs is to ensure everyone relates to the same procedures in routine and emergency cases. Today, SOPs aim to ensure that all employees perform similarly. When all employees perform their tasks properly, it becomes possible to conduct controlled experiments to test the effect of various changing process parameters (Akyar, 2012).

In 2020, after the pandemic outbreak, the world saw colossal change and concern over the SOPs in every social platform. Especially crowded places were prohibited, restricting the usage of public transport. In particular, human travel and outdoor activities could be significantly affected (de Haas et al., 2020; Mogaji, 2020). Laws, regulations,

and other standards are helpful but may not address all local needs. That is why SOPs must be used and implemented (FEMA, 1999)[5] The SOPs in the bus transportation system refer to a new optimization model specially designed to improve procedures and efficient operation of the BRT network. SOPs include route selection, frequencies of buses, and determination of passengers. SOPs help operate the system from short to long-term analysis. SOPS, with an interactive approach, helps optimize the process. Due to the changing economy, there can be a rise in the financial constraints of public transport, which is very important. The government is not willing to absorb the transport system's deficit. To address these problems, standard operating procedures should be designed to cut costs by improving the scheduling of vehicles and people along with the regularity of the service.

H1: Best Practice SOPs have a positive impact on Service quality.

2.4 Technological Enhancements

Technological enhancement refers to developing older ways and techniques to run and operate a system with newer ones, which are cost-effective and create much ease for the users. Technological improvements are all about adding new concepts and ideas to meet customer demands and needs and solve problems (Fahim et al., 2023). As with the moving world towards sustainability, it has become a top priority of the transport and urban department to reduce the use of cars and increase the rapid bus transport system with advanced technologies. Technological advancement has been the eternal theme of the transportation sector. With the advancement in society and economy, an increase in urbanization promotes urban and rural traffic change, and this leads technology to rectify changes in the safety of vehicles and passengers overall. The R&D department of the automotive sector is mainly concerned with the safety technology of cars and passengers to ensure smooth transportation operation.

Different technological advancements in safety are being used, including active and passive safety. An automatic system is in practice in India to provide solutions for real-time tracking, detecting metro buses, and predicting their arrival time. This automatic system addresses the challenges related to GPS outages. The system is evaluated at peak hours; the technology must be straightforward to use with the minimum investment & open to the public. The idea is to manage it through an Android application. There is a positive relationship between technology enhancement & service quality. The study also faces technical challenges. For example, identify bus stops automatically, predicting the arrival time accurately, bus arrival time prediction & automatic bus-stop identification module. Due to the time tracking, it was easy for everyone to manage time effectively, and they didn't have to wait for hours at bus stops.

Moreover, the bus tracking system automatically updates the customer with the current position of the bus, so customers can easily communicate with relatives and family when they reach the destination. Technological enhancement is essential for maintaining a system's existing popularity in the market. Due to changes in worldwide trends, people's choices also change dramatically. Technological innovation and quality management are interrelated, and both have a relationship with progress in leaps (Mandeep & Deepa, 2020). We will check the impact and public demands of the technological aspects of the green line system to enhance service quality. Since the direct relationship between innovative technology and service quality exists, we will check what impacts the transportation system, especially the public transport in the city.

H_2: Technological Improvements will have a positive impact on service quality.

2.5 Service Quality

Service quality refers to the overall effectiveness and success of a system. In our case, service quality refers to the customer's satisfaction level, leading to the customer's

prime choice. Service quality has been conceptualized and defined as the outcome measure of the gap between customers' expected performance of service offered and their perceptions of the level of service received (Parasuraman et al. 1988). Thus, it can be concluded that service quality represents the gap between the customer's expected performance and the services offered. It also interprets which areas of the system need to be enhanced to differentiate the services from its competitors. With such economic globalization, it has become harder for every sector, mainly private ones, to deliver the best quality service at cheaper rates. Friman 2004; Eboli and Mazzulla (2010) studied the effect of quality improvements in the transport sector on public satisfaction levels. And as expected, they found that quality improvements greatly enhance customer satisfaction. Thus, superior service quality has always been one of the core reasons for customer satisfaction and is a vital tactic for business survival and development.

