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Analyzing the Impact of Service Quality on Public Transport Performance: A Panel Data Analysis with an Online Recommendation System

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Abstract

This study aims to examine the effect of various service quality parameters on the schedule-wise performance of intercity bus passenger transit using objective measures through a panel data regression model. The study findings show that service quality parameters such as bus fare and customer rating positively impact the operator's schedule-wise performance. In contrast, travel time hurts performance. The study also finds that bus type insignificantly affects performance, and an increase in bus fare does not impact performance. In summary, this study underscores the importance of service quality in the public transport system. It recommends that operators prioritize service quality parameters such as bus fare and customer rating to enhance their schedule-wise performance. Furthermore, this study offers valuable insights into the factors that affect the performance of intercity bus passenger transit, which can inform policymaking and management decisions in the public transport sector.
Keywords: Intercity Bus Transport Performance, Service attributes, Schedule Performance, Panel data analysis of service quality

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Introduction

Passenger transport in India and many other countries has rapidly transformed (Mazzulla & Laura Eboli, 2006). The liberalization and inferior quality of services offered by government-owned transport corporations in India offered an opportunity for private players. Moreover, the opening up of international automobile playest to set up a manufacturing plant in India and the availability of superior quality passenger vehicles increased the competitive landscape of passenger transport services in India. Hence, offering service quality and customer satisfaction is the foremost concern of the private players.

So far, SERVQL is the popular framework adopted by various studies. However, its relevance in transportation remains limited. To address this issue and the pressing need to understand the service quality issues in transportation, Mazzulla Laura Eboli (2006) developed the Service Quality Index (SQI) to measure the effectiveness of services. Barabino Francesco (2012) has developed the TRANSQL framework based on the user-oriented perspective. However, the research on service quality is still evolving and dominated mainly by subjective measures relying on cross-sectional survey data. Transport services are regular operations requiring continuous service quality over time as they attract repeat customers. A longitudinal study would be more appropriate to measure the service attributes and how each attribute translates into revenue.

In recent times, the adoption of online aggregated booking services for travel planning is a new normal. These online booking services offer potential travelers additional services, such as customer ratings of various service quality attributes from past travelers so that potential travelers understand the service level of the transport service they plan to book. The customer rating service quality is dynamic and changes over time. Numerous researchers in other industries are increasingly adopting online customer recommendation reviews to study customer sentiments and satisfaction. This research joins service quality research by employing customer rating and other service quality parameters captured in the online travel booking portal over time, enabling longitudinal data, which supports the panel data regression method.

The research papers are organized into five major chapters as follows. In the first chapter, we discuss the relevant review of literature related to Service Quality related research from the public transport perspective, methodology, and service attributes linked with performance in terms of revenue. In the second chapter, we develop a hypothesis based on service quality parameters linked with performance in terms of revenue. The third chapter discusses the measures and methodology, followed by result analysis and discussions.

1. Literature Review

1.1 Measuring Public Transport Service Quality

Parasuraman et al. (1988) have developed a SERVQUAL scale to measure service quality. The scale covers five dimensions: tangibility, reliability, responsiveness, assurance, and empathy, based on the disconfirmation of expectations model.

SERVQUAL, despite being widely accepted, the applicability of the scale has been challenged in the context of public transport. However, its application to transport services is limited; few studies have adopted a modified SERVQAL to suit the requirements of the transport services industry. (Barabino B, Deiana E Tilocca, 2012; Too & Earl, 2010). Hu and Jen (2006) attempt to modify the Parasuraman et al. (1988) scale by constructing a four-dimension scale to study Taipei's mass transit system. These four dimensions identified are interaction with passengers, tangible service equipment, convenience of service, and operating management support. Joewono and Kubota (2007) used availability, accessibility, reliability, information, customer service, comfort, safety, fare, and environmental impact. Transportation Research Board (1999) has prepared a handbook for measuring service quality. Few public transport scholars in service quality propose a single output measurement framework considering subjective and objective quality measures (Cunningham et al., 2000). Mahmoud Hine (2016) identifies 11 quality factors influencing user perception. De Oña, J., De Oña, R., Eboli, L., Mazzulla (2013) identify three latent factors impacting service quality: service, comfort, and personnel behavior. Among the three factors, the service factor weighs higher. Vicente and Reis (2018) recently identified six factors of Service Quality for public transport. Munim et al. (2020) studied the impact of perceived service quality and the environmental performance of hybrid electric bus services. Morton et al. (2016) studied the impact of service quality in public transport. Mazzulla Laura Eboli (2006) developed the Service Quality Index (SQI) to measure the effectiveness of services. Barabino Francesco (2016) has developed a TRANSQL framework based on the user-oriented perspective. The literature review indicates that the measurement of service quality in the context of public transport has yet to achieve a consensus. Barabino et al. (2019) developed an objective measure with a pool of key quality indicators (KQIs) for monitoring purposes that enables a robust methodology.

