ADDIS ABABA UNIVERSITY

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SCHOOL OF GRADUATE STUDIES

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

Performance Evaluation of Public Transport Service Prioritizing Commuter Preferences for Comfort, Affordability, Safety, and Security: Case of Addis Ababa City

By

Shambel Assefa

A Thesis Submitted to the School of Graduate Studies in Partial Fulfillment of the Requirements for the Degree of Master of Science

In

Road and Transport Engineering

Advisor

Dr. Bikila Teklu

June, 2023

Addis Ababa, Ethiopia

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Declaration

I at this moment declare that this research titled "Performance Evaluation of Public Transport Service Prioritizing Commuter Preferences for Comfort, Affordability, Safety, and Security: Case of Addis Ababa City" is my own original work completed under the supervision of Dr. Bikila Teklu. The work has not been submitted for a degree at this or any other university, and all sources of materials used in the thesis were fully acknowledged.

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ABSTRACT

Public transportation is an essential component of a nation's success, with benefits that extend beyond just those who use trains or buses. To maintain these benefits and continue to attract passengers, it is crucial to evaluate the performance of public transport services. This M.Sc. thesis aims to do just that in the case of Addis Ababa, focusing on five modes of transport, including minibus taxis, midi buses, public service buses, Anbesa buses, and Sheger buses. To undertake this, the study uses both subjective and objective measures, including ANOVA and LOS analysis, tariff comparison, and computation of fatalities and injuries. A multinomial logistic model also employed to determine how commuters prioritized the service aspects of public transport.

The results show that minibus taxis were found to be the most comfortable mode of transport followed by public service buses, Sheger buses, Anbesa city buses, and midi buses. The minibus taxi provides the least affordable service, while Anbesa and Sheger buses had the highest affordable service without significant difference. Public service buses, Anbesa buses, and Sheger buses have the highest mean leading safety performance without significant differences. On the other hand, minibus taxis and midi buses are the least performers. Furthermore, the taxi had the highest fatal and injury involvement than other public transport combined. The midi-bus is the least performer interims of security followed by minibus taxi.

The model also revealed that monthly income, age, frequently used mode, and education level have significant predictors for commuters' modal preference decisions. This research contributes to policymakers by providing recommendations for designing transportation policies that better meet the needs and preferences of the public, leading to increased ridership and improved access to transportation for all.

Key word: *Public transport, Performance evaluation, Comfort, Affordability, Safety, Security, Analysis of variance, Level of service, Multinomial logistic model*

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List of Acronyms

Addis Ababa Light Rail Transit	AALRT
Anbesa City Bus Enterprise	ACBE
Analysis Of Variance	ANOVA
Closed-Circuit Television	CCTV
Confidence Interval	CI
Department Of Transport	DoTs
European Union	EU
Highway Capacity Manual	HCM
Level Of Service	LOS
Light Rail Transit	LRT
Metropolitan Planning Organizations	MPOs
Public Service Employ Transport Service Enterprise	PSETSE
Safety Performance Indicator	SPI
Sheger Mass Transport Enterprise	SMTE
Statistical Package for Social Sciences	SPSS
Transit Capacity and Quality of Service Manual	TCQSM
Transit Cooperative Research Program	TCRP
United States Codes	U.S.C.
World Health Organization	WHO

CHAPTER ONE

1. INTRODUCTION

1.1 Background

Addis Ababa, the capital city of Ethiopia, has been undergoing a rapid increase in population, and it is projected to surpass 7.4 million inhabitants by 2030. The predominant means of transportation in the city are buses, minibuses, walking, private taxis, and private cars, accounting for 7%, 34%, 44%, 6%, and 9%, respectively (UNHABITAT; UITP, 1988). This highlights the city's heavy reliance on public transportation. However, public transportation systems in developing countries such as in Latin America, Africa, and Asia are typically inadequate, lacking comprehensive policies, and plagued by issues such as overcrowding, discomfort, unreliability, and danger. In addition, the transportation sector also contributes significantly to environmental pollution and noise levels in the city, according to a study by Almeida Motta et al., (2013).

These issues are evident in the public transportation options available in Addis Ababa. So that, the passengers may experience discomfort, isolation, or vulnerability to crime though it is depending on their physical and environmental circumstances of the transit, socioeconomic status and frequency of users. As a result, Addis Ababa's public transportation system requires creative solutions to meet the growing demand for transportation services. This could be achieved by conducting a performance evaluation of public transport service and understanding commuter preferences for the transit service aspects.

There are two distinct perspectives to consider when evaluating the performance of transit services namely objective and subjective (Eboli & Mazzulla, 2008). The subjective approach considers the viewpoints and beliefs of passengers, while the objective approach involves measuring performance using quantifiable indicators that can be expressed as numerical values.

Numerous researchers emphasize the importance of considering the customer's viewpoint when evaluating the performance of transit systems. As an example, (Berry et al., 1990) asserted that "customers are the ultimate judge of service quality". However, passengers may appraise transit services in different ways that do not necessarily correlate with their frequency of use. This is because performance metrics, which are general indicators of overall performance, presume uniformity in service quality (Hensher et al., 2007). Nevertheless, relying exclusively on such measures has its drawbacks, including the subjective nature of users' evaluations and the inability to account for the perceptions of non-users. Furthermore, inadequate respondent sampling or user judgment heterogeneity may result in significant statistical errors.

To bridge existing gaps and produce a comprehensive and dependable outcome, this M.Sc. research incorporates both objective and subjective performance assessment metrics. Consequently, this study evaluates and compare the performance of chosen public transportation modes using both objective and subjective methods and identifies how commuters prioritize the attributes of mass transit when deciding on a mode of transportation. Objective performance is appraised through the application of several widely accepted standards such as the Highway Capacity Manual 2000 (HCM 2000), Transit Capacity and Quality of Service Manual (TCQSM, 2013), the national safety plan crash computation formula (T - Federal Transit Administration, 2019), and Texas Transportation Institute Level of Service Manual (Bullard & Fitzgerald, 1981). These manuals offer a benchmark for different levels of service analysis aspects such as passenger load and in-vehicle noise levels, as well as providing a formula for calculating crash incident rate to analyze lagging safety performance. Conversely, the subjective measures are evaluated using the one-way analysis of variance (ANOVA) as statistical analysis tool.

1.2 Statement of Problem

Addis Ababa is public transit dependent city (Gebeyehu & Takano, 2007). However, the city has more than 596,938 registered vehicles, which account for 56% of Ethiopia's total vehicles. Out of this, more than 300,000 are cars (Addis Ababa Annual Road Safety Report, 2018). This clearly points out that the city's vehicular ownership has been increasing greatly. As the demand for private transportation increases, the issue of congestion, air pollution, noise and accidents will be inevitable (Meshesha Fenta, 2014). Additionally, the city continues to face significant challenges regarding mobility issues and the adverse effects of motorized transportation, as well as concerns surrounding road safety (Tulu et al., 2019).

This can be mitigated by improving the service quality of public transport in terms of providing more convenience and better service environment, hence it is the key to have higher mode share and increase the attractiveness of the service. This could be done by performing performance evaluation and understanding commuters' preferences. However, people's preferences for public transport mode are influenced by a complex interplay of factors, and can vary depending on the individual and their specific circumstances. Such as the introduction of private transportation could raise the concept of comfort and personal safety (Chen & Li, 2017).

Therefore, this M.Sc. thesis aims to evaluate and compare the performance of Addis Ababa public transport modes in terms of comfort, affordability, safety, and security and identifies how commuters prioritize these attributes when deciding on a mode of transportation by using multinomial logistic regression model. The following point present how this study selects comfort, affordability, safety, and security of mass transit as key attributes.

- To attract more transit users, transportation services should be tailored to meet the service level expected by customers (Imre & Çelebi, 2017). Therefore, to ensure that performing performance evaluation is pivotal.

- Public transport should be accessible to all, regardless of their financial situation. Urban transport affordability one of the major issues of concern in developing countries, as high costs have negatively impacted the livelihood of the urban populace around the world, as evidenced by the number of trips that they have had to forego due to unaffordability (Carruthers et al., 2005). Therefore, addressing this issue is crucial because by providing affordable transport, we can alleviate livelihood of the citizens.

- Due to the raising the number of private transport and the introduction of new modalities that provides transport services: passenger latent variable concept such as personal safety and comfortable feelings are growing. Therefore, to attract new user and increase the existing transit performance, addressing those issue is vital.

- During COVD-19, mobility remains an essential element of the city of Addis Ababa and the city's mobility is dependent on public transport; studying the performance of public transport in terms of comfort (factors like passenger loading factor, cleanness etc.) and safety is important.

- To facilitate the modal shift, understanding how commuters prioritize the attributes of mass transit when deciding on a mode of transportation is necessary.

As a result, the findings of this study will provide valuable insights to transport sectors and policymakers about the strengths and weaknesses of the system. Moreover, it provides insights to policymakers to design transportation policies that better meet the needs and preferences of the public, leading to increased ridership and improved access to transportation for all.

1.3 Research Questions

The research questions for the thesis are the following:
- How do different modes of public transport perform in terms of comfort, affordability, safety, and security?
- How do comfort, affordability, safety, and security influence mode choice preferences among urban commuters when selecting a mode of public transport?

1.4 Objective

1.4.1 General Objective

The main aim of this M.Sc. thesis is to conduct a comprehensive performance analysis and comparison of various public transport modes operating in Addis Ababa. The study intends to evaluate the performance of these modes of transportation in terms of comfort, affordability, safety, and security. The research also aims to investigate how these attributes influence the commuter's mode preferences. To achieve these objectives, the study focuses on five selected modes of public transport, including minibus, midi-bus, public service employee transport service enterprise buses (PSETSE), Anbesa city bus (ACBE), and Sheger mass transport (SMTE). By examining these transport systems, the study aims to provide insights into their strengths and weaknesses, as well as the opportunities and challenges for improving the quality of public transport services in Addis Ababa. Ultimately, the findings of this research will serve as a valuable resource for policymakers, urban planners, and transportation authorities to enhance the performance of public transport systems, promote sustainable mobility, and improve the overall quality of life for residents of Addis Ababa.

1.4.2 Specific Objective

- To conduct a comprehensive and a comparative analysis of the performance of five selected modes of public transport in Addis Ababa, namely minibus, midi-bus, public

service transport service enterprise (PSETSE), Anbesa city bus (ACBE), and Sheger mass transport (SMTE), in terms of comfort, affordability, safety, and security.

- To determine how comfort, affordability, safety, and security are prioritized by commuters in the mode choice preferences for a particular mode of public transport.
- To make policy recommendation used to design transportation policies that better meet the needs and preferences of the public and how to encourage modal shift towards mass transport based on parameter estimate of the model.

1.5 Significance of the Study

The research evaluates and compare the level of comfort, affordability, safety, and security offered by the present public transportation system in Addis Ababa and identify passenger's trade-off these attributes when making choosing their mode of travel. This research would have the following significance:

1. Enhancing the reputation of the transport provider: A good reputation is essential for any transport provider. Evaluating public transport performance helps to identify areas that need improvement, leading to a better reputation for the provider.
2. Encouraging sustainable transport: Sustainable transport is essential for reducing emissions and mitigating the impact of climate change. Evaluating public transport performance in terms of affordability and comfort can help to encourage more people to use public transport instead of private cars, leading to reduced emissions and a more sustainable future.
3. Reducing accidents and incidents: Safety and security are essential aspects of public transport. Evaluating public transport performance in terms of safety and security can help to identify areas that need improvement, leading to reduced accidents and incidents.
4. Increasing accessibility: Public transport should be accessible to all, regardless of their financial situation. Evaluating public transport performance in terms of affordability can help to identify areas where fares may be too high, leading to increased accessibility for those on lower incomes.

5. To assist the current transit agencies and transportation planners in identifying how these factors are selected by commuters in modal choice consideration and determining the performance level of the services to adopting a positive action plan.

6. Insufficient studies on comparative performance evaluation: Comparative performance evaluation of different modes of public transport is essential for policymakers to make informed decisions.

In conclusion, evaluating and comparing public transport performance in terms of comfort, safety, security, and affordability and identifying how these are prioritized by commuters in mode choice preference decision are crucial for enhancing the reputation of the transport provider, encouraging sustainable transport, reducing accidents and incidents, and increasing accessibility. Moreover, it can help stakeholders in prioritizing investments, to make more informed decisions and enhancing the city's transportation system.

1.6 Scope and Limitation of the Study

1.6.1 Scope of the Study

This M.Sc. research aims to comprehensively evaluate the performance of the current public transportation service by prioritizing commuter preferences for comfort, affordability, safety, and security in Addis Ababa. Despite certain limitations like restricted time, budget, and data availability, the research has endeavored to analyze five modes of public transport in the study area: minibus taxis, midi buses, the Public Service Employees Transport Service Enterprise (PSETSE), Anbesa City Bus Enterprise (ACBE), and the Sheger mass transport service (SMTE).

1.6.2 Limitation of the Study

The present study has some noteworthy limitations that can be addressed in future research. Firstly, the study only examined five modes of transportation instead of analyzing all modes of transportation, which could provide a more comprehensive view.

Secondly, this study relied solely on subjective data to evaluate security performance, as objective data were unavailable. Thirdly, the data was collected before the implementation of the new transportation tariff, which could impact the affordability performance. Consequently, these limitations increase the potential for biases and confounding factors that may have influenced the results. However, by addressing these shortcomings in future research, the findings could be considerably strengthened and provide a more accurate representation of the transportation service's performance.

1.7 Organization of the Thesis

This M.Sc. thesis is organized into Six distinct chapters. The initial chapter serves as an introduction to the study, setting the stage for the subsequent chapters. The second chapter offers a concise literature review, focusing on public transport performance evaluation measures and relevant studies. In the third chapter, a comprehensive account of the study area, design, data collection, and analysis process, as well as the methodology employed, is provided. Building upon this foundation, chapter four and five present the result and discussion part of the thesis to answer the two-research question separately. Chapter four encompasses the presentation of performance evaluation results, while the chapter five delves into the consideration of commuter mode choice preferences. Finally, chapter six gives the conclusions and recommendations of the study, and proposed areas for future research to enhance public transportation in the City of Addis Ababa.