Poor construction quality is a severe global issue the construction industry faces, although its magnitude varies considerably among projects (Ali and Wen, 2011). This is particularly true in public transport, where service quality is most important because improving quality levels can attract more users (Eboli & Mazzulla, 2008). In the context of Green Bus services, service quality includes the buses' conditions, timely schedule, near-to-zero breakdowns, and the highest comfort level of transportation. In the public's view, service quality may consist of some other parameters, but we will choose standard parameters that everyone will agree on. Service quality provides mediation between our two independent variables, i.e., Best Practice SOPs and Technological Enhancement, and our dependent variable, i.e., customer's prime choice. Bodur (2018) studied the effect of applying best practices and found enhanced quality. Matas (2004) examined the impact of service quality on customer choice. Thus, we have used service quality to mediate between best practices SOPs and the customer's prime choice. Similarly, Mandeep and Deepa (2020) found a direct relationship between technological enhancements and service

quality, whose direct effect on customer prime choice has already been declared by Matas (2004). Thus, service quality will mediate between two independent variables, i.e., best practice SOPs and Technological Enhancements, and the customer's prime choice dependent variable.

H_3: Service quality has a positive impact on customer choice.

2.6 Road Quality

Road quality refers to the design of roads and the reliability of the whole infrastructure related to the transport system. Considering the city's road situation, road quality and infrastructure attract transport users. The city has seen unreliable road structures during extreme conditions, especially rain. Furthermore, it also lacks necessary lighting and has poor-quality road signs. It requires proper design and engineering with proper calculations to keep traffic smooth and on dependable roads. No one wants to wait in a traffic jam, significantly when the road ahead is damaged and traffic squeezes through. These scenarios often happen out in the city. Further, there also exists a risk of accidents happening in such conditions. The design of roads and vehicles contributes to preventing road accidents (WHO 2003). Engineering provides the most scientific design to make the roadway safe for all users (Sikdar and Bhavsar, 2009).

In the Green Line, the road quality includes the design of the roads, proper provision of flyovers and stops, railway over and under bridges (if applicable), bus lay-byes, proper service roads, junctions improvements, overhead signs, and proper lighting. Informatory sign boards, road markings, crash barriers, and all other safety-related equipment are necessary in an emergency. (Baxter and Jack 2008).

When the road quality improves, and all the protocols are met, the people will be attracted to this service, and hence, it will become more manageable for the public to choose public transportation in common. In this study, we checked road quality's

moderating effect on the relationship between service quality and customer choice. Within our study area, we didn't find conclusive evidence that road quality moderates service quality and customer choice. Since service quality has a direct relationship with the customer's choice, checking the effect of road quality will either enhance or decrease the impact of quality on choice. Road Safety management seeks to maintain and improve the existing safety of a road network by reducing crashes and providing a safe road environment for its users to enable its continued use effectively and securely (Maqbool, 2019). Transportation infrastructure plays a vital role in sustainable development and has an enormous effect. Roads lead to different locations within or out of a city and accommodate different human activities while coupling environmental, social, and economic systems. Roads are a part of the infrastructure, increasing the quality of life. The customer's prime choice of service quality is linked with road quality, which is a part of infrastructure design. From now on, it has been receiving more attention and debate. It has also become a direct pursuit of economic growth.

H_4: Road quality will positively moderate the relationship between Service quality and customer choice.

2.7 Availability

Availability refers to the accessibility level of the service for the common public, in our case. Due to the increase in population, access has been limited for every person. Especially in developing countries, the demand for public transport is growing daily. As more employment opportunities are created, transportation demand will increase simultaneously. In developing countries, the demand for passenger trips is higher due to economic growth (Yan and Chen 2002). More demand for passengers, depletion of fleet size, traffic characteristics, and frequency of buses.

People don't like waiting for buses in crowded lanes. The problem is especially apparent during peak hours when buses are not enough to accommodate all the passengers. The low availability of public transport contributes significantly to this problem. Car ownership has proliferated to fill the absence of public road transport, especially with the federal government's policy to promote the national automotive industry (Chee & Jacqueline, 2013). To tackle this, Chee and Jacqueline suggested that limiting other transportation sources, primarily privately owned vehicles, would increase people's concerns. Getting a private car and a driving license in Pakistan is so easy. Thus, people tend to possess private vehicles more. The policies should be there, and some restrictions should be applied to private vehicles. The quality of services for public vehicles has to be improved to shift the public's interest towards public transportation. It is also essential to improve the quality of bus services, especially in terms of regular arrival and departure times (Chee & Jacqueline, 2013). This requires proper scheduling of the service and the increased number of buses in the fleet, which are the two core reasons to make the service available for the maximum number of people. Usually, routes are merged in case of overcrowding, and that's good for the service quality as it will take less time than regular routes. It will also reduce traffic and pollution on the roads and reduce the number of buses compared to usual. Since availability significantly impacts customers' prime choice and service quality, we use this as a moderation effect in the relationship between service quality and customers' prime choice. These factors will significantly help the service become the customer's prime choice.