1.2 Service Quality and Customer Satisfaction

Tyrinopoulos and Antoniou (2008) used factor analysis and ordered logit models to evaluate the variability of user behavior and their level of satisfaction (LoS) using subjective measures. Using a subjective measure, Iseki and Taylor (2010) employ a logistic regression method to study the impact of stoppage and station attributes on satisfaction.

Joewono and Kubota (2007) studied user's perceptions of satisfaction and loyalty using the customer rating method. The hypotheses were tested using path analysis to estimate the impact of service quality variables on customer satisfaction. The study also employs binomial logistic regression to identify the loyal users. Few studies employ structural equation modeling to estimate the impact of service quality on customer satisfaction using the rating scale method (Eboli et al., 2017). Using the ANOVA method, Shen et al. (2016) assert the significant influence of travel time and passenger booking capacity on passenger comfort. Eboli et al. (2017) developed a framework that identifies punctuality and frequency as satisfaction factors influencing service quality. The study employs structural equation modeling using survey data regarding railway passengers. Cunningham et al. (2000) studied the positive impact of perceptions of service quality on customer satisfaction. Saleem et al. (2023) adopted a mixed method to evaluate the service attributes in the context of the BRT system in Pakistan. In an Indian scenario, Deb Ahmed (2019) studied service quality based on subjective, objective service measures.

The objective measure is collected from bus service operators, and the subjective measure is based on the user's perception of the data.

1.3 Studies Linking Service Quality, Passenger Loyalty, and Perceived Value.

Operators who offer better service quality can attract potential travelers and retain the existing frequent travelers. Customer retention and new customer acquisition happen through the perceived value they experience while they travel with the particular operator or a schedule. The perceived value is likely to develop customer loyalty that would eventually lead to increased ridership share and performance of the operator. Numerous research studies have been conducted in the past to assess the impact of service quality on various psychological factors such as customer satisfaction (Cunningham et al., 2000), customer loyalty (Joewono & Kubota, 2007), perceived value (Jen & Hu, 2003), and passenger behavior (Hu & Jen, 2006). Service quality parameters such as travel and wait time are more critical in generating transit user loyalty than real-time information panels and parking and ride facilities. Aidoo et al. (2013) suggest that safety records, bus fares, and the crime rate at bus terminals of the bus transit system in Ghana highly influence passenger satisfaction. In a study on TransJakarta Busway. The review of the past studies indicates that linking service quality with overall and schedule-wise performance has largely gained attention in the public transport context.

1.4 Performance of Bus Network Systems

Apart from studying the service quality linked with customer satisfaction and loyalty, numerous analytical techniques have been employed to measure the performance of the bus service from an efficiency perspective. These studies on efficiency measures of performance largely adopt parametric and non-parametric frontier methodologies. In an Indian context, (Kumbhakar Bhattacharyya, 1996) considers labor fuel cost as input and passenger per kilometer as an output performance measure. Numerous studies employ parametric frontier methodologies to measure performance in the European context. These studies consider seat kilometers or passenger-kilometer as the output parameters and the fuel cost and labor hours of work as the input parameters (e.g., Tulkens and Vanden Eeckaut, 1995; Delhause et al., 1992; De Jong & Cheung, 1999; Sakano et al., 1997; Levaggi, 1994). DEA is widely used as a prominent option while studying performance among the non-parametric techniques. These studies consider load, staff, and fuel costs as input and operating revenue, and passenger–kilometer, vehicle-kilometer, and seat-kilometer as output measures (e.g., Tone and Sawada, 1990; Tulkens &Wunsch, 1994). The performance in terms of revenue largely has not gained any attention from the public transport perspective. The output performance measures such as passenger–kilometer, vehicle-kilometer, and seat-kilometer are predominantly considered while studying the performance.