1.8   Conceptual Framework

The figure below illustrates the conceptual framework followed during carrying out this research. Initially, the existing different alternate public transport modes data are collected and used to evaluate the performance to improve the transportation performance and to enhance modal shift.
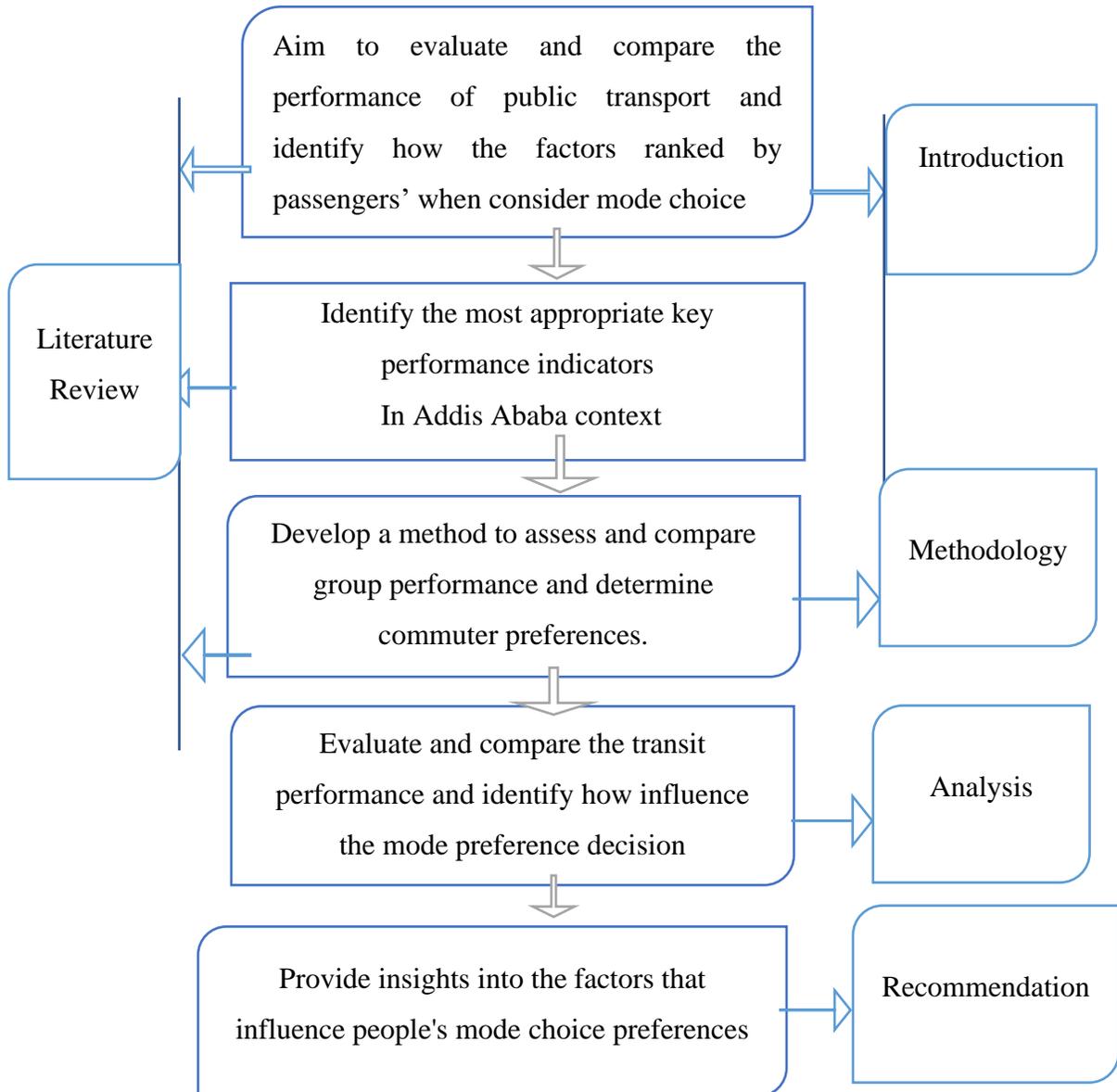
Figure 1-1 Conceptual framework

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Introduction

The literature review section of this thesis provides an overview of existing research on public transportation performance evaluation and its relationship to mode choice preference. This section explores a range of topics, including the various methods used to assess public transportation performances. Additionally, this section discusses how mass transit attributes such as comfort, affordability, safety, and security, influencing the mode choice preference of individuals. Finally, the section presents an empirical review and conceptual framework, which is serving as the basis for the research design and methodology used in this study.

2.2 Public Transport Performance Measures

Performance, in general terms, refers to any evaluation or comparison measure, and can be viewed as a characterization of performance that is either quantitative or qualitative in nature (Eboli & Mazzulla, 2012) . Performance evaluation refers to the systematic and objective assessment of the effectiveness, efficiency, and quality of a transit service in relation to its intended goals and objectives, taking into consideration the current operating conditions and constraints(Rahul Raoniar, Amudapuram Mohan Rao, 2015). To conduct a comprehensive performance evaluation of the public transport system, it is imperative to have a clear understanding of the relevant performance metrics. These metrics can be based on user perceptions of the service or feedback from an experienced evaluation team. It is essential to establish a solid foundation of knowledge before conducting any evaluation to ensure accurate and insightful results.

2.2.1 Transit Performance Measure Points of View

According to the Guidebook used for Developing a Transit Performance-Measurement System by a Transit Cooperative Research Program, there are three performance measure point of view (Ryus & Ferreira, 2003) . The definition, its major concern and measuring parameter are summarized in as follow.

Table 2-1 Transit Performance Measure Point of View

	Customer	Agency	Vehicle or Driver
Definition	Customer can judge the performance of the transit.	Measures of how well the service is working	Vehicle-oriented measures
Concern	Comfort, Service availability, reliability, Safety and security, convenience of service, Service delivery	Most concerned with organizational performance like; Economic, Transit impact	Capacity; Travel time
Parameters	Passenger environment, vehicle accident rate, passenger accident rate, crime rate, percentage of vehicles with devices, customer satisfaction	Fleet maintenance, cost efficiency and cost effectiveness, community economic impact, employment impact, mobility and environmental impact	Vehicle capacity, roadway capacity, volume to capacity ratio; delay

Source: Summarized by the researcher from (A Guidebook used for Developing a Transit Performance-Measurement System by a Transit Cooperative Research Program and Sponsored by the Federal Transit Administration developed by (Ryus & Ferreira, 2003).

Number of researchers have concurred that when assessing transit performance, it is essential to consider the perspective of the customer.

In fact, (Beirão & Sarsfield Cabral, 2007) have gone as far as to suggest that the customers themselves should be considered the ultimate arbitrators of service quality. The assessment of transit services by passengers is often not simply based on the length of time they have utilized the service. Rather, it is typically connected to overall measures of performance indicators (Hensher et al., 2007). As such, (Batarce et al., 2015) have also posited that the evaluation of transit performance from the passenger's point of view must encompass indicators of service quality.

The Transit Capacity and Quality of Service Manual, also known as TCQSM, highlights the paramount importance of meeting the needs and expectations of passengers. According to the manual, passengers are primarily concerned with the availability, comfort, and convenience of the transit service. Availability refers to the frequency and hours of service, while service delivery encompasses reliability, comfort, passenger environment, and overall customer satisfaction. Moreover, safety and security are also crucial aspects of the transit experience, and they can be measured by factors such as vehicle and passenger accident rates, crime rates, and the percentage of vehicles equipped with safety devices. By prioritizing these key areas, transit providers can ensure that their service meets the needs of their passengers and delivers a high-quality experience.

2.2.2 Public Transport Service Aspects

Transit service features can be categorized into two groups: those are directly related to the service, such as frequency, and those are subjective and harder to measure, such as comfort, which are dependent on individual customer preferences (Eboli & Mazzulla, 2012). Assessing the performance of public transportation services involves considering various crucial factors, including service availability, reliability, comfort, cleanliness, safety, security, fare pricing, information accessibility, customer care, and environmental impact are important to capture the holistic manner of the services. This study gives special attention to evaluating aspects that are difficult to measure, such as comfort, affordability, safety, and security.

2.2.2.1 Public Transport Comfort Performance Indicators

The comfort of commuters during their transit is crucial, encompassing both the physical comfort of the vehicle and the environmental conditions at stops and on board. Research on bus comfort can be broadly classified into two groups. The first group examines vehicle performance and operational factors that affect passenger comfort, such as vibrations, acceleration, jerk magnitude, and vehicle noise (Castellanos & Fruett, 2014; Sekulić et al., 2013; Zhang et al., 2014) and the second group define comfort on board refers to features like clean and soft seating, pleasant temperature, minimal crowding, a smooth ride, and low levels of noise and vibrations, as well as the absence of unpleasant odor, and so on (Eboli & Mazzulla, 2012).

Another study (Bullard & Fitzgerald, 1981) revealed that various factors such as crowding, acceleration, temperature, and noise influence the comfort of public transit passengers. However, among these factors, in-vehicle crowding is the most significant determinant of comfort. Discomfort arises when the probability of getting a seat is less than 40% (Vovsha et al., 2014). Crowding can also cause anxiety, stress, and invade personal space, affecting passenger well-being and vehicle choices (Li & Hensher, 2011). Overall, passenger loads have a significant impact on the comfort level of transit trips in terms of the inability to get seats and the level of crowding within the vehicle(National Research Council (U.S.). Transportation Research Board., 2000).

The tradeoff between passenger comfort and transport loading factor is important for optimizing the loading process of a vehicle. Extreme passenger loading, also known as "Crush loads", can result in negative outcomes such as theft, discomfort, and harassment, making it crucial to mitigate such potential issues. Therefore, it is imperative to prioritize efficient and effective loading procedures to promote a safe and comfortable transport experience for all. Some study reveals that up to four passengers per square meter is acceptable (de Palma et al., 2015) . However, In Mumbai Suburban Railway during peak hours experience an extreme crowding by occupying 14 to 16 people per square meter.

(https://en.wikipedia.org/wiki/Mumbai_Suburban_Railway). This case is named as Super-Dense Crush loads. According to transit capacity and quality of service manual crush load is typically the load above 150 percent of a bus seating capacity (Transit Capacity and Quality of Service Manual: Part 2 Bus Transit Capacity Contents, 2013). After reviewing the available literature, it can be concluded that several factors contribute significantly to the overall comfort level of a transportation system. These factors include the degree of crowding, the availability and comfort of seating, the cleanliness of the environment, the level of in-vehicle noise, the availability of information, and the effectiveness of air conditioning. Therefore, for the purposes of this study, these factors have been selected as key indicators of comfort performance.

Public Transport Comfort Performance Evaluation Methods

An effective way to improve public transit service quality is by assessing the existing service quality. Among the various evaluation methods, the level of service (LOS) concept-based approach is commonly employed due to its practical effectiveness (Wang et al., 2022). However, transit comfort is often not considered in performance measures due to a lack of available data and the difficulty in quantifying many of the associated factors. To address this issue, the Transportation Research Board of the United States introduced the Transit Capacity and Quality of Service Manual (TCQSM), which includes the level of service concept and aims to account for transit comfort. (Tumlin & Walker, 2005) also try to fill these difficulties by define in their study separate level of service (LOS) indicators for frequency, span of service, loading, and travel speed. In addition, Highway capacity manual and Texas institute of transportation develops level of service analysis manual. In this study those level of service manual is used to evaluate a passenger density and in vehicle noise level respectively.

There are two common approach that is used to calculate in-vehicle passenger load level of service (LOS); these are: passengers per seat when a vehicle is designed mostly for seat and standing passenger per area, when a vehicle is designed to accommodate more standees than seated passenger (Eboli & Mazzulla, 2012).

Therefore, in this study passenger per seat level of service analysis standard value is adopted because the city transit system is designed mostly for seat.

$$Loading\ Factor = \frac{Number\ of\ carried\ passenger}{Avalable\ seat} \qquad \dots\dots\dots\dots\dots\dots \qquad Equation\ 2\text{-}1$$

Highway Capacity Manual Standard 2000

Table 2-2 In-vehicle Passenger load level of service (LOS)

LOS	Bus		Rail		Comments
	m^2/P	P/seat	m^2/P	P/seat	
A	>1.20	0.00-0.50	>1.85	0.00-0.50	No passenger need sit next to another
B	0.8-1.20	0.51-0.75	1.30-1.85	0.51-0.75	Passengers can choose where to sit
C	0.60-0.79	0.76-1.00	0.95-1.29	0.76-1.00	All passengers can sit
D	0.5-0.59	1.01-1.25	0.5-0.94	1.01-2.00	Comfortable loading for standees
E	0.40-0.49	1.26-1.50	0.30-0.49	2.01-3.00	Maximum schedule load
F	<0.40	>1.50	<0.30	>3.00	Crush load

Source: Highway Capacity Manual 2000

Passenger load level of service (LOS) for bus and rail is measured using square meters per passenger, but the ranges used to determine the LOS value differ. This is because the level of crowding that passengers will tolerate varies between the two modes of transportation. Rail modes typically provide more standing area than buses, resulting in different ranges for LOS values(National Research Council (U.S.). Transportation Research Board., 2000).

Texas Transportation Institute Level of Service Manual

Given the absence of specific guidelines or regulations regarding in-vehicle noise level limitations in our country, it is both reasonable and necessary to draw upon a guidance document from another country.

Considering this, the present study employs the Texas Institute of Transportation Level of Service Analysis Manual as a valuable resource for analyzing in-vehicle noise levels. Although originating from a different country, this guidance document provides a comprehensive framework that is applicable to this research objectives and offers a standardized approach to evaluating and understanding vehicle noise. By utilizing this resource, the study aims to fill the regulatory gap in our country and ensure a rigorous assessment of in-vehicle noise levels within the context of this research. Noise is defined as loud, discordant, or disagreeable sounds experienced by passengers while inside the transit vehicle (Bullard & Fitzgerald, 1981). Texas Transportation institute are presented in vehicle noise level as follow.

Table 2-3 In-vehicle noise level of service (LOS)

LOS	Noise(db)
A	Less than 60
B	61 -75
C	76-85
D	86-90
E	91-95
F	More than 95

Source: Texas Transportation Institute Manual

Note "System rated LOS F if noise in vehicle is over 95 dB; 100 dB+ for l hours/day can cause permanent hearing loss." The best audible frequencies are those between 1,000 and 4,000 hertz (MICHTA & HANISZEWSKI, 2018).