As availability influences as a moderator between service quality and customer prime choice, we must consider the performance characteristics of the bus service because improving the quality of our service and making its availability on time ultimately becomes the customer prime choice for public transport. To our extent of study, availability has never been studied as a moderator between service quality and customer

choice. The operator took various steps to improve riders' experience and the quality of service, including equipping buses with air-conditioning, maintaining hygiene and comfort of the buses, providing Wi-Fi service on certain buses, etc. (Chee and Jacqueline 2013). The first performance characteristic of bus service is reliability. Usually, it is measured as a percentage of bus arrivals at the station with a delay of 0 to 4 minutes, depending on the traffic conditions along the route. The second performance characteristic of bus service is frequency. This is the main issue of increasing reliability. Proper progression of buses along the route can reduce delays in arriving buses at each stop. The third performance characteristic of bus service is capacity. Using the full capacity of the buses can reduce operating costs. Usually, during peak hours, the bus capacity is full, and passengers may not be able to get off at bus stops along the route. The fourth performance characteristic of bus service is safety. It's more than a private car. Finally, the fifth performance characteristic of bus service is cost. It includes operating and investment costs. Operating costs include all the costs associated with the system's routine operations, including fuel, maintenance, and service costs.

However, there is a limit to how we reduce the passenger waiting time and how we update the passengers about the buses' information. So we ensure some constraints, like if distances between buses were the same, by assuming constant arrival rates over a short time. Uneven advances can lead to uneven loadings and groupings of passengers, which irritates both passengers on grouped buses and those waiting at stops. Real-time information provides passengers information about upcoming bus arrivals at the bus stop. Passengers can also access real-time information via mobile phone apps or the Internet.

H_5: Availability positively moderates the relationship between Service quality and customer choice.

2.8 Mediating Mechanisms

2.8.1 Service Quality as a mediator between Best Practice SOPs and Customers' Choice

Best Practice SOPs (Standard Operating Procedures) are not just essential, but they are the key to the service provided in all public transport systems. These procedures streamline the job, making it easier to perform with limited errors, thereby increasing efficiency. Standard procedures in public transport are the foundation of a consistent and reliable service. Well-defined SOPs can significantly elevate the service quality in public transportation. For example, periodic maintenance programs, safety checks, and customer service systems are routine tasks and building blocks that make the service experience more reliable and enjoyable for customers (Jeeradist et al., 2016). This adherence to SOPs indicates the commitment of public transportation services to reduce operational failures and increase service efficiency. In turn, a higher level of service quality ensures positive decision-making by customers, as it is evident that customers would prefer a transportation service that is uniformly reliable, safe, and secure (Dell'Olio et al., 2011). On the other hand, Ibrahim & Borhan (2020) also highlight that customer satisfaction and loyalty are directly connected to the perceived quality and reliability of services for public transportation.

H_6: Service Quality mediates the relationship between best practice SOPs and customer choice.

2.8.2 Service Quality as a mediator between Technological Enhancement and Customers' Choice

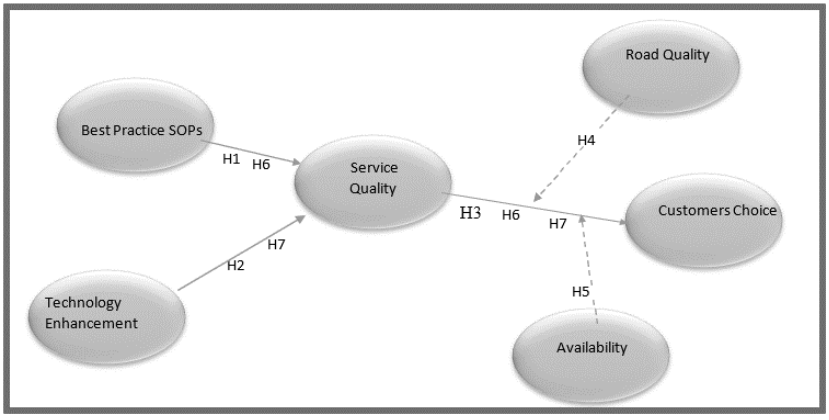
Technological improvements significantly modernize public transport systems in terms of quality service. Modern innovations, such as real-time tracking, automated ticketing systems, and modern safety assurance systems, increase the convenience and attractiveness of the public transit system to users. Issues like long waiting times and

