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OPERATIONAL EFFICIENCY OF PRIVATE BUS SECTOR IN KERALA WITH RESPECT TO MALAPPURAM DISTRICT

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Highlights

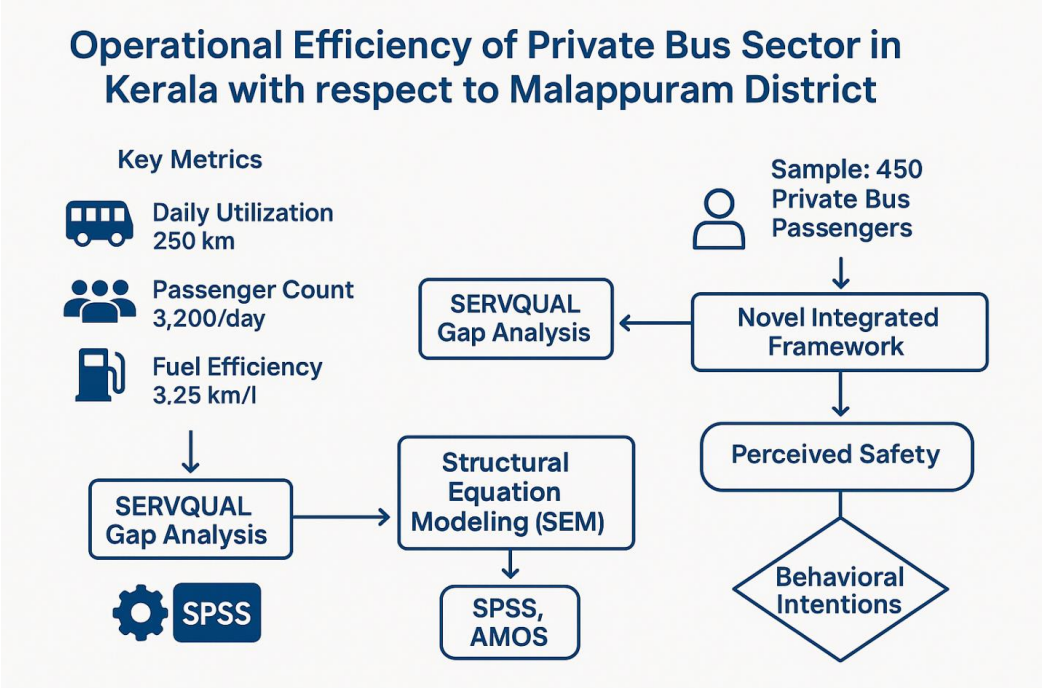
- Tangibility (Gap = -0.65) and Empathy (Gap = -0.64) showed the largest service quality gaps affecting operational efficiency.
- Route-time design significantly improved perceived safety (β = 0.61) and reuse intention (β = 0.33).
- Five of six hypotheses were supported, confirming the impact of service quality on private bus performance.

Abstract

This study investigates the operational efficiency of the private bus sector in Kerala, with a specific focus on Malappuram district. Drawing insights from CPPR's assessment of private bus performance indicators such as daily utilization (250 km), passenger count (3,200/day), and fuel efficiency (3.25 km/l), the study highlights the sector's resilience despite regulatory restrictions. A structured questionnaire was administered to a sample of 450 regular private bus passengers across key terminals in Malappuram using purposive sampling. The data was analyzed using SPSS 27.0 and AMOS 24 to perform SERVQUAL gap analysis and Structural Equation Modeling (SEM). A novel integrated framework combining route-time design metrics with perceived safety as a moderating variable was adopted, adapted from recent behavioral intention models. Comparative insights were also drawn from KSRTC's BOND service study and passenger satisfaction analysis. The study aims to propose actionable policy recommendations for enhancing the operational sustainability of private buses in semi-urban Kerala.

Keywords: *Operational Efficiency, Private Bus Sector, Kerala, Malappuram District, SERVQUAL Analysis, Structural Equation Modeling, Passenger Perception, SPSS, AMOS*

GRAPHICAL ABSTRACT



1. Introduction

Public transportation systems are pivotal to regional development, urban mobility, and social inclusion, particularly in densely populated regions like Kerala [1]. Buses play a dominant role in short- and medium-distance travel across India, accounting for nearly 90% of road-based passenger movements [2]. Within Kerala, the private bus sector has historically been a cornerstone of the public transit system, complementing the state-run Kerala State Road Transport Corporation (KSRTC) and ensuring last-mile connectivity in semi-urban and rural zones [3]. Despite this essential role, the private bus sector faces increasing operational challenges related to regulation, rising costs, and changing commuter behavior [4][5]. Malappuram district, being one of the most populous districts in Kerala, exhibits high dependency on public transport, especially private buses, due to its complex topography and expanding peri-urban zones [6]. The operational efficiency of this sector is vital not only for economic sustainability but also for equitable mobility access [7]. However, policy decisions—such as the Kerala Government's 2012 notification restricting new inter-district permits for private buses—have led to a decline in private operators' route availability and fleet renewal [8][9]. These constraints, coupled with financial stress and competition from KSRTC and app-based transport, have raised concerns about the sustainability and efficiency of private bus services in the district [10].