2.2.2.2 Public Transport Affordability Performance Indicators

The affordability of transportation services refers to the financial cost incurred by travelers when using them. It is influenced by various factors such as travel demand and supply, government funding, cost of living, competitiveness, quality, and transportation costs (Mohammed & Senadheera, 2022). Moreover, the type of transit service provided has an impact on affordability. The affordability of public transit fares is determined by several factors, including the monetary expense of a bus trip (such as the cost of a one-way ride and transfer fees), the availability of discounted fares for certain groups (like students), the availability of volume discounts (such as monthly passes), and the cost of parking at bus stops (Eboli & Mazzulla, 2012) .

In developed countries, the fare aspect of public transportation is considered a significant factor in the decision of which mode of transportation to use. While some studies argue that cost is not a major factor in choosing transportation modes, others, like (Beirão & Sarsfield Cabral, 2007) claim that although public transportation is generally seen as cheaper than driving, the cost is crucial for low-income public transportation users. Additionally, (Redman et al., 2013) revealed that while service reliability and frequency are important in attracting car users to public transportation, reducing fares can also entice car users to try public transportation initially.

The cost of transportation, or fare, is a clear indicator of affordability, with lower fares making for more affordable trips. However, travel time can also play a role in determining affordability, as longer travel times can be less attractive to travelers, particularly if it interferes with work or other commitments. By considering both fare and travel time as indicators of affordability, a more complete understanding of the affordability of different transportation options can be obtained. Several research studies have examined both fare and travel time as indicators of affordability performance. For instance, in Melbourne, Australia, and Delhi, India, researchers incorporated both fare and travel time as affordability performance indicators.

The results of these studies revealed that, in general, rail systems in Melbourne and metro systems in Delhi were less affordable than bus systems in terms of both fare and travel time. These findings underscore the critical role that fare and travel time play in determining the affordability of public transport systems, and emphasize the need to consider these factors when designing and improving such systems.

In general, this study also suggests that both fare and travel time can be useful indicators of public transport affordability and should be considered together when assessing the affordability of different transportation options.

Public Transport Affordability Performance Evaluation Methods

When evaluating the affordability of public transport, it is essential to approach the subject from a multifaceted perspective, taking into account a range of factors including transport expenses and population income. In the academic literature, there are two overarching categories for measuring public transport affordability. The first category, referred to as observed affordability measures, centers on examining the daily transportation costs incurred by individuals. On the other hand, the second category of affordability measures examines the estimated number of trips required for individuals to fulfill their fundamental requirements (Falavigna & Hernandez, 2016). Armstrong has developed a comprehensive framework to determine the affordability of public transport. According to his methodology, affordability is measured by analyzing the monthly expenditure on public transport and comparing it with the average income of the population. To ensure that public transport is affordable, the cost should ideally fall within a certain range, typically between 2-5% of the average income. However, if the cost exceeds 10%, it is considered to be unaffordable, which may limit access to essential transit services. The Armstrong's approach provides a valuable tool for policymakers and transportation planners to assess the affordability of public transport and make informed decisions to improve access and equity in transportation (Armstrong-Wright & Thiriez, 1987).

2.2.2.3   Public Transport Safety Performance Indicators

The concept of safety is closely linked to the level of protection against accidents or incidents, especially within the realm of transportation (Eboli & Mazzulla, 2012). It is a critical factor in marketing mass transit systems and building passenger confidence in their ability to provide safe transportation. To achieve this, every aspect of the transit system, including its services, equipment, and facilities, must be designed with safety in mind. This requires the incorporation of safety equipment such as seat belts, as well as the employment of skilled drivers who are well-versed in safety protocols (Priyanto & Romadhona, 2009). To maintain a safe operation of the transit system, it is crucial to regularly assess its performance by employing suitable indicators that can effectively monitor safety performance.

There are two types of Safety Performance Indicators (SPIs): leading SPIs and lagging SPIs. Leading indicators are proactive and help monitor progress towards a desired state, while Lagging SPIs are reactive and used to measure past performance (T - Federal Transit Administration, 2019). The common example of lagging indicator is accidents and injuries and examples of leading indicators include safety audits, availability of safety equipment, and number of safety interviews, number of educations per month. Therefore, the use of both leading and lagging indicators can indicate cause and effect pathways (Priyanto & Romadhona, 2009).

Public Transport safety Performance Evaluation Methods

Public transport safety performance indicators are used to assess the safety of public transport systems, identify areas for improvement, and measure progress towards safety goals. Here are some commonly used safety performance indicators (SPIs):

- Accident rate: This measures the number of accidents per million passenger journeys.

- Fatality rate: This measures the number of passenger fatalities per million passenger journeys. This includes all fatalities resulting from accidents and other incidents.

- Injury rate: This measures the number of injuries per million passenger journeys. This includes all injuries, including minor injuries that occur on public transport.

- Near-miss rate: This measures the number of incidents that are close to causing an accident per million passenger journeys. This includes incidents such as sudden stops, equipment failures, and other incidents that could have resulted in an accident.

- Customer satisfaction: This measures the level of satisfaction among passengers with the safety of the public transport system. This can be measured through surveys and feedback mechanisms.

- Response time: these measures the time it takes for emergency services to respond to incidents on public transport.

These indicators have been identified and recommended by International Association of Public Transport (UITP), the World Bank, The US Department of Transportation (DOT), and the National safety plan. For instance, National safety plan categorizes of safety performance indicators (SPIs) as fatalities, injuries, safety events (e.g., fires, derailments) and system reliability (i.e., mean distance between failures by mode). Based on these categories the Central Mississippi Planning and Development District has been establishing safety performance targets to address the safety performance measures identified in the National Public Transportation Agency Safety Plan. Public transportation providers, State Departments of Transportation (DOTs), and Metropolitan Planning Organizations (MPOs) have established seven safety performance targets for four safety performance measures, including the total number of reportable fatalities and injuries by mode, the rate of reportable fatalities and injuries per total Vehicle Revenue Miles (VRM) (in 100 thousand VRM) by mode, the total number and rate of reportable safety events per total Vehicle Revenue Miles (VRM) (in 100 thousand VRM) by mode, and the mean distance between major mechanical failures by mode, also known as system reliability.

(Source:http://cmpdd.org/transportation/performance-management/transit-safety-performance-management/.

To establish a dependable and trustworthy transit system that can effectively and securely transport passengers to their intended destinations, it is imperative to prioritize safety above all else. One of the key safety performance indicators utilized in this study is the total number of fatalities and injuries by mode. By monitoring these measures, transit operators and governing bodies can pinpoint areas in need of improvement and implement measures to enhance the safety of public transportation systems. Overall, prioritizing safety is crucial for creating a transit system that is both efficient and dependable.

2.2.2.4 Public Transport Security Performance Indicators

As stated in the Transportation Research Board, the European Commission has proposed a hierarchy of quality determinants in public transportation in Europe. This hierarchy includes multiple categories, and safety and security are among them. (JOEWONO & KUBOTA, 2006). The hierarchy define security as the actual degree of safety from crime or accidents and the feeling of security resulting from that and other psychological factors. The security class consists of three aspects, first; Safety from crime which includes, Staff/police presence; lighting; visible monitoring; layout; identified help points; secondly, Safety from accidents: Presence/visibility of supports; avoidance/visibility of hazards; active safeguarding by staff; and thirdly, Perceptions of security: Conspicuousness of safety measures; "mastery of network"; press relations. From this, safety from crime is considered as security aspect. Therefore, to evaluate and identify where improvements can be done, security performance indicators are selected. Some potential indicators are presented as follow:

- Crime statistics: The number of crimes reported on public transport, such as theft, assault, and vandalism, can be tracked over time to identify trends.
- Passenger feedback: Surveys or other forms of feedback from passengers can provide valuable insights into their perceptions of security on public transport.
- Response time: The time it takes for security personnel or law enforcement to respond to an incident on public transport.

- Security incidents: The number of security incidents, such as bomb threats.

- Compliance: The percentage of passengers who comply with security protocols,

- Training and preparedness: The number of security personnel who have undergone training and the level of preparedness of public transport operators to respond to security incidents can be tracked and used to assess the effectiveness of security measures.

- CCTV coverage: The extent and quality of CCTV coverage on public transport can be tracked and used to assess the effectiveness of surveillance measures.

These indicators have been identified and recommended by several esteemed transportation and security organizations, including The European Conference of Ministers of Transport (ECMT), The International Association of Public Transport (UITP), The US Department of Transportation (DOT), The American Public Transportation Association (APTA), and The Transportation Security Administration (TSA). These organizations have collaborated to provide a comprehensive set of indicators that can be used to develop a performance framework to evaluate the effectiveness of public transport security measures. By utilizing these indicators, transportation stakeholders can identify areas where improvements can be made to enhance the security of public transport systems.

2.3   Mode Choice Behavior

Mode choice behavior is a complex decision-making process where individuals select a transportation mode for a specific trip. This process is influenced by various factors such as trip purpose, distance, travel time, cost, comfort, and convenience (Paulley et al., 2006). Socio-economic and personal factors such as perception, personality, social norms, and propensity are also playing a crucial role in the decision-making process (Bamberg & Schmidt, 2003; Lanken et al., 1994; Tertoolen et al., 1998). Overall, people's preferences for public transport mode choice are influenced by a complex interplay of factors and can vary depending on the individual and their specific circumstances.

Many studies were performed throughout the world to identify the impact of many variables of mode choice preference decision and try to answer how those variables affect the decisions. A study published in the Journal of Transport Geography in 2018 examined the factors that influence the choice of public transportation in the city of Tehran, Iran. The study found that age, income, and trip purpose were significant predictors of public transportation choice, with younger people, lower-income individuals, and those traveling for work or education more likely to use affordable mode of public transportation. The study also found that safety and comfort were important factors in public transportation choice (Nadimi, R, 2018).

Another study published in the Journal of Transport Economics and Policy in 2018 also examined the factors that influence the choice of public transportation in the city of Jakarta, Indonesia. The study found that age, gender, education level, and trip purpose were significant predictors of public transportation choice, with older people, women, those with higher education levels, and those traveling for work or education more likely to use safe and secured public transportation. The study also found that affordability was an important factor in public transportation choice. (Susilo, Y. O., Widodo, T., & Joewono, T. B. (2018).

In general, understanding commuter preferences regarding transit service aspects is crucial for improving the quality of public transport. This understanding is essential for providing increased convenience and a better service environment to transit users, ultimately enhancing the attractiveness of public transport and increasing its mode share (Chen & Li, 2017).

2.4 Empirical Review

Many studies related to urban transport in general, and public transport in particular, have been conducted in different regions, either concentrating on the specific attributes and performances of the system, or the general system-level evaluations. For instance, one of the studies conducted in turkey Istanbul by Imre and Çelebi (2017) entitles with "Measuring Comfort in Public Transport: A case study for İstanbul aimed to better define and measure

comfort in public transport. They introduced a new index based on qualitative and quantitative indicators to assess comfort and addressed the issue of invalid load factor ratios due to the removal of seats in many vehicles. The study also stated that comfort is one of the most important determinants of public transport. The study was conducted on BRT, M2 Metro, and T1 Tram lines, and the data was collected through questionnaire consisting of matrices of comfort factors to collect the pair-wise comparison judgments. The study finally gets priority weights for comfort determinants are crowdedness, Air-conditioning, In-vehicle information and guidance, in-vehicle cleanness and Seat comfort in decreasing order (Imre & Çelebi, 2017).

Rahman et al. also conducted a study in 2018 to compare the comfort levels of different transportation modes in Dhaka, Bangladesh. The study was designed to provide a comprehensive understanding of the comfort factors that influence commuters' experiences while using different modes of transportation in the city. To achieve this objective, the researchers utilized a combination of subjective and mechanical approaches to collect data on four comfort factors: speed, temperature, noise, and jerking. The mechanical data were collected using an Arduino micro-controller along with various sensors, while the subjective data was collected through a custom-built Android app questionnaire. The results of the study, obtained through one-way analysis of variance (ANOVA), revealed that private cars were the most comfortable mode of transportation, followed by AC buses, rickshaws, and autos. (Rahman et al., 2018)

According to a study conducted in Tehran by Ebrahimi and Bridgelall in 2021, a decision-based model with uncertainty was employed to identify factors that influence mode choice and to rank their attractiveness to riders of public transit modes in the city. The study revealed that the most influential service attribute for mode choice was safety, followed by reliability, frequency, comfort, travel cost, information provision, and accessibility, in descending order of importance. The findings of the study indicate that the subway system exhibited the highest level of passenger attraction potential, followed by ride-hailing services, bus rapid transit, vans and taxis, and finally public bus services.(Ebrahimi & Bridgelall, 2021).

However, it is important to note that while studies have been conducted on transit performance in various parts of the world, they have been limited in scope, only focusing on a few cities, variables, and mass transit modes. As a result, there is a pressing need to conduct further studies in more cities, including Addis Ababa, to aid in the development of transit performance. Furthermore, in Addis Ababa, there has been a lack of research into the comparative performance evaluation of various modes of public transport, despite it being critical for policymakers to make informed decisions. Therefore, this study aims to address this gap by conducting a thorough performance evaluation and comparison of the five groups of public transport in Addis Ababa, while also identifying how these variables are prioritized by passengers' when they consider a mode choice preference.

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the systematic approaches for gathering and examining data that are pertinent to the research questions. It outlines the research design, study location, sample and sampling methods, data collection procedures, and data analysis techniques. More information about each of these aspects is provided in the following sections.

3.2 Study Area

Addis Ababa was selected as the study area due to its status as a public transport-dependent city. With a population of 2,738,248 according to the 2007 national census, comprising 52.4% females and 47.6% males, the city boasts an impressive array of public transportation options, including light rail transit, which distinguishes it from other cities in Ethiopia.