safety concerns are thus addressed, improving the quality of services. When the service quality is high, passengers will prefer public transport over other modes of travel. This shift shows that technology investment and sustainable urban mobility are crucial to achieving customer satisfaction (Irshad et al., 2022). For example, Watkins et al. (2011) found that real-time tracking systems diminish perceived waiting times. Some variations in the rank take place only in the perception of the quality of public transportation service.

Moreover, Dilek and Dener (2023) demonstrate that automated ticketing systems streamline the boarding process, making public transportation more efficient and attractive to passengers. According to Etuk et al. (2021), implementing advanced safety features increases passenger confidence, giving riders better service delivery. The discussion in this report reveals that technological advancements should be integrated to enhance service provision quality while reducing road transport's operational propensity.

H_7: Service Quality Mediates the Relationship between Technological Enhancements and Customer Choice

Figure 1 Conceptual Model



3 Methodology

A questionnaire was developed and distributed among the Karachi citizens willing to use public transport, i.e., Green Line BRT services in Karachi, and some of their expectations regarding this transport and transport-related services. According to Ambak et al. (2016), any multivariate statistical study requires a minimum sample size of 200 participants; our study will thus target an audience of a minimum of 200 participants.

The deduction approach is used in this study. Deduction is a process whose goal is to draw valid conclusions from different premises (Bara et al., 2001). It means that the research was conducted based on the already developed theory with modification (theory modification). This approach is associated with scientific investigation (quantitative approach). Experimental research determines if the independent variable causes an effect on the dependent variable. It provides a conclusion based on statistics by studying the population sample (Creswell, 2011). This research is based on a non-probability sampling technique. In this technique, the researcher can subjectively select any unit representing the population based on their accessibility. This method is used where random sampling is impossible (Etikan, 2016). In non-probabilistic sampling, the exact sample frame (access to all respondents related to the research) is not accessible. In this study, accessing the sample frame is practically not possible; hence, a non-probabilistic sample design is used.

This study uses the purposive sampling technique, where the researcher relies on his judgment regarding sample selection. If we go for a probabilistic sampling design approach, it will not only consume more time. Thus, being pre-judgmental will save us time. This technique is effective when only limited people can be the primary data source. In this study, since we aim to develop and analyze the prime choice of the public for public transport, we will only look for those who are somehow related to public transport rather than random selection.

When taking population size = 450, a confidence interval of 95%, and an error margin of 5%, we get a sample size of 317. Thus, it is part of this group (450 people) whose opinions we care about. Since public transport is standard and green buses have arrived in the city, sampling went easy.

4 Data Analysis

Outer loadings show how much our indicators and latent variables are related to each other, i.e., are they valid enough to be a part of successful research? The outer loadings show that all the constructs exhibit discriminant validity. All outer loadings are greater than 0.708 (air et al., 2022). Outer loadings of the items are provided in Table 1.

Table 1 Outer Loadings

Construct	AV	BP	CC	RQ	SQ	TE
AV1	0.758					
AV2	0.823					
AV3	0.884					
AV4	0.640					
BP1		0.628				
BP2		0.848				
BP3		0.892				
BP4		0.798				
BP5		0.645				
CC1			0.846			
CC2			0.836			
CC3			0.704			
RQ1				0.844		
RQ2				0.828		
RQ3				0.722		
RQ4				0.695		
SQ1					0.782	
SQ2					0.838	
SQ3					0.791	
SQ4					0.711	

TE1	0.693
TE2	0.768
TE3	0.669
TE4	0.800
TE5	0.797

Note: All the items' outer loadings are greater than the threshold value of 0.708.