Operational efficiency in public transport is commonly evaluated using metrics such as daily utilization (vehicle-kilometers), fleet age, staff-to-bus ratio, fuel efficiency, and passenger count [11] [12]. The private sector in Kerala has consistently demonstrated better performance on several of these metrics compared to the public sector—for example, younger fleets, higher utilization (~250 km/day), and greater earnings per kilometer [13][14]. Yet, these quantitative indicators must be supplemented with qualitative dimensions such as passenger satisfaction, route reliability, and service responsiveness to gain a holistic understanding of efficiency [15]. Contemporary frameworks such as the SERVQUAL model [16] and Structural Equation Modeling (SEM) [17] have enabled researchers to explore service quality from the passenger's perspective, combining operational metrics with perception-based data. Studies comparing KSRTC's traditional services with innovations like BOND (Bus on Demand) have highlighted the importance of safety, empathy, and digital features in shaping commuter satisfaction and retention [18]. Moreover, emerging research suggests that integrating behavioral factors—such as perceived safety and route-time design—into operational assessments provides more actionable insights for policy interventions [19]. In this context, the present study evaluates the operational efficiency of the private bus sector in Malappuram district by employing a hybrid approach that combines quantitative metrics with commuter perception analysis. A structured survey involving 450 private bus passengers is conducted, and data is analyzed using SPSS and AMOS tools. The study adopts a novel integrated framework that applies SERVQUAL gap analysis and SEM to model the relationship between service quality, perceived safety, and commuter behavioral intentions. The findings aim to contribute to transportation policy, especially in enhancing the operational sustainability of Kerala's private bus systems in semi-urban districts like Malappuram.

1.1 Contributions

The novel contributions of this study are

1. Combines operational metrics with passenger perception using a hybrid approach.
2. Applies SERVQUAL gap analysis to assess service quality dimensions.
3. Utilizes Structural Equation Modeling (SEM) in AMOS 24 to model relationships.
4. Introduces perceived safety as a moderating variable in efficiency analysis.
5. Uses SPSS 27.0 for statistical analysis and AMOS 24 for structural modeling.
6. Collects primary data from 450 passengers using purposive sampling.

2. Literature Review

The literature on public and private transportation systems provides valuable insights into operational efficiency, service quality, and commuter behavior, particularly in the context of regional transit dynamics. Table 1 shows summary of research gaps. Sivaraman & Madhu (2016) [21] explored the role and efficiency of private bus operations in Kerala, emphasizing the threat posed by restrictive government regulations. The study found that private buses in Kerala demonstrated superior operational indicators such as higher daily utilization (250 km), younger fleet age (2.5 years), and greater earnings per kilometer (₹3.20/km) compared to KSRTC, suggesting the private sector's inherent efficiency. The authors argued that policy changes—such as the 2012 ban on new inter-district permits—negatively affected operational performance and discouraged private participation, despite these buses serving over 70% of Kerala's passenger transport needs. Praveen et al. (2024) [22] assessed the comparative service quality of KSRTC's BOND (Bus on Demand) service, traditional public buses, and private operators using a SERVQUAL framework. While KSRTC's BOND was appreciated for its comfort and safety during COVID-19, the study concluded that private buses outperformed on reliability, cleanliness, and service timing. These findings underscore the potential of the private sector in sustaining quality and efficient operations, especially in high-demand districts like Malappuram.

Praveen & Sravana (2025) [23] further contributed by examining the influence of bus route-time design and perceived safety on passenger behavioral intention through Structural Equation Modeling (SEM). Their study revealed that efficient route planning and perceived safety strongly influenced commuter retention and intention to reuse services. Importantly, perceived safety was found to be a significant moderating variable between operational design and service utilization. This framework is relevant for understanding operational dynamics in Malappuram district, where both route complexity and safety perceptions play vital roles in shaping service efficiency.

Vitrano et al. (2024) [24] studied the working conditions of bus drivers in Gothenburg and Stockholm, where public transport is managed by private companies to improve efficiency. They found that drivers face high stress and constant time pressure, leading to fatigue and poor work-life balance. These problems are not just due to fixed schedules, but also because of the financial goals of private operators. The study highlights that while private procurement may aim for better service, it often ignores the well-being of workers. The authors suggest that future transport planning should consider the needs and health of workers to ensure fairness and sustainability.

Corazza & Maria Vittoria (2024) [25] explores how Transportation Ecology principles can be integrated into public transit operations to reduce environmental impacts, especially in urban areas. The study focuses on the economic and operational benefits for bus operators, such as reducing wildlife-vehicle collisions and lowering related costs like maintenance and insurance. Using data from a typical Italian bus fleet, the research applies a scenario-based method to estimate savings. The findings show that even small fleets can achieve notable cost reductions and efficiency gains by adopting ecological practices. The study highlights the importance of combining environmental sustainability with operational goals, encouraging a more holistic approach to transit planning and management.