This study focuses on five modes of transportation in Addis Ababa, namely minibus taxis, midi-buses, Anbesa city buses, public service transport buses, and Sheger buses. These modes of transportation represent significant modal shares within the city, with minibus taxis accounting for 88.3%, midi-buses comprising 2.4%, and Anbesa city buses representing 3.8%, according to the Addis Ababa Traffic Management Agency report. Additionally, Addis Ababa's heavy reliance on public transportation makes it an ideal location for examining various transportation modes.
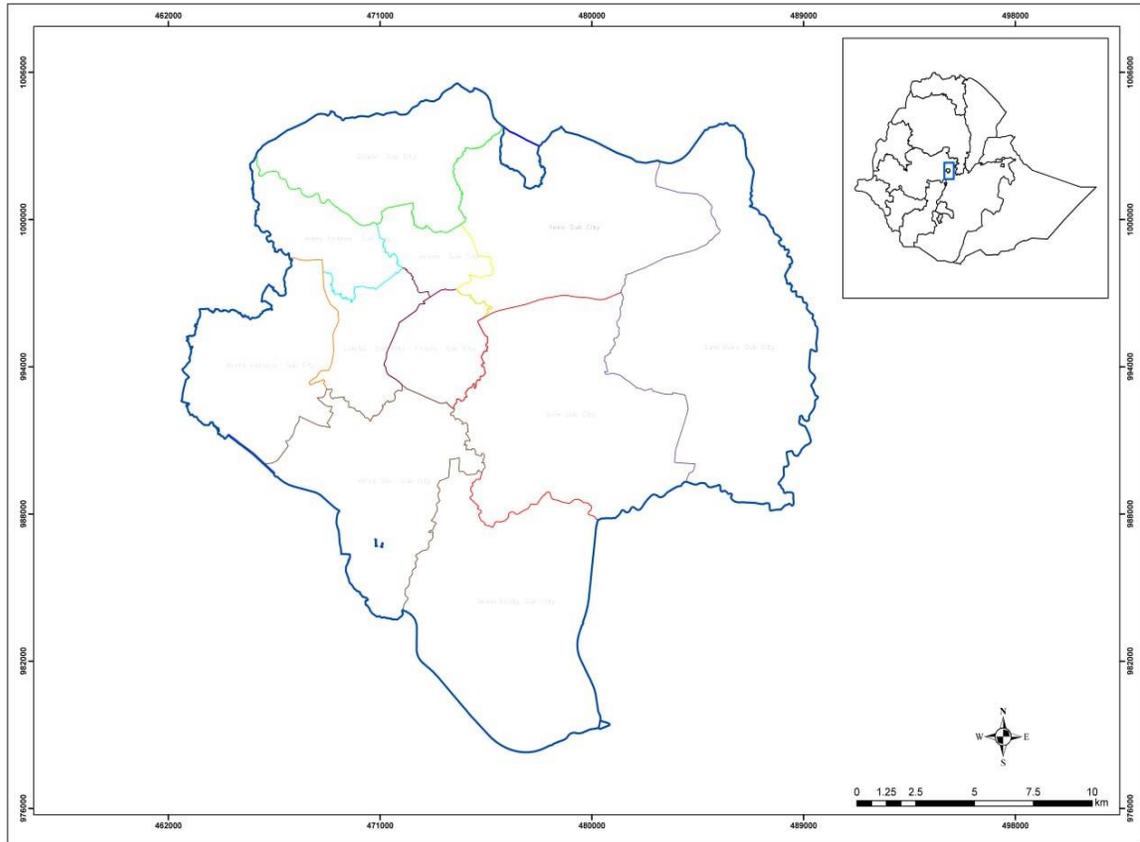
Figure 3-1 Study area

Source: Addis Ababa Plan and Development Commission

3.3 Research Design

This study employed a combination of analytical and observational methods to evaluate the performance of public transport in Addis Ababa and prioritize commuters' transit service aspect preferences. The analytical approach involved utilizing analysis of variance and multinomial logistic regression techniques. These statistical methods were employed to compare the performance of different modes of transport and analyze the relationship between commuters' mode choice preferences and various independent variables, including demographics and trip characteristics.

3.4   Target Population

In research, the term "study population" refers to a specific group of individuals who meet certain criteria and are selected for the purpose of conducting research. The researcher typically focuses on specific characteristics or traits shared by this group, with the aim of generalizing the study results to this particular population. Consequently, in this M.Sc. thesis, the study population comprises individuals who primarily rely on public transportation as their primary mode of transportation in Addis Ababa.

3.5   Sampling Method

Various techniques have been proposed in the literature for selecting individuals to gather information, including purposive sampling, random sampling, and quota sampling (Singh et al., 2014). In this investigation, the simple random sampling method was employed. This method was preferred because it offers an equal chance for every unit in the population to be selected, leading to unbiased and accurate parameter estimates. Additionally, the population is considered homogeneous. Therefore, individuals present at the public transport station and with experience using the selected mode of transport were randomly selected for the investigation.

3.6   Sample Size

The estimation of sample size for a study is essential as it ensures that the sample is neither unnecessarily large, which can be unethical, nor too small, which can lead to unscientific results (Andrade, 2020). Different statistical equations can be used to calculate the necessary sample size, taking into account assumptions such as expected means, standard deviations, event risks in different groups, or expected effect sizes. In this study, the formula developed by Cochran is utilized due to the large population size (Zhang, 2015).

The minimum sample size required for accuracy in estimating proportions by considering the standard normal deviation set at 95% of confidence level (z=1.96), a sample proportion of 50% (p=0.5) a margin of error 5% (e=±0.05).

$$n = z^2 * \frac{pq}{e2} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots Equation\ 3\text{-}1$$

Where:

n= sample size

z=z-score

e=margin of error

p=standard of deviation

$$sample\ size = 1.96^2 \times \frac{0.5 \times 0.5}{0.05^2}$$

$$=384.16$$

The study required a sample size of 400, which was considered sufficient. However, to ensure that the respondents had used all five modes of public transportation and had a comprehensive understanding of them, 626 questionnaires were distributed. Out of these, 400 participants rated all means of transport properly.

3.7 Study Variables

In this study, the evaluation of public transport performance in Addis Ababa focused on several dependent and independent variables. These variables encompassed measures of comfort, affordability, safety, and security to comprehensively assess the effectiveness of the public transport system.

3.7.1 Dependent Variable

This study primarily focuses on the performance of public transportation modes, which is measured by unobserved variables such as transit comfort, affordability, safety, and security. These variables are important factors that influence passengers' willingness to use public transportation. To evaluate these variables, the study utilizes a combination of subjective measures (passenger perceptions) and objective measures obtained through various methods. This approach aims to assess the effectiveness of efforts made by the public transportation sector to enhance the comfort, affordability, safety, and security of mass transit facilities and services.

3.7.2 Independent Variables

In this study, a set of sixteen indicator variables have been chosen to examine transit performance. These factors have been selected based on various sources, such as literature, field observation, and passenger feedback, to ensure the most accurate and relevant findings. To facilitate a more organized and meaningful analysis, these indicators have been grouped together based on the results of a factor analysis. The primary objective of the factor analysis was to identify the underlying factors (latent variable) that are responsible for the observed variables and to validate whether these indicators are accurately categorized in the context of the study area.

Table 3-1 Comfort, Affordability, Safety and Security Performance Indicators

Criteria	Description
Comfort (C)	
C1 Cleanliness of Vehicle	Cleanliness of Vehicle
C2 Availability of Seats	Probability of getting Seats
C3 Seats Comfort	Availability of enough space for leg movement
C4 Sound level	Sound level in the transport service

C5	In-vehicle trip information	Announcement of next stops using screens or audio
C6	Air conditioning on the system	Ventilation and temperature
C7	Crowded the vehicle	Available space for each traveler

Safety(S1) and Security(S2)		
S11	Driving behaviour	Erratic driving like, weaving, swerving, speeding, driving too slowly, and other situations
S12	Seat belt and Anchored seating	Availability of proper seat belt
S13	Safety precautions	In the case of Accident
S14	Door closing' signals	Lit before doors begin to close
S21	Availability of Security staff	The presence of police
S22	Availability of security products	Like CCTV or other surveillance system
S23	Not afraid of being any victim	Not afraid of being pickpocket

Affordability(F)		
F1	Transport price affordability	Tickets cost
F2	Travel Time	Non-monetary costs can include time spent traveling

3.8 Data Source

3.8.1 Primary Data Sources

The study draws upon a set of primary data comprising commuter demographic and socioeconomic data, alongside performance metrics of the chosen public transportation mode. A summary of the required primary data and their corresponding sources is provided in the table below.

Table 3-2 Primary data sources

No	Data type	Source
1	In vehicle Passenger load	Transit stops counting
2	In vehicle sound level	Measure at respective route segment
3	Performance of public transport in terms of study element from passenger perspective	Collected through questionnaire
4	Commuter demographic and trip related data	Collected through questionnaire

3.8.2 Secondary Data Sources

Despite the heavy emphasis on primary data collection, in this study secondary data including crash data and public transport tariffs have been gathered. The table below gives a summary.

Table 3-3 Secondary data sources

No	Data type	Source
1	Crash report data	Addis Ababa Traffic management agency
2	Operational characteristics of the public transports in Addis Ababa for instance, its respective tariff, Type and number	Addis Ababa transport bureau, Anbesa City Bus, Sheger Bus
3	Different published books, article etc.	Academic journals, Online library databases,

Operational Characteristics

The study gathered data on five distinct public transportation modes, namely minibus-taxis, midi-buses, public service buses, Anbesa buses, and Sheger buses. The data was collected from the Addis Ababa Transport Bureau.

Minibus (Taxi)

The minibus is one of the public transport modes on which most of the city's residents are highly dependent. A minibus has a capacity of holding 12 to 16 people per vehicle. According to the Addis Ababa transport bureau, more than 7,500 registered taxis are found. In this study, taxis are being treated as a homogeneous group, disregarding any variations in their vehicular age, capacity, or other operational characteristics, to ensure a consistent and uniform analysis.

Figure 3-2 Minibus taxi

(Source: Alamy Stock Photo)

The Addis Ababa Transport Bureau has the mandate to set respective transport fees. The following table presents the fare charges of minibus taxis in Addis Ababa in April 2022.

Table 3-4 Fare Charge of Minibus

Distance in Km	Tariff
Up to 2.5 Km	3 Birr
2.6 to 5 km	5.5 Birr
5.1 to 7.5km	8.5 Birr
7.6 to 10km	11 Birr
10.1 to 12.5km	14 Birr
12.6 to 15km	17 Birr
15.1 to 17.5km	19.5 Birr
17.6 to 20km	22.5 Birr
20.1 to 22.5km	25 Birr
22.6 to 25km	28 Birr
25.1 to 27.5km	31 Birr
27.6 to 30km	33.5Birr

Source: Addis Ababa Transport Bureau, April 2022

Midi-bus

A midi bus has a capacity of up to 37 passengers, with 22 to 27 passengers seated and up to 10 passengers standing. The most common midi bus in the city is the Higer bus, with a total capacity of 37 passengers, with 27 passengers seating and 10 standing, as shown in the figure below.

Figure 3-3 Midi bus (Higer bus)

(Source: Alamy Stock Photo)

The Addis Ababa Transport Bureau has reported that the city currently has a total of over 780 registered midi buses operating on more than 300 service routes. As the bureau is responsible for determining the transport tariff, the specific tariff for midi-buses is presented in the table below (Tagagne & Ababa, 2018).

Table 3-5 Fare Charge for Midi bus

Distance in Km	Tariff
Up to 8 Km	4.5Birr
8.001 to 12 km	6.5 Birr
12.001 to 16 km	8.5 Birr
16.001 to 20km	10.5 Birr
20.001 to 24km	13 Birr
24.001 to 28km	15 Birr

Source: Addis Ababa Transport Bureau, April 2022

Public Service Employees Transport Service Enterprise (PSETSE)

The purpose of this service is to facilitate convenient commuting for public servants between their residences and workplaces, thereby reducing traffic congestion and promoting efficiency.

Additionally, the bus also offers transportation services to commuters throughout the day, contributing to the overall mobility of the city. Each PSETSE bus is equipped with 60 seats and 20 standing spaces, allowing for the transportation of a significant number of passengers at any given time.

As reported by the Addis Ababa Transport Bureau, there are currently 125 registered PSETSE buses operating in the city, highlighting the popularity and significance of this service. Notably, the PSETSE transport tariff is identical to that of the midi bus, which is detailed in Table 3.5, providing an affordable and easily accessible transportation option for all passengers.

Figure 3-4 Public Service Bus (PSETSE)

(Source: Alamy Stock Photo)

Anbesa city Bus Service Enterprise (ACBSE)

Anbesa City Bus Service Enterprise is a transportation provider that serves the public and is government-owned and operated by the Addis Ababa City Administration. The company has been established in 1935, it is the first public transport company in Addis Ababa. Presently, the enterprise boasts 560 registered city buses that run on over 125 routes, primarily focused on connecting the city's central business and commercial areas.

The company internally manages the bus route and scheduling plan. Anbesa City Bus Service Enterprise operates three bus models: the low-floor bus, which can accommodate 70 passengers with 42 seats and 28 standees, the mid-floor bus, which can transport 70 passengers with 35 seats and 35 standees, and the double-deck bus, which can carry 95 passengers with 70 seats and 25 standees.

Figure 3-5 Anbesa City Bus (ACBE)

(Source: Alamy Stock Photo)

The Anbesa City Bus Service Enterprise has implemented a tariff system that takes into consideration the distance between the origin and destination place names. However, to conduct a thorough comparison from other modes the available data, the tariff system was converted into distance-based tariffs by the researcher, using the data presented in Appendix F as a reference. To achieve this, the researcher employed regression analysis. This analytical technique allowed the prediction of the price variable based on the distance variable, thereby enabling the creation of the model, Anbesa City Bus Service Enterprise is able to offer its passengers a fair and cost-effective pricing system that takes into account the actual distance traveled.
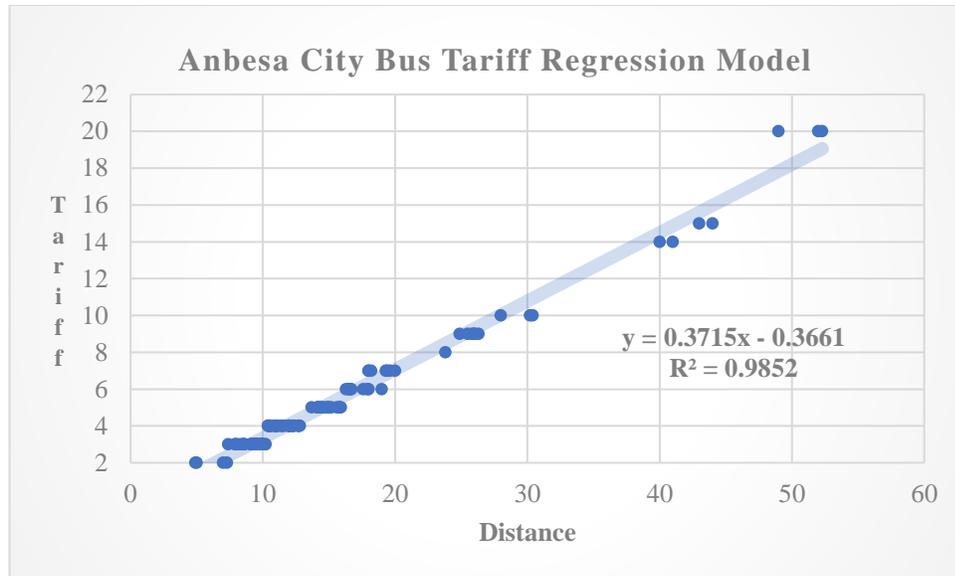
Figure 3-6 Anbesa City Bus Tariff Regression Model

Source: Researcher Survey Analysis Result

From the above regression analysis result

Tariff (In Birr) = 0.3715(distance in Kilometer) - 0.3661

R^2 = 0.9852

Sheger Mass Transport Enterprise (SMTE)

The Sheger Mass Transport Enterprise (SMTE) was officially established on May 27, 2016, through a regulatory framework as a public enterprise under the jurisdiction of the Addis Ababa city government. Presently, the enterprise operates as a major player in the public transportation industry of the city. As per the records of the Addis Ababa Transport Bureau, SMTE possesses a fleet of 330 registered Sheger buses, servicing commuters across 94 different routes within the city of Addis Ababa.