4.1 Construct Reliability and Validity

Construct reliability is checked with the help of composite reliability. The threshold value for composite reliability is 0.7 (Hair et al., 2022). All the constructs show reliability as values of CR for all of the constructs are above the threshold. However, the measures of Cronbach's alpha and Rho-A also exhibit that construct reliability is established as the values for Cronbach's alpha and Rho-A are well above the threshold of 0.70. that Construct validity is examined with average variance extracted, and all constructs show convergent validity as the values of AVE are above the threshold of 0.5 (Hair et al., 2022).

Table 2 Construct Reliability and Validity

Construct	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
CC	0.713	0.731	0.839	0.636
SQ	0.789	0.805	0.862	0.611
AV	0.811	0.896	0.861	0.611
RQ	0.784	0.827	0.857	0.601
BP	0.861	1.03	0.877	0.592
TE	0.801	0.812	0.863	0.559

4.2 Discriminant Validity

Table 3 shows discriminant validity among study constructs via HTMT rations. All the constructs exhibit discriminant validity as the values for HTMT ratios are well under the threshold value of 0.85 (Hair et al., 2022).

Table 3 Heterotrait Monotrait Ratio (Discriminant Validity)

Construct	AV	BP	CC	RQ	SQ
BP	0.477				
CC	0.171	0.063			
RQ	0.19	0.105	1.12		
SQ	0.082	0.058	0.965	0.656	
TE	0.132	0.096	0.596	0.585	0.527

4.3 Structural Model (Hypotheses Testing)

The structural model represents the inner model, i.e., the relationship among constructs. Hence, it shows the results of hypothesis testing. These results are classified into direct and moderated effects and specific indirect effects (mediating effects).

4.3.1 Direct and Moderating Effects

This section analyzes the results for the direct and moderated effects of the constructs. Table 4 reflects that the data support hypotheses H_2, H_3, and H_4 as the p-values are less than 0.05. However, hypotheses H_1 and H_5 are not supported by the data as p-values are greater than 0.05. H_1 shows the effect of best practices SOPs on service quality, H_2 reflects upon the effect of technology enhancement on service quality, H_3 depicts the impact of service quality on customer choice, H_4 shows the interaction effect of service quality and road quality on customer choice, and H5 exhibits the interaction effect of service quality and availability.

Table 4 Hypotheses Testing Results (Direct and Interaction Effects)

Hypotheses	Beta Coefficients	Standard Error	T- Values	P-Values	Decision
H1: BP -> SQ	-0.027	0.09	0.300	0.382	Non-Supported
H2: TE -> SQ	0.421	0.076	5.537	0.000	Supported
H3: SQ -> CC	0.316	0.036	8.806	0.000	Supported
H4:SQ*RQ -> CC	0.033	0.015	2.220	0.013	Supported
H5:SQ*AV-> CC	-0.024	0.024	1.025	0.153	Non-Supported

4.3.2 Specific Indirect Effect

Specific indirect effects in this study tests two mediation paths. The first mediation path is about the mediating role of service quality between best practices SOPs and customer choice and the second specific indirect effect entails the mediation role of service quality between technology enhancement and customer choice. Table 5 indicates the results for the mediation analysis. The results endorse the mediating role of service quality between technology enhancement and customer choice. Both the hypotheses are tested at a 5% level of significance.

Table 5 Hypotheses Testing (Mediation Effects)

Hypotheses	Beta Values	Standard Error	T Statistics	P-Values	Decision
H_6: BP -> SQ -> CC	-0.009	0.028	0.303	0.381	Non-Supported
H_7: TE -> SQ -> CC	0.133	0.030	4.467	0.000	Supported

Note: The level of significance is 0.05.

4.4 Multigroup Analysis

Researchers frequently make the assumption that data sets used in empirical study originate from a singular homogeneous population. Contrary to this assumption, data sets utilized in social sciences sometimes exhibit heterogeneity, meaning that the data were acquired from distinct homogeneous groups. Disregarding this reality, specifically, failing to include heterogeneity, results in dubious conclusions (Jedidi et al., 1997). Hence, this study intends to perform a multigroup analysis (MGA) to investigate the heterogeneity in the data set due to education level of respondents. Multigroup comparisons require establishing measurement invariance to ensure the validity of outcomes and conclusions. Measurement invariance is determined with the help of MICOM analysis.