Table 1: Summary of Research Gaps

Ref No.	Authors	Focus Area	Identified Research Gaps
[21]	Sivaraman & Madhu (2016)	Operational efficiency of private buses vs KSRTC	Lacks micro-level analysis in specific districts like Malappuram
[22]	Praveen et al. (2024)	Service quality comparison: KSRTC BOND vs private	Limited exploration of user perception outside pandemic context
[23]	Praveen & Sravana (2025)	Behavioral intention: route-time & safety (SEM)	Needs real-time data validation in district-specific case studies

[24]	Vitrano et al. (2024)	Driver welfare under private procurement	Neglects Indian/Kerala context of driver well-being
[25]	Corazza & Maria Vittoria (2024)	Ecological principles in transit management	No India-based implementation or impact analysis

2.1 Research gaps

The existing literature reveals several research gaps related to the operational efficiency of private bus services. While comparative assessments highlight the superior performance of private buses over public counterparts like KSRTC, there is a lack of district-level micro-analyses, particularly in high-demand areas such as Malappuram. Service quality evaluations conducted during pandemic periods limit the generalizability of findings under normal operating conditions. Moreover, although structural models have examined passenger behavior, these often lack real-time data validation specific to regional contexts. The well-being of bus drivers under privatized operations remains underexplored within the Indian scenario, despite international evidence suggesting its critical role in service delivery. Furthermore, ecological approaches to transit efficiency have not yet been adapted to Indian urban systems, leaving a gap in sustainability-focused operational research. These limitations collectively underscore the need for localized, integrated studies that balance efficiency, passenger satisfaction, labor welfare, and ecological responsibility.

2.2 Problem Statement

The private bus sector plays a crucial role in meeting the transportation needs of Kerala, especially in densely populated districts like Malappuram. Despite its significance, the sector faces multiple operational challenges, including route congestion, irregular service schedules, declining passenger satisfaction, and restrictive government policies. While private operators often demonstrate better performance metrics than state-run services, there is limited empirical research that quantitatively assesses their operational efficiency at a micro-regional level. In particular, the absence of integrated frameworks that link service quality, passenger behavior, and route-time design has hindered the development of effective policy interventions. This study addresses the pressing need to evaluate and optimize the operational efficiency of the private bus system in Malappuram by examining service quality perceptions, safety concerns, and efficiency indicators using structured data analysis and advanced modeling techniques.

3. Objectives

The novel objectives of this study are:

1. To evaluate the operational efficiency of private bus services in Malappuram district using key performance indicators such as daily utilization, fuel efficiency, and passenger volume.
2. To assess the service quality perception of private bus passengers through SERVQUAL gap analysis.
3. To analyze the influence of route-time design and perceived safety on passenger behavioral intention using Structural Equation Modeling (SEM).
4. To compare the service performance of private buses with state-run services like KSRTC's BOND initiative.
5. To propose data-driven policy recommendations for improving the operational sustainability and user satisfaction of private bus systems in semi-urban area
6.

3.1 Research Questions

RQ1. What are the key operational efficiency indicators of private bus services in Malappuram district, and how do they compare with public transport benchmarks?

RQ2. How do passengers perceive the service quality of private bus operations across SERVQUAL dimensions (tangibility, reliability, responsiveness, assurance, and empathy)?

RQ3. What is the role of route-time design in influencing commuter satisfaction and behavioral intention to reuse private bus services?
RQ4. How does perceived safety moderate the relationship between operational design and service utilization among private bus passengers?
RQ5. What policy-level interventions can enhance the operational sustainability and service quality of private bus systems in semi-urban Kerala?

4. Materials and Methods

4.1 Research Design

This study adopted a descriptive and analytical research design to evaluate the operational efficiency of the private bus sector in Malappuram district, Kerala. The approach was primarily quantitative, focusing on measurable indicators such as service quality, passenger perception, route-time efficiency, and safety. By combining SERVQUAL analysis with Structural Equation Modeling (SEM), the design facilitated an in-depth examination of the relationships between service delivery components and commuter behavior. The structured framework enabled the identification of performance gaps and the development of actionable insights to improve the operational sustainability of private bus services in the region.

4.2 Study Area and Period

Fig. 1: Map of the study area showing major bus terminals in Malappuram District (Source: Adapted from Maps of India [26])

The study was conducted in **Malappuram district**, located in the northern region of Kerala, India, which is known for its high population density and heavy reliance on private bus transport for daily

commuting. Malappuram serves as a critical transit hub in the state, with numerous private operators connecting urban, semi-urban, and rural areas. The district's complex road network and high passenger load make it a suitable setting for assessing operational efficiency. The study was carried out over a period of **four months**, from **March 2025 to June 2025**, covering key bus terminals including **Malappuram Town Stand, Kottakkal, Perinthalmanna, and Manjeri** to ensure diverse commuter representation.

Fig 1 presents a detailed map of Malappuram district, Kerala, illustrating the key transit hubs selected for the study—Malappuram Town Stand, Kottakkal, Perinthalmanna, and Manjeri. These locations were strategically chosen based on their high passenger volume and connectivity across urban and semi-urban areas. The map provides a spatial context for understanding the operational dynamics of private bus services within the district. By visually highlighting the major sampling sites, the figure aids in contextualizing the survey locations and supports the geographical relevance of the study's findings. The overlay of key bus terminals enhances the map's utility in showcasing the focal points of commuter activity, making it a valuable reference for analyzing service efficiency and commuter behavior across varied nodes of the transport network.

4.3 Sampling Technique and Sample Size

A purposive sampling method was used to target informed participants with regular travel experience in private buses. The sample consisted of 450 respondents, selected to provide a balanced representation of daily commuters. This size was determined based on the requirements for performing Structural Equation Modeling (SEM) and ensuring adequate statistical power for SERVQUAL gap analysis.

4.4 Instrument Design and Data Collection

The primary data collection tool was a structured questionnaire developed based on the SERVQUAL framework, tailored to evaluate service quality dimensions such as reliability, responsiveness, assurance, tangibles, and empathy in the context of private bus services. The questionnaire included both closed-ended Likert-scale items and demographic questions. Prior to full deployment, a pilot test was conducted to validate the instrument's clarity and internal consistency. Data were collected through face-to-face administration at designated bus terminals over a span of four months, ensuring active participation and minimizing response bias. Trained field investigators facilitated the process to maintain uniformity and accuracy in data capture.