Figure 3-7 Sheger Mass Transport Enterprise (SMTE) bus

(Source: Alamy Stock Photo)

Table 3-6 Fare Charge of Sheger Bus

Distance in Km	Tariff	Approximate tariff
Up to 4 Km	1.5 Birr	2 Birr
4.1 to 6 km	2 Birr	2 Birr
6.1 to 8 km	2.5 Birr	3 Birr
8.1 to 9 km	3 Birr	3 Birr
9.1 to 10 km	3.5 Birr	3 Birr
10.1 to 12km	4 Birr	4 Birr
12.1 to 13km	4.5Birr	4 Birr
13.1 to 15 km	5 Birr	5 Birr
15.1 to 17km	6 Birr	6 Birr
17.1 to 20km	7 Birr	7 Birr
20.1 to 23km	8 Birr	8 Birr
23.1 to 26km	9 Birr	9 Birr
26.1 to 30 Km	10 Birr	10 Birr
30.1 to 35Km	12 Birr	12 Birr

Source: Sheger Mass Transport Enterprise Main Office, April 2022

3.9   Data Collection Tools

The study incorporated field measured data, a questionnaire and other secondary data. For the field-measured data, in-vehicle passenger counting and sound measuring were conducted on a selected road segment where all modes of public transport operated together. The Megenagna to Piazza and Sheromeda to Mexico route segments were specifically chosen to accommodate buses, minibus taxis, midi buses, public service transport service, Anbesa city buses, and Sheger buses. Figures 3.8 and 3.9 depict the common road segments where all modes of public transport coexist.

In the first road segment, a comprehensive monitoring approach was employed, including the collection of passengers loading data at key bus stop stations such as Megenagna, Shola, Arat Kilo, and Piazza. In-vehicle sound measurements were taken between consecutive stop stations to gain insights into noise levels along the route. Specifically, sound measurements were captured between Megenagna and Shola, Shola and Arat kilo, and between Arat kilo and Piazza.
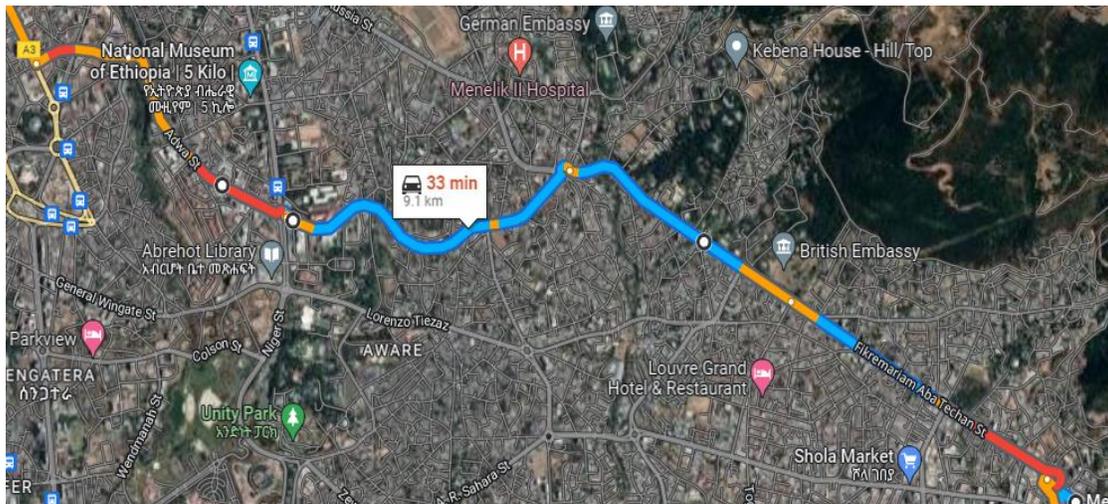
Figure 3-8 Route Segment One (Megenagna to Piasa Via Arat kilo)
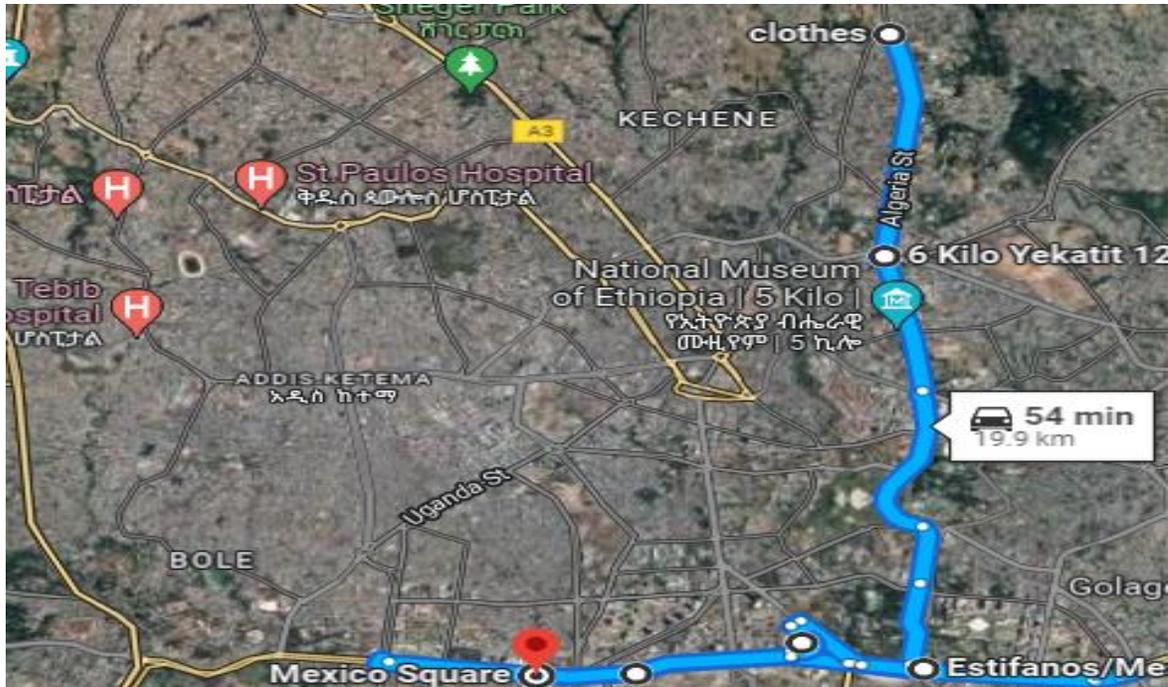
Figure 3-9 Route Segment Two (Mexico to Sheromeda)

Similarly, for the second road segment, passenger loading data is gathered at several locations, including Mexico, Estifanos, Stadium, Arat kilo, Sedest kilos, and Sheromeda. To fully assess the acoustic environment, sound measurements are taken between each of these stops, allowing for a comprehensive analysis of the noise levels along the route. These measurements are taken between Mexico and Estifanos, Estifanos and Stadium, Stadium and Arat kilo, Arat kilo and Sedeset kilo, and between Sedest kilo and Sheromeda.

In- vehicle sound level was measured by using an android app and calibrated the results with the EXTECH 407730 sound level meter. To simulate the experience of a passenger, the device was placed on the seat in the front cabin of each vehicle during five measuring rounds for each selected route. The testing was conducted in Addis Ababa during the morning rush hour, between 7 a.m. and 9 a.m., with a maximum vehicle speed of 20 km/h. In addition, the study also analyzed the travel time of each public transport route. Data collection was conducted from April 5, 2022, to June 17, 2022.
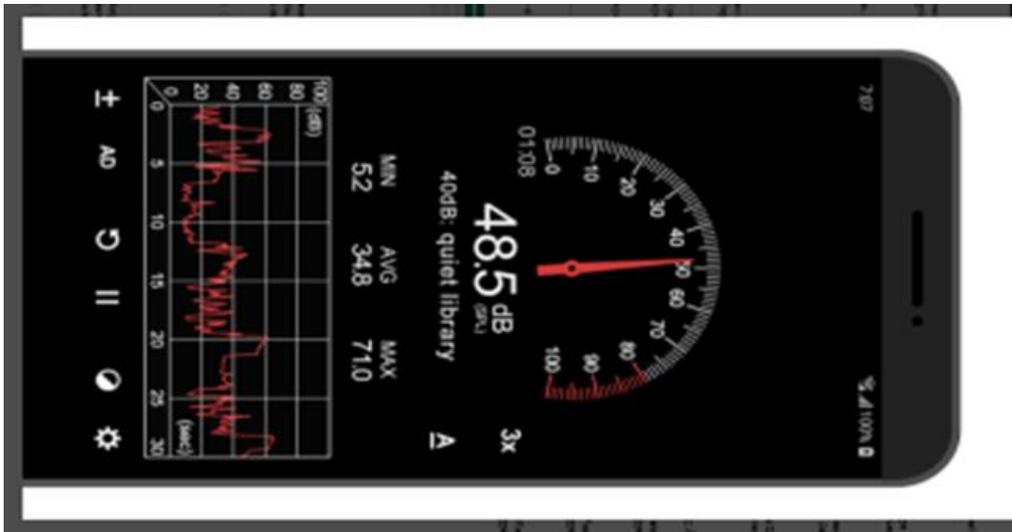
Figure 3-10 Sound Meter Android Application

Figure 3-11 Sound Level Meter EXTECH 407730

Questionnaires' Development

The questionnaire comprised of four distinct sections aimed at gathering comprehensive data. The first section focused on socio-demographic characteristics, such as gender, age, marital status, monthly household income, and education level. The second section delved into trip-maker characteristics, including frequently used mode and trip expenses. Section three consisted of five-point Likert items that allowed passengers to rate the performance of public transport modes based on comfort, affordability, safety, and security performance indicators.

The Likert scale measurement ranged from poor (1) to excellent (5). The final section inquired about the variable factors that affect mode choice preference, such as the mode chosen, reasons for avoiding certain modes, and prioritization of factors when selecting a transport mode. The questionnaire is attached in the **Appendices Part A: Questionnaire.**

3.10 Validity and Reliability

3.10.1 Validity check

Validity refers to the extent to which a study effectively measures the specific concept that the researcher intends to assess, the precision of the analysis of the findings, and the extent to which the conclusions can be generalized (Ghauri & Gronhaug, 2002). According to the authors, validity in terms of questionnaire refers to the ability of the instrument to measure what was intended to measure. Among the different types of validity, content validity is one of the types which show whether the investigated questions are covered by the instrument or not. Before distributing the questionnaire, a pilot study was conducted, which involved presenting the questionnaire to an advisor with expertise in the subject area to gather feedback and to the target participants. The questions are also used by other researchers in public performance evaluation studies. To test the content validity, the questionnaire was distributed by attaching it with the objective and research questions to experienced professionals who are currently working on the transportation sector. After that, the questionnaire was modified based on the received comments and distributed to the targeted populations.

3.10.2 Reliability Check

Cranach's alpha coefficient (α coefficient) was used to test the questionnaire's reliability and determine whether the measurement items are highly consistent with the variables. When the value is 0.7, the consistency and reliability are considered high; when the value is between 0.5 and 0.7, the consistency and reliability are considered acceptable; and when the value is less than 0.5, the consistency and reliability are considered low.

The following table shows the sample reliability test results for the Cronbach's alpha (coefficient) value of the questions.

Table 3-7 Sample Reliability Check Result

Modes	Question 1	Question 2	Question 3
Taxi	0.895	0.900	0.893
Midi bus	0.903	0.844	0.873
Public Service Bus	0.889	0.864	0.863
Anbesa City Bus	0.883	0.894	0.835
Sheger Bus	0.899	0.883	0.843

Source: Researcher own survey result

The above table Cronbach's alpha (α) value indicating that the variables had good internal consistency.

3.11   Data Analysis Methods

Different analytical techniques were used based on the type and importance of the data. Subjective data collected through questionnaires and objective data obtained through counting, measuring, and secondary sources were analyzed using various methods. Table 3.8 presents the required data and the analysis methods employed.

Table 3-8 Performance Evaluation Analysis Tools

No	Required data	Applied on	Analysis method
1	In-vehicle Passenger loading	Transit stops	HCM 2000
2	In vehicle sound level	Route segments	Texas Transportation institute
3.	Passenger perspective performance of public transport	Passengers	ANOVA (statistical analysis tool)

| 4 | Crash data | Vehicle | Crash incident computation formula (section 2.3.2.3 in chapter two) |
| 5 | Demographic and trip maker characteristics | Commuter | Multinomial logistic regression model |

Source: Summarized by Researcher

3.11.1 Subjective Data Analysis

To accurately assess the construct validity, identify patterns and relationships, and reduce data complexity, it is necessary to categorize the indicators affecting the selected study element into their respective latent variables using a statistical technique, despite their already established justification in the literature. To achieve this, the method of factor analysis was utilized. This approach helps to reveal underlying latent variables that explain the correlations between observed variables (indicators).

In Exploratory Factor Analysis (EFA), eigenvalues are used to determine the number of factors to retain. An eigenvalue represents the amount of variance explained by each factor extracted from the data. Typically, in EFA, factors with eigenvalues greater than one are retained, as they account for more variance than would be expected by chance alone. The factor analysis results for each mode of public transport can be found in **Appendices Part D: Factor Analysis**, while the categorized indicators were presented in **Table *3-1* Comfort, Affordability, Safety and Security Performance Indicators.**

To calculate the overall performance value for each mode, the study utilized the average value of the comfort, affordability, safety, and security variables. It was considered important to include participants' experience with all means of transport for a comprehensive comparison of mode performance and to minimize biases. Therefore, a subset of 400 participants was used specifically for performance analysis and commuter mode preference decision.