4.4.1 MICOM Analysis

MICOM involves three steps: Step 1 establishes configural invariance, Step 2 establishes compositional invariance, and Step 3 ensures equality of composite mean values and variances.

4.4.1.1 Step-1: Configural Invariance

Configural invariance ensures that each latent variable in the PLS path model has been specified equally for all the groups. In this study, configural invariance is established qualitatively for the following three requirements: 1) identical indicators are applied to all the groups 2) the indicators data treatment is same for all the groups 3) identical algorithm setting for all the groups.

4.4.1.2 Step 2: Compositional Invariance

The MICOM Analysis (Step 2) assesses the correlations between constructs based on education levels for different groups. The results in Table 6 indicate that most constructs, such as Best Practice SOPs (BP), Customer Choice (CC), Road Quality (RQ), Service Quality (SQ), and Technological Enhancements (TE), have correlation values close to the permutation means with p-values greater than 0.05. It suggests that there are no significant differences across education levels. The exception is the Availability (AV) construct, which has an original correlation of -0.089 and a permutation mean of 0.796, with a p-value of 0.013, indicating a significant difference. At this point in the analysis, it is concluded that multigroup analysis cannot be performed as partial invariance is not established due to a lack of compositional invariance for all the latent constructs in the PLS-path model.

Table 6 MICOM Analysis (Step 2)

Items	Original Correlation	Correlation Premutation Mean	5.00%	Permutation p- Values
AV	-0.089	0.796	0.185	0.013
BP	0.891	0.655	-0.156	0.568

CC	0.999	0.998	0.993	0.406
RQ	0.996	0.998	0.995	0.134
SQ	0.998	0.998	0.994	0.449
TE	0.986	0.991	0.979	0.159

Note: Above table shows MICOM Analysis results (Step 2).

4.5 PLS Predict

The PLS Predict test results compare the PLS-SEM (Partial Least Squares Structural Equation Modelling) approach with the LM (Linear Model) approach. For constructs CC1 and CC2, PLS-SEM shows no predictive relevance, with RMSE values of 0.717 and 0.647 and Q^2_predict values of 0.668 and 0.638, respectively. Conversely, the LM approach attains perfect predictions for these constructs, with RMSE of 0 and Q^2_predict of 1. For constructs CC3, SQ1, SQ2, SQ3, and SQ4, PLS-SEM demonstrates predictive relevance, even though RMSE values are higher than LM. PLS-SEM's RMSE values for CC3, SQ1, SQ2, SQ3, and SQ4 are 1.052, 1.182, 1.116, 1.083, and 1.087, respectively, indicating their effectiveness in predicting these constructs. It suggests that PLS-SEM can effectively predict constructs CC3, SQ1, SQ2, SQ3, and SQ4, though it is less accurate for CC1 and CC2 than the LM approach.

Table 7 ***PLS Predict***

Construct	**PLS-SEM**		**LM**			**Predictive Relevance**
	RMSE	**Q^2_predict**	**RMSE**	**Q^2_predict1**	**PLSLM**	
CC1	0.717	0.668	**0**	1	0.717	NO
CC2	0.647	0.638	0	1	0.647	NO
CC3	1.052	0.185	1.124	0.071	-0.072	YES
SQ1	1.182	0.085	1.21	0.04	-0.028	YES
SQ2	1.116	0.084	1.124	0.071	-0.008	YES
SQ3	1.083	0.112	1.099	0.086	-0.016	YES
SQ4	1.087	0.077	1.096	0.061	-0.009	YES