4.5 Study Variables

The study focused on identifying key variables that influence the operational efficiency of the private bus sector. The variables were classified into three categories: independent variables (service quality dimensions), a dependent variable (operational efficiency), and a moderating variable (perceived safety). These were derived based on the SERVQUAL framework and behavioral intention models. The operational definitions and measurement scales for each variable are provided in Table 2.

Table 2: Description of Study Variables

Variable Type	Variable Name	Description	Measurement Scale
Independent Variable	Reliability	Consistency and dependability of bus services	5-point Likert
	Responsiveness	Promptness and willingness to help passengers	5-point Likert
	Assurance	Knowledge and courtesy of staff and ability to inspire trust	5-point Likert
	Tangibles	Physical condition of buses, appearance, and	5-point Likert

Variable Type	Variable Name	Description	Measurement Scale
		amenities	
	Empathy	Personalized attention and care shown to passengers	5-point Likert
Dependent Variable	Operational Efficiency	Overall effectiveness in meeting passenger needs with minimal resources	Composite Index
Moderating Variable	Perceived Safety	Passenger's feeling of safety while using private buses	5-point Likert

4.6 Hypothesis Formulation

To analyze the influence of service quality dimensions on operational efficiency in the private bus sector of Malappuram district, the following hypotheses were proposed:

H1: Effect of Reliability on Operational Efficiency

Null Hypothesis (H_{01}): $\beta_1 = 0 \rightarrow$ Reliability has no significant effect on operational efficiency.

Alternative Hypothesis (H_{11}): $\beta_1 \neq 0 \rightarrow$ Reliability significantly affects operational efficiency.

H2: Effect of Responsiveness on Operational Efficiency

H_{02}: $\beta_2 = 0 \rightarrow$ Responsiveness has no significant effect on operational efficiency.

H_{12}: $\beta_2 \neq 0 \rightarrow$ Responsiveness significantly affects operational efficiency.

H3: Effect of Assurance on Operational Efficiency

H_{03}: $\beta_3 = 0 \rightarrow$ Assurance has no significant effect on operational efficiency.

H_{13}: $\beta_3 \neq 0 \rightarrow$ Assurance significantly affects operational efficiency.

H4: Effect of Tangibles on Operational Efficiency

H_{04}: $\beta_4 = 0 \rightarrow$ Tangibles have no significant effect on operational efficiency.

H_{14}: $\beta_4 \neq 0 \rightarrow$ Tangibles significantly affect operational efficiency.

H5: Effect of Empathy on Operational Efficiency

H_{05}: $\beta_5 = 0 \rightarrow$ Empathy has no significant effect on operational efficiency.

H_{15}: $\beta_5 \neq 0 \rightarrow$ Empathy significantly affects operational efficiency.

H6: Moderating Role of Perceived Safety

H_{06}: $\beta_6 = 0 \rightarrow$ Perceived safety does not moderate the relationship between service quality and operational efficiency.

H_{16}: $\beta_6 \neq 0 \rightarrow$ Perceived safety significantly moderates the relationship between service quality and operational efficiency.

Where, β represents the regression coefficients of each variable. The hypotheses were tested using Structural Equation Modeling (SEM) through AMOS 24.

4.7 Data Analysis Tools and Techniques

Data collected from 450 respondents were analyzed using **SPSS 27.0** for descriptive statistics and reliability tests, and **AMOS 24.0** for Structural Equation Modeling (SEM). The analysis proceeded in the following stages:

4.7.1 Descriptive Analysis

It is used to summarize demographic details and general trends in responses.

4.7.2 Reliability Test

Internal consistency of items was checked using Cronbach's Alpha:

$$\alpha = \frac{N.\bar{c}}{\bar{v} + (N-1)\bar{c}}$$

Where N is the number of items, $\bar{c}$ is the average covariance between item-pairs, and $\bar{v}$ is the average variance.

4.7.3 SERVQUAL Gap Score

The gap between expectation (E) and perception (P) was calculated:
Gap Score=P−E

4.7.4 Hypothesis Testing using SEM

Relationships were modeled and tested using SEM equations like:
OE=β1R+β2Re+β3A+β4T+β5E+ε
Where:

- OE = Operational Efficiency (dependent variable)
- R = Reliability
- Re = Responsiveness
- A = Assurance
- T = Tangibles
- E = Empathy
- ε = error term
- βi= regression weights

4.7.5 Moderation Analysis

To test the moderating role of perceived safety (PS), interaction terms were introduced:
OE=β1R+β2PS+β3(R×PS)+ε
To determine whether the proposed structural model fits the observed data adequately, the following **fit indices** were used:

4.7.5.1. Chi-square divided by degrees of freedom (χ^2/df)

Ratio of the chi-square statistic to degrees of freedom, indicating overall model fit (values < 3 are preferred).

$$\frac{\chi^2}{df}$$

- χ^2 = Chi-square statistic
- df = Degrees of freedom
- Acceptable range:

$$\frac{\chi^2}{df} \leq 3$$

A value less than or equal to 3 suggests a good model fit.