By employing this approach, the study aimed to provide a thorough evaluation of mode performance while considering sufficient sample size and minimizing potential biases in the analysis.

Statistical Analysis Tool Selection

There are two types of statistical tests: parametric tests and non-parametric tests. Parametric tests rely on specific assumptions, including normal distribution of data, independence of observations, equal variance across groups, and random sampling from the population. In contrast, non-parametric tests do not make these assumptions. To assess whether the data follows a normal distribution, various methods can be used. Graphical methods, such as histograms or normal probability plots, provide visual representations of the data's distribution. Statistical tests, such as the Shapiro-Wilk test or the Kolmogorov-Smirnov test, can be applied to examine the normality of the data. Skewness and kurtosis values also offer insights into the shape of the data distribution.

The skewness coefficient indicates symmetry of the distribution, with values between -1 and 1 suggesting approximately symmetric distribution, whereas a kurtosis value of 3 indicates a normal distribution. Regarding to the Shapiro-Wilk test or the Kolmogorov-Smirnov test, p- value should be greater than significant level. If the data is not normally distributed, it may be transformed to achieve normality, or non-parametric tests can be used instead.

It is generally desirable for skewness and kurtosis measures in statistical software programs like SPSS to be as close to zero as possible. However, data often exhibits skewness and kurtosis. As long as the measures are not excessively large when compared to their standard errors, a slight deviation from zero is not a major issue. To assess this, the measured value (skewness and kurtosis value) needs to be divided by its standard error to determine the z-value. This calculation should yield a z-value between -1.96 and 1.96. Regarding to the Shapiro-Wilk test or the Kolmogorov-Smirnov test, p- value should be greater than 0.05.

The result exhibit that, the z-values for skewness and kurtosis are fall within the range of -1.96 and 1.96 and p-value for the Shapiro-Wilk test or the Kolmogorov-Smirnov test is greater than 0.05, indicating that the data did not deviate significantly from normal distribution. **Appendices Part B: Parametric Test Assumption Result.**

Due to the fact that the data in this study has been found to meet all of the necessary assumptions, including normal distribution, independent observations, equal variance across all groups, and random sampling from the population, the parametric analysis tools are suitable for use. Specifically, to compare the means of the five modes of transportation, an independent analysis of variance (ANOVA) has been chosen as the statistical analysis tool.

One-way Analysis of variance (ANOVA)

One-way Analysis of Variance (ANOVA) is a statistical technique used to determine whether there are significant differences between the means of three or more groups. Here are the steps involved in conducting a one-way ANOVA:

1. Formulate the null and alternative hypotheses: The null hypothesis states that there is no significant difference between the means of the groups, while the alternative hypothesis states that there is a significant difference between the means of the groups.
2. Determine the level of significance (α): The level of significance (α) is the probability of making a Type I error, which is rejecting the null hypothesis when it is actually true. Typically, α is set at 0.05 or 0.01. For this case α is set at 0.05.
3. Collect the data: Collect data from all the groups and record them.
4. Calculate the sum of squares between groups (SSG): SSG represents the variation between the means of the groups. To calculate SSG, first find the mean of each group, and then subtract the overall mean from each group mean. Next, square the differences and multiply them by the number of observations in each group. Finally, add up the values for all the groups.

5. Calculate the sum of squares within groups (SSW): SSW represents the variation within each group. To calculate SSW, find the difference between each observation and its respective group mean. Square these differences and add them up for all the observations in each group. Finally, add up the values for all the groups.

6. Calculate the degrees of freedom (df): The degrees of freedom for SSG are the number of groups minus one (dfG = k - 1), where k is the number of groups. The degrees of freedom for SSW are the total number of observations minus the number of groups (dfW = N - k), where N is the total number of observations.

7. Calculate the mean square between groups (MSG): MSG is obtained by dividing SSG by dfG.

8. Calculate the mean square within groups (MSW): MSW is obtained by dividing SSW by dfW.

9. Calculate the F-statistic: The F-statistic is the ratio of MSG to MSW (F = MSG/MSW).

10. Determine the critical value of F: The critical value of F is obtained from an F-distribution table with dfG and dfW as the degrees of freedom and α as the level of significance.

11. Compare the calculated F-statistic to the critical value of F: If the calculated F-statistic is greater than the critical value of F, then reject the null hypothesis and conclude that there is a significant difference between the means of the groups. If the calculated F-statistic is less than or equal to the critical value of F, then fail to reject the null hypothesis and conclude that there is no significant difference between the means of the groups.

Or.: Calculate the p-value associated with the F-statistic using statistical software or a table of critical values. The p-value represents the probability of obtaining a test statistic as extreme as the one calculated from the sample data, assuming the null hypothesis is true. If the p-value is less than the significance level (e.g., 0.05), reject the null hypothesis and conclude that there is evidence that at least one mean is different from the others.

If the p-value is greater than the significance level, fail to reject the null hypothesis and conclude that there is not enough evidence to say that the means of the groups are different.

12. Post-hoc analysis: If the null hypothesis is rejected, perform post-hoc analysis to determine which groups are significantly different from each other. Some commonly used post-hoc tests are Tukey's HSD, Bonferroni, and Scheffe's methods. For this study Tukey's HSD tests are used.

NB. There are different methods for conducting post-hoc tests, and the choice of test depends on the research question and the level of significance desired.

3.11.2 Transit LOS Analysis

This research examines the levels of passenger occupancy and inside vehicular noise, utilizing two manuals: the Highway Capacity Manual and the Texas Institute of Transportation Level of Service Manual. To evaluate passenger occupancy, the study refers to Exhibit 27.5 of HCM 2000, which is presented in Section 2.2.2. This section provides a table that outlines Passenger Load Level of Service (LOS) benchmarks for buses interims of passengers per seat (P/seat) or passengers per square meter (p/m2). Additionally, to evaluate in-vehicle noise level, the Texas Institute of Transportation Level of Service Manual is utilized, as presented in Section 2.3.2.

3.11.3 Lagging Safety Performance Analysis

Based on the information available, this study utilizes two specific safety performance measures out of the four outlined in the national safety plan. These measures are the number of reportable fatalities and injuries by mode and per 10,000 vehicles, as described in Chapter Two Section 2.3.2.3.

Overall, this approach provides a comprehensive evaluation of the safety performance of different public transportation modes based on reliable and standardized measures.

3.11.4 Mode Choice Model

This thesis aims to determine how transit service aspects are prioritized by commuters when making mode choice decisions. This was captured by asking commuters to rank their preferences for public transport attribute and conducting multinomial logistic regression to identify the relationship with socioeconomic status and trip maker characteristics.

In multinomial logistic regression models, addressing multicollinearity is important. Multicollinearity occurs when there is a high correlation between two or more independent variables, making it difficult to discern the individual effects of each variable on the dependent variable. To detect multicollinearity, one can examine the correlation matrix of the independent variables.

If there are high correlations between some independent variables, it suggests the presence of multicollinearity. In such cases, addressing multicollinearity can be done by removing one or more correlated independent variables or using methods such as principal component analysis or ridge regression to mitigate its impact. In this study, a correlation matrix of the independent variables was performed.

In summary, the research methodology involves defining the latent variables through literature review and factor analysis, designing a questionnaire to collect the factor that affects the mode choice preference. After that, the analysis was performed by using regression analysis and interpreting the coefficient of multinomial logistic regression model to understand how these variables affect the mode choice preference. Overall, this methodical approach provides a robust framework for evaluating and quantifying the impact of various latent variables on the public's transportation choices.

3.12 Ethical Consideration

Research ethics refers to the application of fundamental ethical principles to research activities such as research design and implementation, respect for society and others, resource use and research outputs, scientific misconduct, and research regulation. In research, ethical considerations are a set of principles that guide your research designs and practices. Voluntary participation, informed consent, anonymity, confidentiality, the potential for harm, and results communication are among these principles. The confidentiality of the information provided by the participant is one of the most important ethical considerations. The definition of privacy is that any information related to or provided by participants must never be made available to or accessed by anyone other than the researcher (Cacciattolo, 2015). Informed consent is a fundamental component of conducting ethical research. Before giving consent, individuals should be clear on the aims, methodology, and potential risks they may encounter as a result of being involved in the research. In this study, the participant becomes involved in something voluntarily and willingly. Therefore, in this research, the participant information is protected and used for this academic purpose only.

3.13 Summary

This chapter has presented the research design and process used in this study. The overall methods are summarized in the figure below.
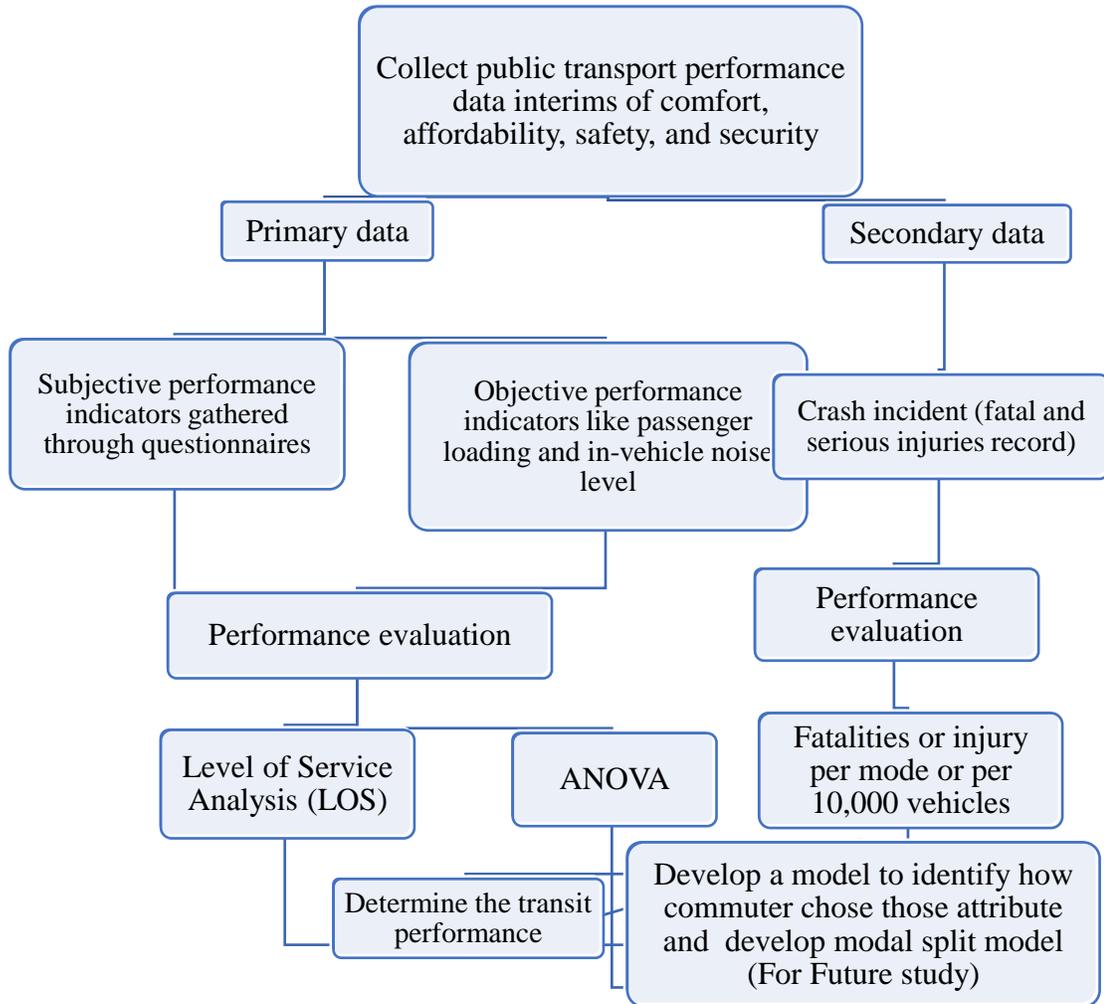
Figure 3-12 Summarized Research Design

Source: Researcher Own Research Design

CHAPTER FOUR

4. PUBLIC TRANSPORT PERFORMANCE EVALUATION RESULTS AND DISCUSSION

4.1 Introduction

This research conducted an evaluation of the public transport system's performance in terms of comfort, affordability, safety, and security. To accomplish this, a variety of evaluation methods were utilized, taking into account the available data. The study aimed to incorporate both subjective and objective methods for evaluating comfort and affordability, as well as leading and lagging indicators for assessing safety, and a subjective approach for measuring security performance. Furthermore, a comparative analysis of their performances is also provided. The results of this study are presented as follows.

4.2 Comfort Performance Evaluation

4.2.1 Subjective Performance Analysis

Seven indicators were used to quantify the level of comfort provided by the different modes and presented in the Table 4.1.

Among the modes of transportation evaluated, the taxi stands out for having the highest coefficient (0.361) for the availability of space for passengers, indicating a low-crowdedness experience. However, it has the lowest coefficient for noise level (0.174), suggesting that it may not provide the most peaceful travel experience. The midi-bus, on the other hand, has the lowest coefficient for cleanliness (0.19) and availability of passenger space, but it offers a comfortable seating experience (0.216). The public service bus (PSETSE) performs well in terms of in-vehicle noise level, with the highest coefficient (0.257), indicating a comfortable travel experience in terms of sound.

Table 4-1 Comfort Performance Indicator Coefficients

Indicator	Minibus (Taxi)	Midi Bus	Public Service Bus	Anbesa City Bus	Sheger Bus
Cleanliness	0.216	0.190	0.201	0.213	0.220
Availability of seats	0.277	0.236	0.215	0.200	0.205
Seats comfort	0.277	0.216	0.221	0.251	0.240
In-vehicle sound level	0.174	0.208	0.257	0.234	0.213
In-vehicle trip information	0.240	0.223	0.221	0.241	0.234
In-vehicle air conditioning system	0.277	0.214	0.206	0.214	0.215
In-vehicle passenger crowding	0.361	0.191	0.201	0.168	0.184

Overall, the regression coefficient analysis shows a significant difference in the availability of space for travelers between taxis and Anbesa buses, with coefficient values of 0.361 and 0.168, respectively. Furthermore, the analysis highlights a significant difference in noise level between public service buses and taxis, with coefficient values of 0.257 and 0.168, respectively.