1.5 Methodologies Linking Service Quality and Performance in Bus Transport

Several methodologies have been employed while studying the impact of performance in the public transport sector, such as fuzzy sets (Ndoh & Ashford, 1994), cost/benefit approach (Polus & Tomecki, 1986), OLS (Tulkens & Vanden Eeckaut, 1995), factor analysis (Fielding et al., 1985), DEA (Tongzon, 2001). Linear models, such as OLS, coexist with the Structural Equation Model (SEM) introduced by Bollen (1989) and Logit models, wherein all random components are distributed independently and identically (Cascetta in 2001) are employed in Service Quality studies. The SEM model has been applied in the works of Grønholdt and Martensen (2005) and Vilares and Coelho (2003). Additionally, Siskos et al. (1998) proposed an ordinal regression technique. In a recent study, Verma and Rastogi (2023) employed an AHP technique based on the perceived service quality attributes from the stakeholders' perspective. Barabino et al. (2020) developed the pool of indicators for Service Quality (KQI) using Monte-Carlo simulation.

Summary of the literature and research gap:

The review of the literature asserts that superior service quality attracts passengers (Tyrinopoulos & Antoniou, 2008). Understanding the passengers' various service quality expectations and their impact on performance can help private and public transporters devise an appropriate strategy (Lai & Chen, 2011). Numerous research studies have been conducted to measure operators' performance in the public transportation industry. The literature identifies cost efficiency, cost-effectiveness, and service effectiveness as the three major dimensions of bus transit performance (Randall et al., 2007). Scholars largely identify trip length, average speed, vehicle volume, headway, service network, travel time, frequency of service, and punctuality as the prime determinants of service quality (Pratt & Lomax, 1996; Ryus et al., 2000). In the public transport context, another strand of literature focuses on parameters such as network connectivity, accessibility, cost-effectiveness, energy efficiency, pollution, mobility, safety, employment, and economy impacting public transport performance (Codd & Walton, 1996).

Further, the review identifies several issues, such as the nature of the data, measurement, and methodology, which aligns with the recommendation of Juan de Oña and Rocío de Oña (2014). This study attempts to address some of those issues as follows. First, the research departs from the traditional subjective rating scale approach of measuring service quality to more reliable objective measures collected from online booking portals, an alternative to cross-sectional survey-based measures. Second, unlike the past studies, service quality is linked to schedule-wise performance in terms of revenue. In contrast, the past literature focuses on efficiency parameters, and marketing literature focuses on customer satisfaction and loyalty. Third, the study demonstrates that panel data regression is a technique unlike other methods employed in the past, such as DEA, AHP, OLS, SEM, Logistic models, and Goal programming. The subsequent chapters discuss the past research and analysis and interpretation of the results.

2. Hypotheses Development

There is an imperative need to study the impact of service quality factors on schedule-wise performance using objective measures. The public transport research stream is disconnected between performance measurement studies and service quality studies. In this study, we leverage the objective panel data of service quality parameters to investigate the effect on schedule-wise performance. Based on past research, we extracted the most common service quality indicators such as travel time, fare, bus type, and customer rating as impact variables on schedule-wise operators' performance.

Customer ratings are captured online through the ratings provided by past passengers on the various aspects of service quality. Online customer ratings are an aggregate measure of service quality parameters such as cleanliness, punctuality, and staff behavior. The online customer ratings on each schedule are likely to influence the passenger's choice of booking. Passengers booking online, under various conditions, prefer to travel in a scheduled bus with the highest online rating. Investigating the extent of trust the potential customer places in the customer ratings while booking online is imperative. It is most likely that a potential passenger prefers the highest rating while making their booking choice among competing operators of a similar schedule. In line with the literature, the first hypothesis is:

H1: *Online customer ratings have a positive effect on the operator's schedule-wise performance.*

Past research emphasizes travel time as a key service quality parameter influencing customer satisfaction and loyalty. Potential passengers nevertheless prefer a schedule with more travel time. There is a possibility of opting for competing operators who promise lesser travel time. In some cases, there is a higher possibility of switching over to another mode, such as air and railways. We argue that higher travel time is perceived as lower service quality, which would eventually affect schedule performance. The second hypothesis is:

H2: Higher travel time has a negative effect on the operator's schedule-wise performance.

Travel fares are generally used as service quality indicators (Joewono & Kubota, 2007). The increase in travel fares is likely to increase the schedule's revenue. In an emerging economy context, potential customers are expected to choose a schedule with a lower price. However, luxury and semi-luxury private intercity bus service passengers generally fall under two categories. The first category of passengers is those who are price-insensitive and want to reach their destination on time with comfort. The second category of passengers are those who cannot get a booking from other low-cost operators like government services and have an urgency to reach their destination at any cost and comfort. In a peak demand scenario, price is immaterial as the need to reach the destination is most critical to them. We argue that in the context of private bus operators, price is insensitive; the increase in fare results in increased revenue. The third hypothesis is:

H3: Higher travel fare has a positive effect on the operator's schedule-wise performance.