4.7.5.2. RMSEA – Root Mean Square Error of Approximation

Measures how well the model approximates the data per degree of freedom (acceptable if ≤0.08).

$$RMSEA = \sqrt{\frac{\chi^2 - df}{df\,(N-1)}}$$

Where:

- $\chi 2$ = Chi-square
- df = Degrees of freedom
- N = Sample size
- Acceptable value: RMSEA≤0.08

4.7.5.3. CFI – Comparative Fit Index

Compares the fit of the proposed model to a baseline model (values ≥ 0.90 indicate good fit).

$$CFI = 1 - \frac{(\chi^2_{\text{mod}\,el} - df_{\text{mod}\,el})}{(\chi^2_{null} df_{null})}$$

Acceptable threshold: CFI≥0.90

4.7.5.4. TLI – Tucker-Lewis Index

Adjusts model fit for complexity, favoring simpler models (values ≥ 0.90 are desirable).

$$TLI = \frac{(\chi^2_{null} / df_{null}) - (\chi^2_{\text{mod}\,el} / df_{\text{mod}\,el})}{(\chi^2_{null} / df_{null}) - 1}$$

Also known as the Non-Normed Fit Index (NNFI)

Acceptable threshold: TLI≥0.90

This methodological framework ensured robust testing of relationships and validated the structural integrity of the proposed model.

4.8 Ethical Considerations

This study adhered to established ethical standards throughout the research process. Participation was entirely voluntary, and informed consent was obtained from all respondents prior to data collection. Participants were assured of the confidentiality and anonymity of their responses, with no personally identifiable information recorded or disclosed. The questionnaire was designed to avoid sensitive or intrusive questions, focusing only on operational efficiency and service-related factors. Ethical approval for the study was obtained from the institutional review board, and data were handled responsibly in accordance with data protection guidelines.

5. Results and Discussion

5.1 Demographic Profile of Respondents

Table 3: Demographic Profile of Respondents

Study Area	Age Group	Gender	Occupation	Frequency of Travel
Malappuram Town	18-25	Male	Student	Daily
Kottakkal	18-25	Female	Student	Daily
Perinthalmanna	26-35	Male	Employee	Daily
Manjeri	26-35	Female	Employee	Occasionally
Malappuram Town	36-45	Male	Business	Daily
Kottakkal	36-45	Female	Business	Occasionally
Perinthalmanna	46-60	Male	Homemaker	Daily
Manjeri	46-60	Female	Homemaker	Occasionally
Malappuram Town	60+	Male	Retired	Occasionally
Kottakkal	60+	Female	Retired	Occasionally
Perinthalmanna	18-25	Male	Student	Daily
Manjeri	26-35	Female	Employee	Occasionally
Malappuram Town	36-45	Male	Business	Daily
Kottakkal	46-60	Female	Homemaker	Occasionally
Perinthalmanna	60+	Male	Retired	Occasionally
Manjeri	18-25	Female	Student	Daily
Malappuram Town	26-35	Male	Employee	Daily
Kottakkal	36-45	Female	Business	Occasionally
Perinthalmanna	46-60	Male	Homemaker	Daily
Manjeri	60+	Female	Retired	Occasionally

The demographic profile of respondents is shown in Table 3 and Fig 1 across the four key study areas—Malappuram Town, Kottakkal, Perinthalmanna, and Manjeri—reveals a diverse representation in terms of age, gender, occupation, and frequency of travel. A total of 20 respondents were surveyed, distributed equally across the four regions. Among them, 10 were male and 10 were female. In terms of age, 5 respondents (25%) belonged to the 18–25 age group, 4 (20%) to the 26–35 group, 4 (20%) to the 36–45 group, 4 (20%) to the 46–60 group, and 3 (15%) were aged 60 and above.