4.2.2 Objective Performance Analysis

To gain a more complete and accurate understanding of the quality of service provided to passengers, it is recommended that objective performance evaluation be conducted. This will help to identify areas for improvement and ensure that the travel experience is as comfortable and convenient as possible for passengers. The following section presents the analysis of in-vehicle passenger loading and in-vehicle noise level of service.

4.2.2.1 In- vehicle Passenger Load

According to the HCM, the passenger per seat level of service analysis is appropriate for buses and some other small vehicles. Table 4.2 and 4.3 presents the result.

Table 4-2 In-vehicle Passenger Loading Level of Service Analysis for Megenagna to Piasa

	Megenagna to Piasa (7:45 PM)									
Stop Station	Taxi		Midi bus		Public Service Bus		Anbesa Bus		Sheger Bus	
	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS
Megenagna	1.167	D	1.85	F	1.667	F	2.619	F	2.262	F
Shola	1.167	D	2.11	F	1.75	F	2.857	F	2.381	F
Arat kilo	1.167	D	1.3	E	1.5	F	1.786	F	1.905	F
Piasa	1.167	D	0.89	C	1.25	D	1.19	D	1.071	D

	Megenagna to Piasa (5:30 PM)									
Stop station	Taxi		Midi bus		Public Service Bus		Anbesa City Bus		Sheger Bus	
	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS
Megenagna	1.167	D	1.31	E	1.417	E	2.5	F	2.024	F
Shola	1.167	D	1.48	E	1.567	F	2.786	F	2.5	F
Arat kilo	1.167	D	0.83	C	0.883	C	1.429	E	1.548	F
Piasa	1.167	D	0.57	B	0.75	B	1.071	D	1.024	D

	Piasa to Megenagna (7:45 AM)									
Stop station	Taxi		Midi bus		Public Service Bus		Anbesa City Bus		Sheger Bus	
	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS
Megenagna	1.167	D	1.67	F	1.233	D	2.143	F	1.905	F
Shola	1.167	D	2	F	1.45	E	2.619	F	2.262	F
Arat kilo	1.167	D	1.85	F	1.333	E	2.5	F	2.381	F
Piasa	1.167	D	1.67	F	1.117	D	2.262	F	1.952	F

	Piasa to Megenagna (5:30 PM)									
Stop station	Taxi		Midi bus		Public Service Bus		Anbesa City Bus		Sheger Bus	
	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS
Megenagna	1.167	D	2.07	F	1.7	F	2.5	F	1.976	F

Stop	Taxi		Midi bus		Public Service Bus		Anbesa bus		Sheger bus	
Shola	1.167	D	2.3	F	1.833	F	2.714	F	2.19	F
Arat kilo	1.167	D	1.67	F	1.533	F	2.024	F	2.333	F
Piasa	1.167	D	1.48	E	1.217	D	1.667	F	1.786	F

Based on Table 4.2, minibus taxis had an average of 1.167 passengers per seat load along the route segment, placing them in category D, indicating an acceptable loading for travelers. In contrast, Anbesa city buses had a maximum of 2.857 passengers per seat during the morning peak at Shola station, resulting in an under-crushing load and an overall level of service value of F.

Sheger mass transport buses carried 2.381 passengers per seat during the peak morning period at Shola bus stop, which designates them as having similar overall passenger loading performance and level of service value as Anbesa city buses, indicating that these modes are under-crushing load. Midi buses and public service buses show similar passenger loading performance, with an overall level of service value that falls in the F category. Nevertheless, they perform slightly better than Anbesa city buses and Sheger mass transport buses.

Table 4-3 In-vehicle Passenger Loading Level of Service Analysis for Shiromeda to Mexico

Shiromeda to Mexico (7:30 AM)										
Stop Station	Taxi		Midi bus		Public Service Bus		Anbesa bus		Sheger bus	
	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS
Shiromeda	1.13	D	1.259	E	1.067	D	1.667	F	1.429	E
Sedest kilo	1.13	D	1.333	E	1.233	D	2	F	1.786	F
Arat kilo	1.13	D	1.63	F	1.333	E	2.238	F	1.976	F
Estifanos	1.13	D	1.481	E	1.25	E	2.238	F	1.667	F
Stadium	1.13	D	1.185	D	1.217	D	2	F	0.952	C
Mexico	1.13	D	0.926	C	1.117	D	1.667	F	0.952	C
Shiromeda to Mexico (5:30 PM)										

Stop station	Taxi		Midi bus		Public Service Bus		Anbesa bus		Sheger bus	
	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS
Shiromeda	1.13	D	1.333	E	1	C	1.571	F	1.31	E
Sedest kilo	1.13	D	1.593	F	1.083	D	1.762	F	1.619	F
Arat kilo	1.13	D	1.852	F	1.25	D	2.143	F	1.81	F
Estifanos	1.13	D	1.481	E	1.383	E	1.762	F	1.595	F
Stadium	1.13	D	1.185	D	1.067	D	1.548	F	1.19	D
Mexico	1.13	D	0.889	C	0.917	C	1.31	E	1.071	D

<center>Mexico to Shiromeda (7:30AM)</center>

Stop station	Taxi		Midi bus		Public Service Bus		Anbesa bus		Sheger bus	
	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS
Mexico	1.13	D	1.111	D	1.267	E	1.595	F	1.31	E
Stadium	1.13	D	1.296	E	1.333	E	1.905	F	1.786	F
Estifanos	1.13	D	1.593	F	1.417	E	2.286	F	2	F
Arat kilo	1.13	D	1.185	D	1.083	D	1.905	F	1.714	F
Sedest kilo	1.13	D	0.889	C	0.9	C	1.262	E	1.429	E
Shiromeda	1.13	D	0.889	C	0.717	B	1.095	D	1.333	E

<center>Mexico to Shiromeda (5:30 PM)</center>

Stop station	Taxi		Midi bus		Public Service Bus		Anbesa bus		Sheger bus	
	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS	P/seat	LOS
Mexico	1.13	D	1.296	E	0.9	D	1.667	F	1.548	F
Stadium	1.13	D	1.63	F	1.117	D	2	F	1.81	F
Estifanos	1.13	D	1.741	F	1.267	E	2.286	F	2.238	F
Arat kilo	1.13	D	1.259	E	1.083	D	2.476	F	1.952	F
Sedest kilo	1.13	D	0.926	D	1.167	D	2	F	1.762	F
Shiromeda	1.13	D	0.852	D	1.267	E	1.643	F	1.524	F

Road Segment Two also has a similar level of passenger loading value for the chosen modes of transportation as road segment one. Table 4.3 presents the result. This result is consistent with the regression analysis result presented in Table 4.1, which stated that minibus taxis have good performance in terms of passenger loading, while Anbesa city buses have the lowest performance.

4.2.2.2 In-vehicle Noise Level

Table 4-4 In-vehicle Sound Level of Service (LOS) Analysis

Road segment	Taxi		Midi bus		Public Service Bus		Anbesa bus		Sheger bus	
	Noise(dB)	LOS	Noise(dB)	LOS	Noise(dB)	LOS	Noise(dB)	LOS	Noise(dB)	LOS
Megenagna-Shola	71.9	B	73.9	B	71.2	B	70	B	69.7	B
Shola- Arat Kilo	73.4	B	75.1	C	71.9	B	70	B	70.5	B
Arat Kilo-Piazza	71.6	B	73.4	B	70.6	B	68.9	B	69.4	B
Mexico -Stadium	72.6	B	75.1	C	71.6	B	71.2	B	71.6	B
Stadium Estifanos	71.4	B	73.5	B	72	B	70.9	B	71.3	B
Estifanos—Arat Kilo	76.5	C	83.2	C	75.4	C	81	C	81.34	C
Arat Kilo-Sedest Kilo	75.2	B	82.5	C	74.7	B	78.7	C	79.9	C
Sedest Kilo-Shiromeda	74.1	B	81.9	C	73.9	B	78.1	C	78.8	C

Based on this analysis, public service buses offer the highest level of in-vehicle sound quality, denoted by its performance labeled as 'B'. On the other hand, midi buses have a comparatively higher in-vehicle sound level than other modes of transport. The average noise levels of the modes are presented in the Figure 4.1.
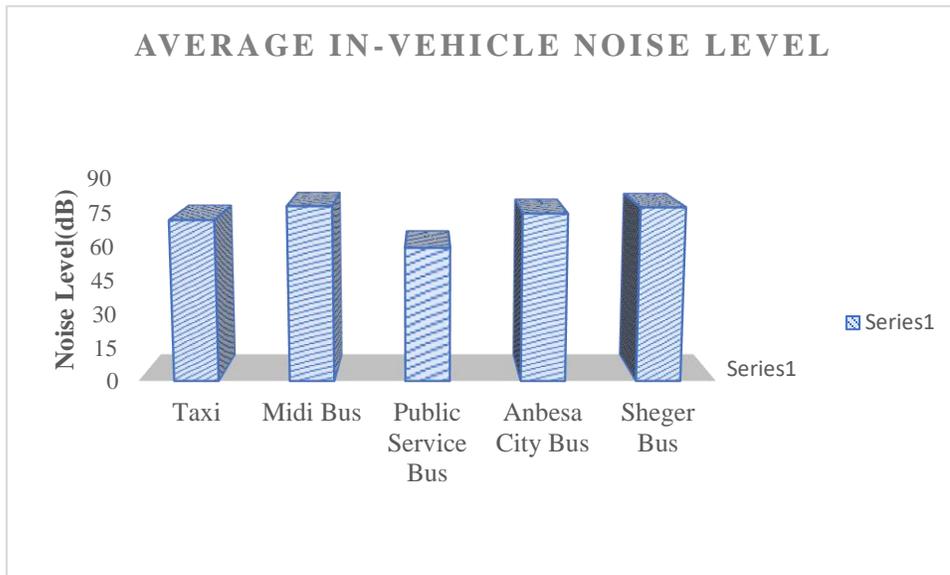
Figure 4-1 Average In-vehicle Noise Level

The findings, presented in Figure 4.1, reveal that the midi bus produces the highest noise, averaging at 77.46 dB, followed by Sheger bus at 76.9 dB, while the public service bus produces the least amount of noise at an average of 69.29 dB. These results are consistent with the subjective performance analysis results presented in Table 4.1, which indicate that the public service bus has good in-vehicle sound performance. Moreover, these findings provide insights into the noise generated by different vehicles and can be used to inform policies and regulations aimed at reducing noise pollution in urban areas.

4.2.3 Overall Comfort Performance Analysis

The comfort levels for each mode were assessed by evaluating seven comfort indicators, as presented in the preceding section. The overall comfort rating for each mode was determined by calculating the average of all the comfort indicators measured. The resulting values are presented in the table below.

Table 4-5 Overall Comfort Performance

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Minibus Taxi	400	2.9042	.65408	.03270	2.8399	2.9685
Midi Bus	400	2.1509	.58214	.02911	2.0937	2.2082
Public Service Bus	400	2.6500	.65244	.03262	2.5859	2.7141
Anbesa Bus	400	2.2723	.58061	.02903	2.2152	2.3293
Sheger Bus	400	2.5178	.62837	.03142	2.4560	2.5796
Total	2000	2.4990	.67536	.01510	2.4694	2.5287

According to the findings of the analysis, it has been determined that the average comfort level of the minibus taxi stands at 2.904 followed by public service bus having 2.65. On the other hand, the midi-bus exhibits a value of 2.15. Based on these figures, it can be deduced that the minibus taxi and public service bus have exhibited the highest average comfort performance among the modes of transportation. Moreover, to compare comfort performance among the five groups, analysis of variance (ANOVA) is often appropriate, and it can provide more information than pairwise comparisons between groups. Indeed, the first step is setting the hypothesis.

Hypothesis

- **Null hypothesis H₀**: There is no significant difference in mean comfort level among the modes. Accept this hypothesis if sig (p value) is greater than the significance level (in this case α=0.05).

- **Alternate hypothesis H₁**: At least one of the mode's mean-comfort levels is different. Accept this hypothesis if sig (p value) is less than the significance level (in this case α= 0.05).

Table 4-6 One-way Analysis of Variance

	Sum of Squares	df	Mean Square	F	p-value
Between Groups	143.946	4	35.987	93.504	.000
Within Groups	767.808	1995	.385		
Total	911.754	1999			

Based on the statistical analysis conducted, it has been determined that the obtained p-value falls below the critical value of 0.05. This outcome indicates that there is a notable difference in the average comfort levels among the five modes of public transportation. Therefore, the null hypothesis is rejected.

The ANOVA test only provides evidence of the existence of a significant difference in comfort performance among the modes of transportation. However, to identify which specific mode of transportation demonstrates a significant difference, a post-hoc test is necessary. Table 4.7 presents the results of the post-hoc test, which should be used to identify the mode of transportation that exhibits a significant difference in comfort performance.

Table 4-7 Comfort Performance Post hoc Multiple Comparison Result

(I) Modes		Mean Difference (I-J)	Std. Error	P-value	95% Confidence Interval Lower Bound	Upper Bound
Taxi	Midi Bus	.75323[*]	0.04387	0.000	0.6335	0.8730
	Public Service Bus	.25417[*]	0.04387	0.000	0.1344	0.3739
	Anbesa Bus	.63189[*]	0.04387	0.000	0.5121	0.7517
	Sheger Bus	.38635[*]	0.04387	0.000	0.2666	0.5061
Midi Bus	Taxi	-.75323[*]	0.04387	0.000	-0.8730	-0.6335
	Public Service Bus	-.49906[*]	0.04387	0.000	-0.6188	-0.3793
	Anbesa Bus	-.12134[*]	0.04387	0.045	-0.2411	-0.0016
	Sheger Bus	-.36687[*]	0.04387	0.000	-0.4866	-0.2471
Public Service Bus	Taxi	-.25417[*]	0.04387	0.000	-0.3739	-0.1344
	Midi Bus	.49906[*]	0.04387	0.000	0.3793	0.6188
	Anbesa Bus	.37772[*]	0.04387	0.000	0.2580	0.4975
	Sheger Bus	.13219[*]	0.04387	0.022	0.0124	0.2520
Anbesa Bus	Taxi	-.63189[*]	0.04387	0.000	-0.7517	-0.5121
	Midi Bus	.12134[*]	0.04387	0.045	0.0016	0.2411
	Public Service Bus	-.37772[*]	0.04387	0.000	-0.4975	-0.2580
	Sheger Bus	-.24554[*]	0.04387	0.000	-0.3653	-0.1258
Sheger Bus	Taxi	-.38635[*]	0.04387	0.000	-0.5061	-0.2666
	Midi Bus	.36687[*]	0.04387	0.000	0.2471	0.4866
	Public Bus	-.13219[*]	0.04387	0.022	-0.2520	-0.0124
	Anbesa Bus	.24554[*]	0.04387	0.000	0.1258	0.3653

*. The mean difference is significant at the 0.05 level.