Note: Above table shows PLS Predict test results

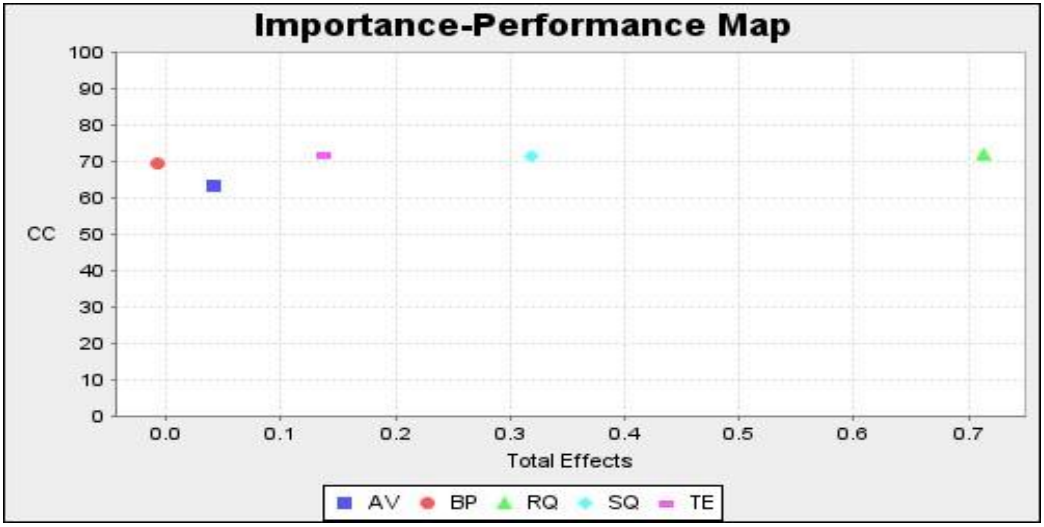
4.5.1 Importance Performance Map Analysis (IPMA)

Importance Performance Map Analysis (IPMA) shed critical insights into factors leading to customer choice in a public transportation system. SQ is of the most significant importance, indicating an improvement in timeliness, comfort reliability, general satisfaction, etc., which will translate into significant development of this particular customer preference base. Currently, the performance of SQ is moderate, hence leaving the scope for much improvement. Equally influential are the technological enhancements, where real-time tracking, automation systems, and safety technologies perform very strongly. However, innovations should be a continuous process to meet customer expectations. Road quality (RQ) and Availability (AV) are critical factors that may affect customer choice. RQ's performance is moderate, including road infrastructures and their maintenance, which needs significant development—integrating AV through more buses, higher frequency, and route coverage results in higher customer preference. Best Practice SOPs (BP) are relatively less critical for customer choice, although highly effective. The analysis indicates that the attractiveness of public transport could increase with an improvement in service quality, technological upgrades, quality of roadways, and availability, hence encouraging more people to ride than in their cars.

4.5.1.1 IMPA Constructs Level

Service quality (SQ) is the most critical construct, and improvements in timeliness, comfort, and reliability are needed to boost customer preference. Technological enhancements (TE) perform well but must continue evolving. Road quality (RQ) and Availability (AV) are critical, requiring significant infrastructure and service coverage development. Best Practice SOPs (BP) ensure high operational standards and service quality, contributing to overall reliability.