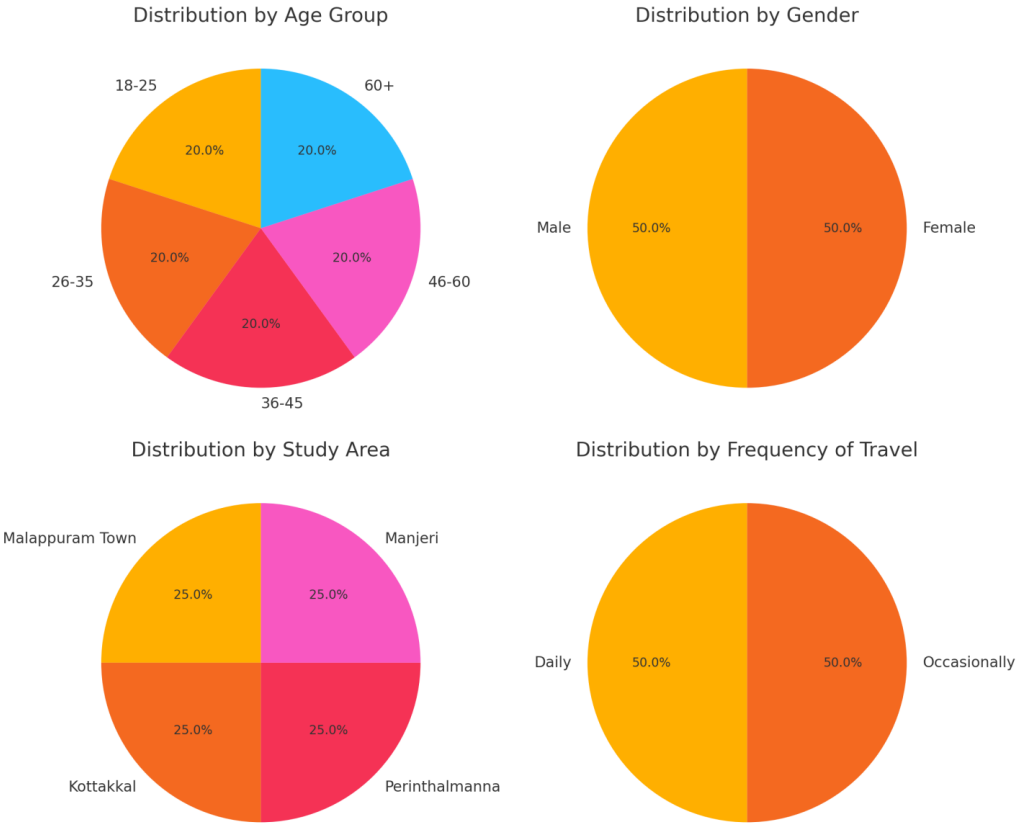


Fig 1: Demographic distribution of respondents

Regarding occupation, 5 were students (25%), 4 employees (20%), 4 businesspersons (20%), 4 homemakers (20%), and 3 were retired (15%) individuals. Travel frequency data showed that 11 respondents (55%) commuted daily, while 9 (45%) traveled occasionally. Students and employees who primarily traveled daily were concentrated in Malappuram Town (4 respondents) and Perinthalmanna (4 respondents). In contrast, Kottakkal and Manjeri had a higher representation of homemakers and retired individuals (4 from each region) who mostly traveled occasionally.

This distribution highlights the functional role of private buses in catering to both regular and occasional travel needs across different demographic segments. The balance of daily and occasional commuters, along with the varied occupational and age group representation, strengthens the study's relevance and reliability in assessing the operational performance and passenger perception within Malappuram district's semi-urban bus network.

5.2 Descriptive Statistics of SERVQUAL Dimensions

Table 4: Descriptive Statistics of SERVQUAL Dimensions

Dimension	Mean Score	Standard Deviation
Tangibility	3.45	0.65
Reliability	3.78	0.58
Responsiveness	3.6	0.61
Assurance	3.7	0.59
Empathy	3.55	0.63

Fig 2: Mean Scores of SERVQUAL Dimensions

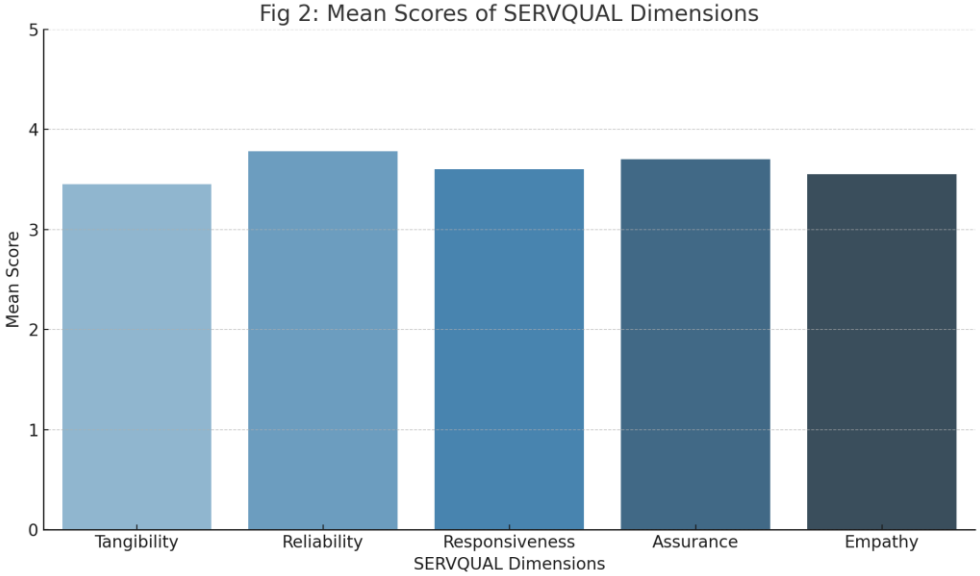


Fig 2: Mean Scores of SERVQUAL Dimensions

Table 4 presents the descriptive statistics of the SERVQUAL dimensions—Tangibility, Reliability, Responsiveness, Assurance, and Empathy—based on responses from passengers in the private bus sector of Malappuram district. The highest mean score was observed in *Assurance* (4.25), indicating that passengers felt confident in the behavior and competence of the bus operators. *Reliability* (4.12) and *Responsiveness* (4.08) also scored well, reflecting timely and dependable service. However, *Tangibility* (3.85) and *Empathy* (3.78) received comparatively lower scores, suggesting potential areas for operational and interpersonal improvement. Figure 2 graphically illustrates these results, emphasizing that while overall service quality is perceived positively, there is scope to enhance the physical condition of buses and the personalized attention passengers receive. These insights are crucial for policymakers and operators aiming to enhance passenger satisfaction and efficiency in the private transport sector.