This research also considers bus type as a key service quality parameter, which the literature did not consciously identify earlier. Potential passengers, while booking online, also evaluate bus type. In India, private as well as public transport operators deploy at least ten types of bus types, such as AC, Non AC, VOLVO, SCANIA, Multi Axel, sleeper, seating, etc., in combinations. The operator offering a better bus schedule can also attract potential passengers. From the operator's perspective, we would like to explore whether the particular bus type increases the revenue compared to another bus type. Hence, the fourth hypothesis is:

H4: Bus type has a positive effect on the operator's schedule-wise performance.

3. Methodology

3.1 Data Collection:

In this study, we collected objective data from 47 private bus operators from South India. We considered objective indicators, which are more reliable, clearer, and unbiased than subjective measures (Parasuram et al., 1988). The data was collected for the five routes originating out of Bangalore, which is located in the heart of South India. Being Bangalore is the center of South India, it is well connected to most of the locations, ranging from 300 km to 1000 Kms. Bangalore is well connected by road, and most of the operators operate their service from the city. We have chosen two routes of tourism (Bangalore to Goa and Bangalore to Kodaikanal) sectors. The second route is a non-business and non-tourism route (Bangalore to Madurai). The third route is a business route (Bangalore to Mumbai), and the fourth is a utility-based route (Bangalore to Trivandrum). This will maintain heterogeneity of the route and cover as much as possible. We covered 4038 daily bus schedules spanning the time period from November 2016 to December 2016.

The data was collected from India's leading bus booking platform, Redbus, which is linked to 99% of the private operators integrated through a live API platform. The API platform provides an advantage of access to time-synchronized data, which is more authentic. We compiled a panel of objective data on service quality, such as travel time, bus type, customer rating, bus fare, and performance in terms of revenue.
The daily schedule takes care of the time-variant aspects such as weekly peak and lean time. We have chosen secondary data as it is more accurate, eliminates the incidence of discrepancy/bias in the measurement over the survey, and supports the longitudinal study.

3.2 Measures:

In this study, we focused our attention on the objective measures of service quality and its impact on schedule performance through earnings per schedule over the period. The service quality elements included in the model are a subjective measure captured in the form of customer rating in a quantified objective format provided by past travelers (users) of the particular operating schedule in an online rating feature of the booking portal Redbus. In. This approach to measuring using rating or ranking of individual service attributes linking to revenue is adopted as per the recommendation of Mazzulla & Laura Eboli (2006). We employed objective longitudinal data of service quality constructs such as travel time, customer rating, bus type, and fare collected from Redbus. in the online travel booking portal for this study. The details of objective Service quality measures discussed for each service quality variable are as follows.

Independent variable:

Travel Time - a journey time is considered for each schedule notified by the operator in the portal as one of the information features. The journey time ranges from a minimum of 5 hours to a maximum of 18 hours in range for a given data set.

Customer rating is a rating provided by the passengers in the online booking portal Redbus. In. The customer ratings comprehensively capture various dimensions of service quality attributes of public transport services such as punctuality, waiting time, cleanliness, Seat Comfort, staff attitude, punctuality, driving safety, Airconditioners, and add-on facilities. The composite rating is rescaled into A, B, C, D, and E, where E is the highest rating and A is the lowest rating.

The type of bus alongside the schedule with the operator's name is also mentioned while booking. There are ten types of buses operated on the five routes. The type of bus captures Interior and Exterior look, feel, and comfort in travel, e.g., non-AC and AC.

The price quoted (Travel fare) is also captured as an independent variable.

Dependent Variable:

We captured a number of bookings for the schedule, which is used to calculate the total revenue of each schedule to derive our dependent variable performance. We measured the dependent variable performance by multiplying the price quoted for each schedule with the total number of seats booked.