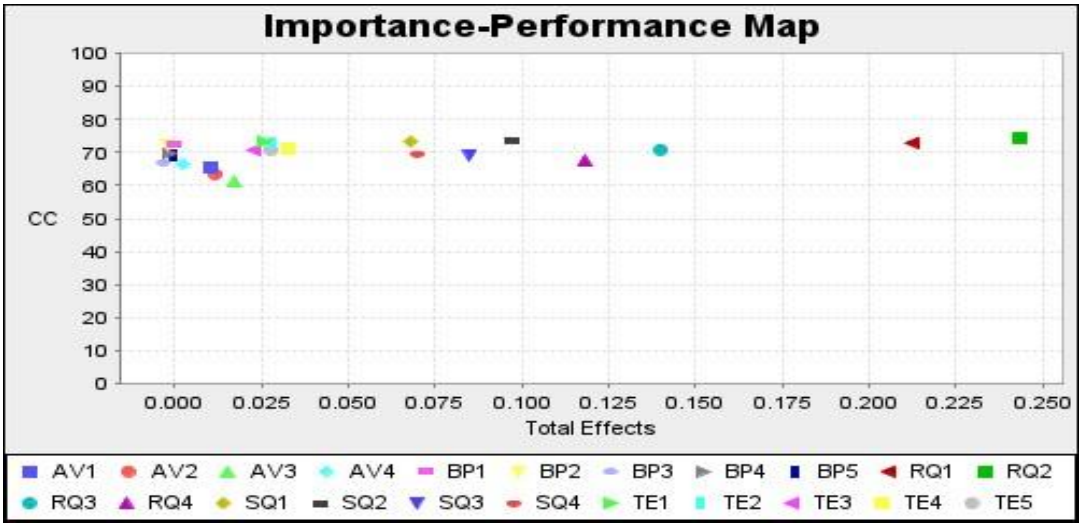
Figure 2 IMPA – Indicator Level



4.5.1.2 IPMA Indicators Level

At the indicator level, the analysis provides more granular insights. An indicator is a specific measurement used to assess performance or quality. Service quality (SQ) indicators like timeliness, comfort, and reliability are essential but currently moderate in performance. Technological enhancements (TE) such as real-time tracking and automated systems perform well but need continuous improvement. Road quality (RQ) indicators, including infrastructure and maintenance, and availability (AV) indicators, like fleet size and route coverage, require significant enhancement. Best Practice SOPs (BP) indicators ensure operational efficiency and reliability, contributing to high service standards.

Figure 3 IPMA Indicator Level



4.6 Discussion

The study results show that the adoption of Best SOPs and the use of advanced technology contribute to the quality of services of public transport systems, with specific reference to the case of the Green Line BRT System in Karachi. This increased level of service positively affects passengers' choice of a public transport service above private cars. In this respect, our results extend the research findings (e.g., Matas 2004), emphasizing that the downward trend in public transport ridership is reversible when raising service quality. This literature shows that technological improvements and best practice SOPs can help improve public transport service quality, as confirmed in our study.

Our findings have important implications for policymakers and transport authorities. Deploying the latest technologies and best practice SOPs helps improve the overall service quality of public transportation systems (Abu Bakar et al., 2022). Not only does this approach improve consumer satisfaction, but it could also dramatically reduce

traffic jams and environmental footprint as it would push people to use fewer private vehicles and rely more on public transport. In terms of recommending public transportation, this study also demonstrates the importance of service quality in choosing public transportation. Real-time tracking, automation for ticketing, technology, and having defined SOPs make the public transport system more accountable, reliable, and efficient (Preece et al., 2024).

5 Conclusion

In conclusion, our study underscores the pivotal role of road quality in shaping public transportation preferences in Karachi. The high expectations for road quality are driven by increased traffic and the easy acquisition of private vehicles, exacerbated by poor municipal maintenance and ineffective drainage systems. These factors lead to frequent road damage and traffic congestion, significantly deterring public transport use. Additionally, the lack of adherence to best practice SOPs further diminishes service effectiveness and quality.

5.1 Theoretical implications

Theoretically, this research enriches the framework by integrating service quality, technological advancements, and best practice SOPs within the public transportation sector, reinforcing the relevance of the Theory of Planned Behavior and social safety theory. Our findings emphasize the necessity for substantial infrastructure improvements and efficient service scheduling to enhance public transport systems. Moreover, the study provides practical guidance on implementing modern technological innovations, such as real-time tracking and automated ticketing systems, to boost service quality and customer satisfaction.

5.2 Methodological Implications

Methodologically, the research demonstrates the effectiveness of using cross-sectional surveys and advanced statistical analyses, including PLS-SEM and IPMA, to gather and analyze public perceptions and expectations, applying non-probability and purposive sampling allowed for targeted insights from specific segments of Karachi's population, serving as a model for future research in other urban settings. Addressing the identified core issues with advanced solutions can significantly improve public transportation systems, providing a comprehensive understanding of the factors influencing public transport choice and offering a foundation for further studies and practical applications to promote sustainable urban mobility.

5.3 Limitations and Further Research

This study faced several limitations; it may not be representative of the entire Karachi population since data was collected from only 450 participants, and a non-probability sampling technique was used, limiting the generalizability of findings. Regarding the emphasis on best practice SOPs and technological enhancements, other influential factors such as socioeconomic status and personal preferences received less focus. The cross-sectional design captured perceptions at a single moment without observing changes over time.

Future research should address these limitations by incorporating sustainability, fleet planning, customer and staff behavior, cultural differences, and literacy levels. Longitudinal studies provide insights into how perceptions and behaviors evolve and the long-term impact of improvements. Comparative studies between different cities or regions could highlight best practices while investigating policy interventions like subsidies and infrastructure improvements, offering practical strategies for promoting public transport. Behavioral insights into social norms, perceived convenience, and

environmental concerns could deepen understanding of transportation preferences. Furthermore, integrating emerging technologies like AI and IoT in public transportation could enhance service quality and customer satisfaction. Addressing these areas would provide a more comprehensive understanding of public transportation preferences and contribute to urban mobility strategies.

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