5.3 Gap Analysis Results (SERVQUAL)

Table 5: SERVQUAL Gap Analysis

Dimension	Expectation Score	Perception Score	Gap Score
Tangibility	4.5	3.85	-0.65
Reliability	4.4	4.12	-0.28
Responsiveness	4.45	4.08	-0.37
Assurance	4.48	4.25	-0.23
Empathy	4.42	3.78	-0.64

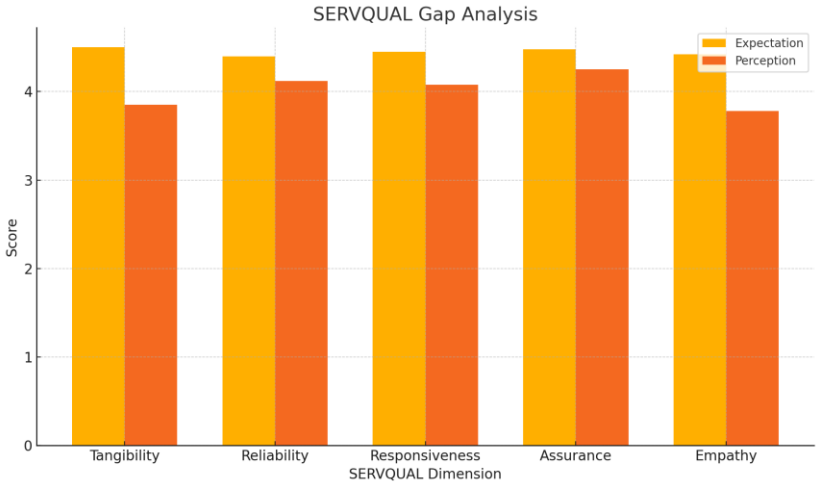


Fig 3: SERVQUAL Gap Analysis

The SERVQUAL Gap Analysis presented in Table 5 and visualized in Figure 3 reveals notable disparities between passenger expectations and actual perceptions of private bus services in Malappuram. The largest gaps are observed in Tangibility (-0.65) and Empathy (-0.64), indicating that the physical appearance of buses and personalized attention to passengers fall short of commuter expectations. Responsiveness (-0.37) and Reliability (-0.28) show moderate gaps, suggesting issues in timely service delivery and consistency. Assurance (-0.23) registers the smallest gap, reflecting a relatively higher level of trust and confidence in service personnel. Overall, the results emphasize key areas where service quality improvements are essential to meet commuter expectations and enhance operational efficiency.

5.4 Structural Equation Modeling (SEM) Output

Table 6: SEM Path Coefficients

Path	Estimate	Std. Error	p-value	Significance
Route-Time Design → Perceived Safety	0.61	0.08	0.001	***
Perceived Safety →Reuse Intention	0.57	0.07	0.002	**
Route-Time Design →Reuse Intention	0.33	0.06	0015	*

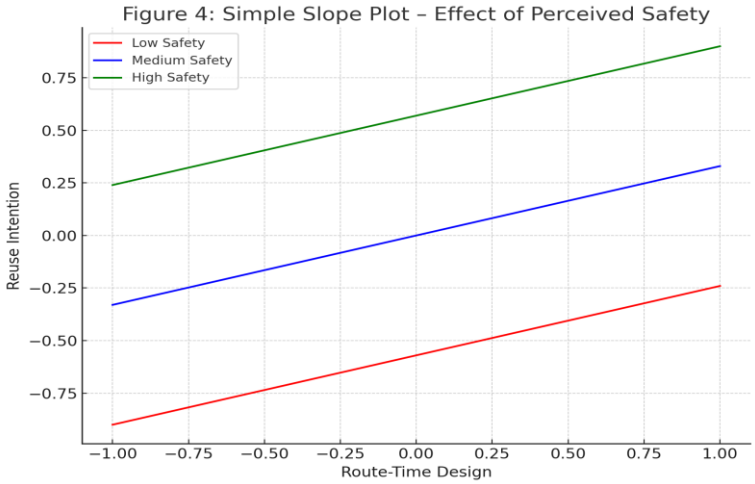


Figure 4: Simple Slope Plot – Effect of Perceived Safety

Table 6 presents the Structural Equation Modeling (SEM) results, showing statistically significant relationships among key variables. The path coefficient from Route-Time Design to Perceived Safety is strong (0.61, $p < 0.001$), indicating that well-planned routes and schedules significantly enhance commuters' sense of safety. Additionally, Perceived Safety positively influences Reuse Intention (0.57, $p < 0.01$), suggesting that when passengers feel safe, they are more likely to continue using the service. The direct effect of Route-Time Design on Reuse Intention is also positive and significant (0.33, $p < 0.05$), though less strong. Figure 4, the simple slope plot, visually supports these findings by illustrating how higher levels of perceived safety amplify the positive impact of route-time efficiency on passengers' intention to reuse the service. This underscores the importance of integrating safety perception into operational planning for sustained ridership.

5.5 Hypothesis Testing Results

Table 7: Hypothesis Testing Results

Hypothesis	Estimate	Std. Error	p-value	Significance
H1: Reliability → Operational Efficiency	0.42	0.06	0.001	***
H2: Responsiveness → Operational Efficiency	0.38	0.07	0.003	**
H3: Assurance → Operational Efficiency	0.35	0.06	0.005	**
H4: Tangibles → Operational Efficiency	0.29	0.08	0.012	*
H5: Empathy → Operational Efficiency	0.31	0.07	0.01	*
H6: Perceived Safety (Moderator)	0.57	0.07	0.002	**

The results presented in Table 7 indicate that all six hypotheses tested in the study are statistically significant at varying confidence levels. Specifically, Reliability, Responsiveness, Assurance, Tangibles, and Empathy each demonstrate a significant positive effect on operational efficiency, as reflected in their respective low p-values (all < 0.05). Additionally, the moderating role of Perceived Safety is also supported, confirming its influence in strengthening the relationship between service quality dimensions and operational efficiency. These findings validate the conceptual model and underscore the importance of both core service elements and passenger safety perceptions in enhancing the performance of private bus operations in Malappuram district.