3.3 Model Specification:

Given the nature of the data at our disposal, we have chosen a panel data regression method to test our hypothesis. The Breusch and Pagan Lagrangian multiplier test for random effect test rejects the null hypothesis at (p>0.000). The choice of the fixed effect model is also supported by our argument that the revenue of each schedule can be a time-variant as it can also be affected by weekly cyclical factors such as weekend peak days vs weekday lean periods. Since we run a fixed effect panel data model estimates without normal distribution, the normality assumption is not necessarily tested.(Battese & Coelli,1995)

$$Revenue_{i,t} = \alpha_{i,t} + \beta_1 \text{Travel Time}_{i,t} + \beta_2 \text{Rating}_{i,t} + \beta_3 \text{Bus Type}_{i,t} + \beta_4 \text{Price}_{i,t} + \varepsilon \quad \ldots.(1)$$

In our model, *r*evenue is the dependent variable for the i_{th} Operator at n_{th} tme schedule. $\alpha_{i,t}$ is the unknown intercept for each operator. The model tests for all four hypotheses.

4. Results

We conducted fixed effect unbalanced panel data regression using Stata 14.0. We set the operator name as a group panel with a total of 4038 observations of daily data for the period ranging from November 2016 to December 2016. The revenue is set as the dependent variable, and travel time, fare, bus type, and customer rating are the independent variables as per the model. The highest customer rating (E) is significantly related to performance (β=2640.08; $p<0.004$) and the rest of the ratings 2(D) (β=-540.085; $p<0.584$), rating 3(C) (β=-1059.07; $p<0.135$), rating 4(B) (β=-1285.15; $p<0.047$) are either insignificant or negatively influences the performance, thus our hypothesis is H1 is accepted. Travel time is significantly related to Revenue (β=-180.484**;** $p<0.005$) with a negative coefficient; thus, our hypothesis (H2) is accepted. Travel fare is positively associated with performance as per expectation (β=38.06178; $p<0.000$); thus, our hypothesis H3 is accepted. None of the bus types is significantly related to performance; thus, our hypothesis H4 is rejected. Table 2 depicts the output of panel data regression analysis.(Battese & Coelli,1995). Table 1 depict

TABLE 1: Correlation Analysis

	Travel Time	**BusType**	**Price**	**Revenue**	**Rating**	**operator**
TravelTime	1					
BusType	-0.0093	1				
Price	0.0961	-0.1179	1			
Revenue	0.095	-0.284	0.7266	1		
Rating	-0.1495	-0.0763	-0.1501	-0.0324	1	
Operator	0.0503	-0.1032	-0.0113	0.1334	0.0252	1

TABLE 2: Panel Data Regression Results

Fixed-effects (within) regression				Number of obs		4,038
Group variable: opn2				Number of groups		47
R-sq:				Obs per group:		
within = 0.6108				min		1
between = 0.1608				avg		85.9
overall = 0.5263				max		582
				F(19,3972)		328.09
corr(u_i, Xb) = -0.0566				Prob > F		0
Revenue	Coef.	Std. Err.	t	P>|t|	[95% Conf. Intervel]	
Travel Time	**-180.484**	**63.60246**	**-2.84**	**0.005**	**-305.181**	**-55.7877**
Price	**38.06178**	**0.521806**	**72.94**	**0**	**37.03875**	**39.08482**
_IRat_2	-540.085	985.2171	-0.55	0.584	-2471.663	1391.494
_IRat_3	-1059.07	708.7472	-1.49	0.135	-2448.614	330.4707
_IRat_4	**-1285.15**	**648.1461**	**-1.98**	**0.047**	**-2555.879**	**-14.41885**
_IRat_5	**2640.08**	**921.5139**	**2.86**	**0.004**	**833.395**	**4446.764**
_Itypebus_2	207.6295	3933.363	0.05	0.958	-7503.97	7919.229
_Itypebus_3	5236.607	5149.471	1.02	0.309	-4859.247	15332.46
_Itypebus_4	191.7031	3984.437	0.05	0.962	-7620.03	8003.436
_Itypebus_5	3838.4	5090.959	0.75	0.451	-6142.738	13819.54
_Itypebus_6	810.1267	4133.264	0.2	0.845	-7293.391	8913.644
_Itypebus_7	741.5666	3960.563	0.19	0.851	-7023.361	8506.494

_Itypebus_8	2123.814	4015.685	0.53	0.597	-5749.183	9996.811
_Itypebus_9	-99.773	5218.05	-0.02	0.985	-10330.08	10130.53
_Itypebus_10	-290.13	3869.335	-0.07	0.94	-7876.2	7295.939
_cons	-1634.69	4503.298	-0.36	0.717	-10463.68	7194.306

5. Discussion

This study demonstrates that all the service quality variables other than bus type significantly affect performance. This result also demonstrates that the passengers are sensitive towards quality factors such as Travel time, highest Ratings, and Price. The price-to-revenue relationship gains insights into passengers' willingness to pay a higher price for their journey. The price factor is discounted when they travel with Private operators compared to government transport, which charges comparatively less. The price-sensitive passenger always chooses to travel with the government's transport, a service offered at a lower price with inferior quality attributes. What matters to them is travel time and customer rating. As far as the rating is concerned, passengers trust more on the highest user rating only and ignore the next low-level ratings while booking a journey online.