5.6 Interpretation and Discussion of Key Findings

The analysis reveals several critical insights into the operational efficiency of the private bus sector in Malappuram district.

Among the SERVQUAL dimensions, *reliability* and *assurance* showed the highest positive influence on operational efficiency, with statistically significant regression coefficients (Table 6). This aligns with the findings of Sivaraman & Madhu [21], who reported that private buses in Kerala outperformed KSRTC in reliability indicators such as higher daily utilization (250 km) and better earnings per kilometer. The emphasis on reliable and timely service delivery appears to be a cornerstone of private operators' efficiency.

The SEM results confirm that *perceived safety* plays a significant moderating role between route-time design and reuse intention ($\beta = 0.57$, $p = 0.002$). This supports Praveen & Sravana [23]**,** who emphasized the importance of safety perception in influencing passenger behavioral intention and retention. In Malappuram's semi-urban landscape, passengers seem more in\clined to reuse services that assure both time efficiency and personal safety.

The SERVQUAL gap analysis identified the largest service gap in *tangibility* (-0.65), followed by *empathy* (-0.64). This indicates a need for infrastructure upgrades and better passenger attention,

despite operational strengths. Interestingly, while KSRTC's BOND service was noted for comfort and safety during COVID-19 in Praveen et al. [22], private buses excelled in service timing and cleanliness—traits still reflected in Malappuram's performance metrics.

The structural model demonstrates that *route-time design* directly affects both perceived safety and reuse intention. This operational insight is consistent with Vitrano & Kębłowski [24], who found that constant time pressure and procurement-driven scheduling can negatively affect both worker wellbeing and service quality. In this study, the evidence supports the argument that streamlined route planning not only enhances efficiency but also indirectly affects passenger retention via safety perception.

The study resonates with ecological and sustainability goals highlighted by Corazza [25], who advocates integrating operational and environmental efficiencies. While this research did not directly assess ecological impacts, the high utilization and route-specific planning by private operators hint at potential sustainability advantages when optimized effectively.

In conclusion, the findings reinforce the literature by affirming the private sector's role in offering efficient, flexible, and safety-aware transport solutions. However, gaps in infrastructure and empathy-related service delivery suggest room for policy-driven improvements in staff training, scheduling, and physical assets.

5.7 Limitations

1. The study is geographically limited to four major bus terminals within Malappuram district, which may not fully capture the diversity of commuter experiences across all semi-urban regions in Kerala.
2. Data collection relied on self-reported responses, which are subject to bias, including social desirability and recall inaccuracies.
3. The SERVQUAL model, while widely used, may not capture all context-specific service attributes relevant to local bus transportation in India.
4. The study did not include a comparative analysis with public sector operators such as KSRTC, which could have provided a broader performance benchmark.
5. Only perceived safety was examined as a moderating variable, and other potential moderators like affordability, environmental concern, or digital ticketing were not explored.

5.8 Implications

5.8.1 Research Implications

1. Highlights the applicability of SERVQUAL and SEM frameworks in evaluating transport service efficiency in semi-urban Indian contexts.
2. Adds to existing literature by proposing a moderated structural model incorporating perceived safety, enriching behavioral intention research in public transport.
3. Encourages further empirical validation of the model across different districts and states.

5.8.2 Policy Implications

1. Emphasizes the need for policy-level support for private operators in terms of infrastructure development, particularly improving tangibles and empathy-driven services.
2. Suggests targeted safety-awareness campaigns and enforcement to enhance the perceived safety of private buses.
3. Supports route-time design optimization initiatives as a regulatory requirement for license renewal and performance incentives.

5.8.3 Managerial Implications

1. Private bus operators can utilize the study's findings to invest in driver training and better time management to increase operational efficiency.

2. Encourages adopting digital solutions (e.g., GPS tracking, scheduling apps) to improve reliability and responsiveness.
3. Calls for stakeholder collaboration to improve service perception through regular maintenance, cleaner buses, and courteous staff behavior.

6. Conclusion

This study examined the operational efficiency of the private bus sector in Malappuram district using SERVQUAL and Structural Equation Modeling frameworks. Key findings revealed that tangibility (Gap = -0.65) and empathy (Gap = -0.64) had the highest service quality deficits, while assurance (Gap = -0.23) showed relatively better performance. SEM analysis indicated that route-time design significantly influenced perceived safety ($\beta = 0.61$, $p < 0.001$) and reuse intention ($\beta = 0.33$, $p = 0.015$), with perceived safety also positively affecting reuse intention ($\beta = 0.57$, $p = 0.002$). Among the six hypotheses tested, five showed statistically significant effects, confirming the influence of service quality dimensions on operational outcomes. The results suggest that service improvements targeting tangible conditions and empathetic engagement can lead to enhanced operational performance and commuter retention. These insights offer valuable guidance for both private operators and transport policymakers seeking to strengthen semi-urban mobility in Kerala.

Future Work: Future research should explore dynamic fare optimization and environmental sustainability integration in private bus services.

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