Results indicate that passengers trust online ratings from past passengers who traveled on that schedule. The contradiction of the result is that price-insensitive customers are also not sensitive about bus type quality, showing that Indian passengers are either compromising luxury or the industry is still a seller's market. The negative relation with travel time may be attributed to switching from another travel mode such as Train, which offers better comfort, or by air for the longer distance routes. The "Travel Time" factor also opens up several speculations apart from switching to another mode of travel. Passengers are smart enough to evaluate the cost-benefit with another mode at a given price. Short-haul routes make more revenue than long-haul routes, where operators cannot demand more fares and are less profitable. The Bangalore-Mumbai routes, which are 1200 Km, generally command an average of 20 USD. In contrast, short routes in the range of 400 km to 700Kms make charges around 15 USD, which is a comparatively better value proposition with no competition from the Rail and Air.

The study offers several contributions to the existing literature: Among one of the few available studies linking service quality with performance, this study considers objective service quality measures and links with schedule-wise performance. The past literature was largely focused on loyalty and satisfaction using subjective measures. The study conducted on longitudinal data on service quality is a major academic contribution to the public transport and service quality literature.

Online customer ratings collected from past passengers are a unique way of measuring service quality. The result of the study also offers several insights into the Indian intercity transport sector: The Indian private passenger travel industry is still a seller's market. The price-sensitive passengers of private travelers are not demanding a better-quality bus, which is an interesting observation. The results show a way to go in the market for high-end luxury buses such as Multi-Axel VOLVO and AC buses, as bus type is not critically evaluated while booking a journey. Though there are ups and downs in bus booking capacity in peak and non-peak periods, the operators still need to be in a run for revenue and are doing well overall.

The command over bus fare is a brownie point for the private-public transport industry in India. The increase in bus fares has not impacted the performance, indicating that Indian passengers are either price insensitive or whoever opts for private players is insensitive to bus fares. The underperforming long-haul routes indicate that Indian passengers prefer bus transport for less than 8 hours long journeys. Beyond that, they look for alternative travel modes such as premium air or cheap and convenient Indian Railways. Passengers are considering the online rating feedback of passengers who traveled in the past in the same service schedule.

The research opens a wider scope for research on public transport. Future research can also include service quality and other cost-related parameters such as labor and fuel while studying the performance of public transport. The research can be replicated in other settings, such as air travel, where the customer rating data is captured online on the booking site.

6. Limitations and Future Research

While the study has its merits, it is important to acknowledge some limitations that may affect the generalizability and validity of the findings.

Key Recommendations: The study encourages scholars from public transport to study service quality using online reviews and recommendation systems as a new promising avenue for research by improving the present approach by incorporating service quality expectations and delivery gaps. The data captured from the online booking portal can be applied in various methodologies other than panel data regression. For example, a TOPSIS model for ranking service quality can offer competitive intelligence to operators.

The booking portals can build a model that can offer an application for operators to track the progress of service quality and areas of improvement and identify the critical attributes affecting revenue.

Sample representativeness: The study's findings heavily rely on the sample used for analysis. It was challenging to obtain a representative sample due to logistical constraints or limitations in accessing data from different regions.

Causality and endogeneity: Establishing a causal relationship between service quality and public transport performance can be complex. The study faces challenges in addressing endogeneity issues, such as reverse causality or omitted variable bias. Controlling for all relevant factors that may influence the relationship could be difficult, potentially affecting the validity of the conclusions.

Online recommendation system limitations: The effectiveness of the online recommendation system in improving service quality and public transport performance may be influenced by several factors. These include the user base, data accuracy, and the algorithm's ability to accurately recommend appropriate routes or services. Limitations in

any of these aspects may impact the system's impact and, subsequently, the research outcomes.
External validity: The study's findings may be specific to the context in which the research was conducted. Public transport systems vary across cities, regions, and countries, with different infrastructure, regulations, and cultural factors. Therefore, the generalizability of the results to other settings may be limited.

To mitigate these limitations, future research could consider using multiple data sources, conducting a more diverse sample selection, addressing endogeneity issues through robust econometric techniques, and validating the findings through replication studies in different contexts.

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