According to the post-hoc multiple comparison analysis, it has been observed that the p-value is found to be less than 0.05 for all the combinations. This statistical inference suggests that there exists a significant variation in the mean level of comfort among the five groups. To provide further elucidation, a means plot has been presented in the figure below.
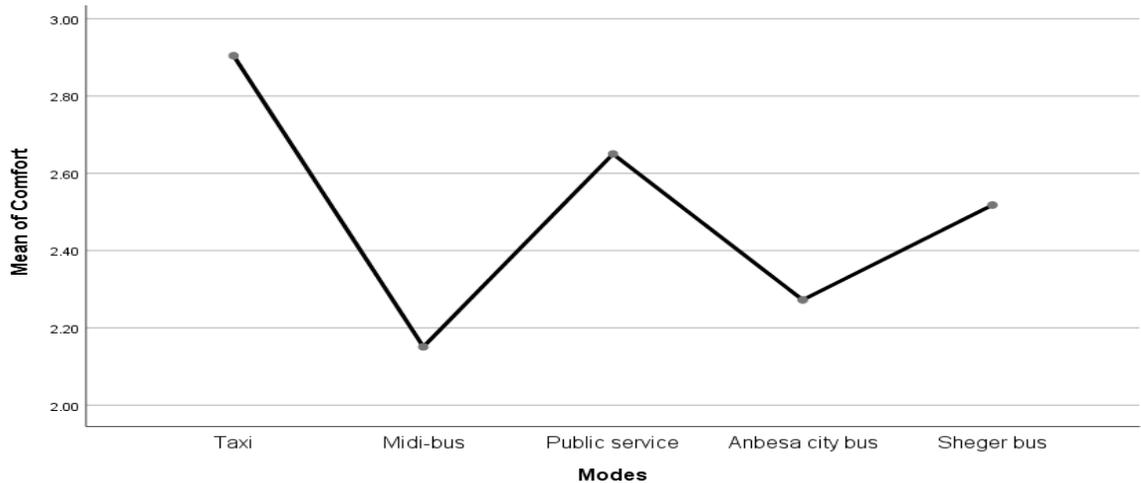
Figure 4-2 Means Plot for Public Transport Comfort Performance

These results provide insights into the difference in comfort levels among various public transportation modes in Addis Ababa and can guide efforts to enhance passenger comfort and satisfaction. Based on Figure 4.2, minibus taxis demonstrated the highest level of comfort performance followed by public service buses. On the other hand, midi buses exhibited the lowest level of comfort.

4.2.4 Summary

The subjective analysis of the study found that minibus taxis performed well in terms of comfort, with the highest indicator coefficient for available space for travelers, while the Anbesa bus had the lowest coefficient for space availability, indicating that the bus has a high passenger loading rate. This result is in line with the passenger loading Level of Service analysis, which revealed that minibus taxis had an overall Level of Service D, while Anbesa bus had a Level F with a 2.86 P/seat value.

Regarding in-vehicle noise levels, the study found that public service buses performed well in both subjective and objective analyses, with the lowest sound level among the different modes of transportation, at 69.29 dB, and the highest indicator coefficient, at 0.257, in subjective evaluations. For transit operators, a poor Level of Service value may indicate a need to increase service frequency, as suggested by (Norhisham et al., 2018). Additionally, improving vehicle quality can lead to increased passenger usage of public transportation, as passengers are more likely to use clean, well-maintained, and comfortable vehicles.

4.3 Affordability Performance Evaluation

This analysis section focuses on the affordability performance of public transportation, utilizing analysis of variance to compare different modes. Regression analysis is also employed to examine the affordability performance indicator coefficient. The findings are further supported by conducting a tariff comparison to validate the results. Finally, the Armstrong threshold value is used to evaluate the overall affordability performance.

4.3.1 Subjective Performance Analysis

Two indicators were used to quantify the level of affordability provided by the different modes. Table 4.8 presents these.

Table 4-8 Affordability Performance Indicator Coefficients

	Taxi	Midi bus	Public Service Bus	Anbesa City Bus	Sheger Bus
Travel time	0.750	0.667	0.630	0.618	0.663
Ticket cost	0.669	0.721	0.712	0.722	0.726

The analysis revealed that minibus taxis have the highest coefficient (0.75) for travel time, indicating a faster travel experience.

However, they also have the lowest coefficient for ticket cost (0.669), suggesting that the fare charges may not be affordable for all. For the other modes of transport evaluated, affordability is mainly determined by the tariff, as indicated by the regression coefficient for travel time and tariff.

4.3.2 Objective Performance Analysis

To substantiate the analysis of affordability performance, an objective assessment was conducted, and the findings are presented in Figure 4.3. The data shows that minibus taxis charge a tariff of 1.4 Birr per kilometer, while midi buses and public service buses have a tariff of 0.65 Birr per kilometer. Additionally, both Anbesa buses and Sheger buses have a tariff of 0.34 Birr per kilometer.
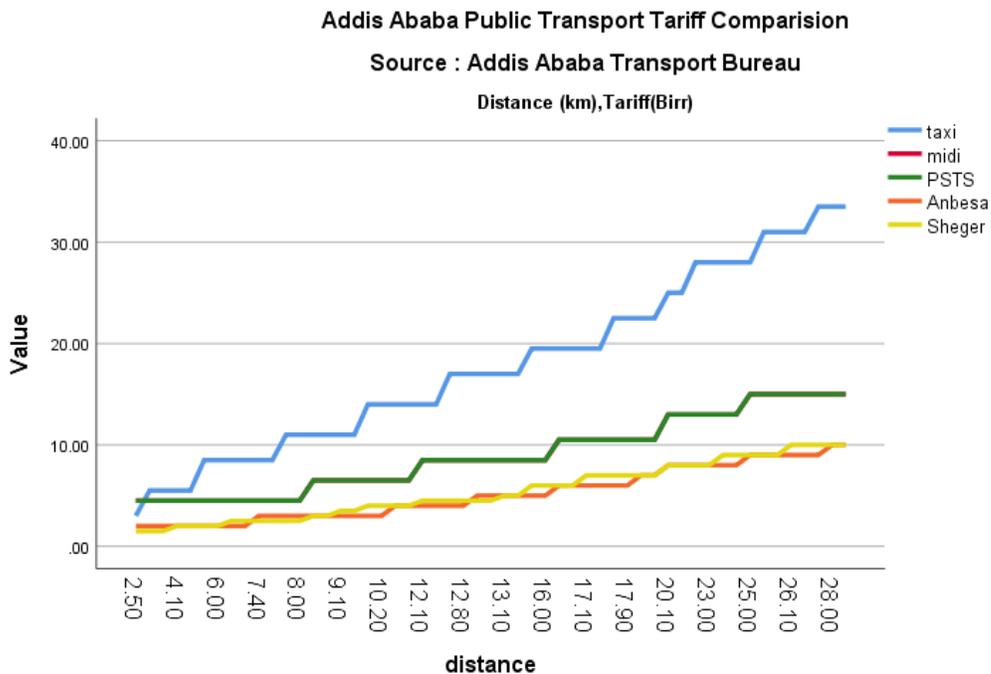
Figure 4-3 Addis Ababa Public Transport Tariff Comparison

4.3.3 Overall Affordability Performance Analysis

The affordability performance level for the five modes were assessed by evaluating two affordability indicators as presented in the preceding section. The overall affordability rating for each mode was determined by calculating the average of the two affordability indicators measured. The resulting values are presented in the Table 4.9.

Table 4-9 Overall Affordability Performance

Mode	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Taxi	400	1.8075	.94216	.04711	1.7149	1.9001	1.00	5.00
Midi Bus	400	2.5025	1.05962	.05298	2.3983	2.6067	1.00	5.00
Public Service Bus	400	3.4450	1.03666	.05183	3.3431	3.5469	1.00	5.00
Anbesa Bus	400	3.8425	.94335	.04717	3.7498	3.9352	1.00	5.00
Sheger Bus	400	3.8600	.88734	.04437	3.7728	3.9472	1.00	5.00
Total	2000	3.0915	1.26725	.02834	3.0359	3.1471	1.00	5.00

Based on Table 4.9, Anbesa city bus (ACBE) and Sheger bus (SMTE) had mean affordability levels of 3.84 and 3.86, respectively. In contrast, minibus taxis had a mean value of 1.8705. To assess if there is a statistically significant difference in mean affordability levels, a one-way analysis of variance (ANOVA) was conducted. The first step in ANOVA is to formulate a hypothesis.

Hypothesis

- Null hypothesis (H0): there is no significant difference in the mean level of affordability among the groups.
- Alternative hypothesis (H1): at least one of the mean-affordability levels of the modes is different. H1 will be accepted if the calculated p-value is less than α= 0.05.

The analysis was conducted using ANOVA, and the results are presented in the following table.

Table 4-10 One-Way Analysis of Variance

	Sum of Squares	df	Mean Square	F	p-value
Between Groups	1310.053	4	327.513	343.852	.000
Within Groups	1900.203	1995	.952		
Total	3210.256	1999			

The results of the one-way analysis of variance (ANOVA) indicate that there is a statistically significant difference in the mean levels of affordability among the group. This suggests that at least one of the mode affordability levels is significantly different from the others, as evidenced by the p-value of less than 0.05. Therefore, to further elucidate the nature of these differences, multiple post-hoc comparisons between the groups are performed.

Table 4-11 Post hoc Multiple Comparison Result

(I) modes		Mean Difference (I-J)	Std. Error	P-value	95% Confidence Interval	
					Lower Bound	Upper Bound
Taxi	Midi Bus	-.69500	.06901	.000	-.8834	-.5066
	Public Service Bus	-1.63750	.06901	.000	-1.8259	-1.4491
	Anbesa Bus	-2.03500	.06901	.000	-2.2234	-1.8466
	Sheger Bus	-2.05250	.06901	.000	-2.2409	-1.8641
Midi Bus	Taxi	.69500	.06901	.000	.5066	.8834
	Public Service Bus	-.94250	.06901	.760	-1.1309	-.7541
	Anbesa Bus	-1.34000	.06901	.000	-1.5284	-1.1516
	Sheger Bus	-1.35750	.06901	.000	-1.5459	-1.1691
Public Service Bus	Taxi	1.63750	.06901	.000	1.4491	1.8259
	Midi Bus	.94250	.06901	.760	.7541	1.1309
	Anbesa Bus	-.39750	.06901	.000	-.5859	-.2091
	Sheger Bus	-.41500	.06901	.000	-.6034	-.2266
Anbesa Bus	Taxi	2.03500	.06901	.000	1.8466	2.2234
	Midi Bus	1.34000	.06901	.000	1.1516	1.5284
	Public Bus	.39750	.06901	.000	.2091	.5859
	Sheger Bus	-.01750	.06901	.999	-.2059	.1709
Sheger Bus	Taxi	2.05250	.06901	.000	1.8641	2.2409
	Midi Bus	1.35750	.06901	.000	1.1691	1.5459
	Public Service Bus	.41500	.06901	.000	.2266	.6034
	Anbesa Bus	.01750	.06901	.999	-.1709	.2059

The statistical analysis indicates that, except for the combination of the Sheger bus and Anbesa city bus, as well as the midi bus and public service bus, all other combinations show a p-value less than 0.05. This suggests that there is a significant difference in affordability among all modes of public transportation, except for the mentioned exceptions. The figure below visually represents the differences among the five modes.
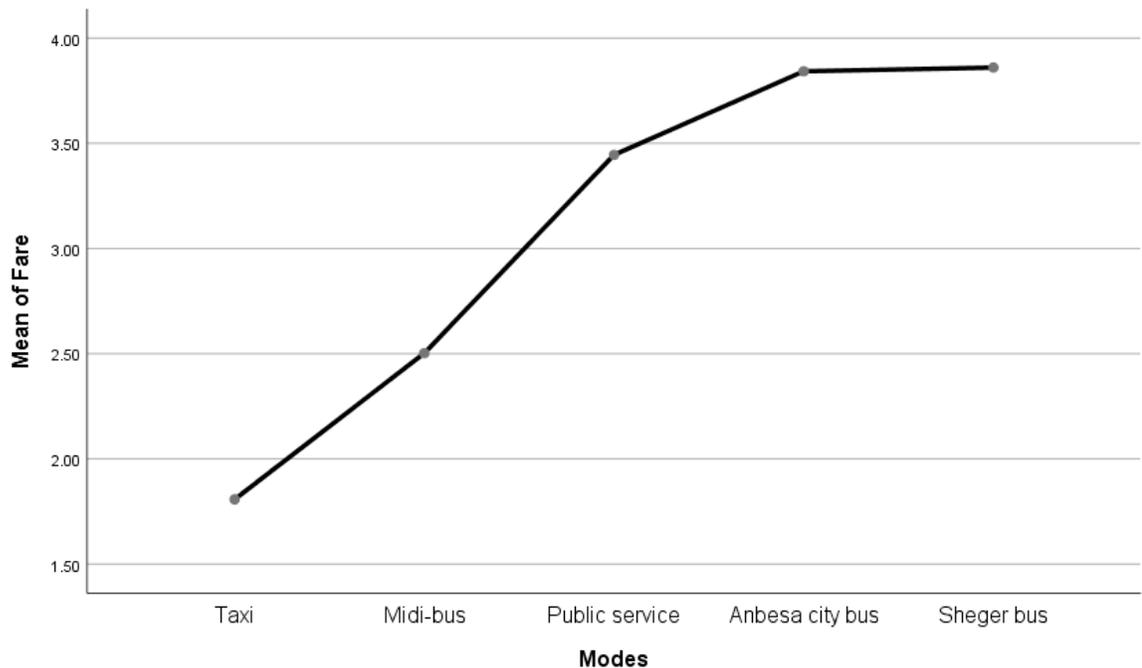
Figure 4-4 Means plot for Public Transport Affordability Performance

The result indicates that, minibus taxi systems are considered less affordable than larger bus systems in terms of fare prices. This suggests that passengers may have to pay more for minibus taxi services compared to utilizing larger buses for their transportation needs. However, when considering affordability in terms of travel time, minibus taxis are found to be highly favorable. This implies that although the fare prices may be relatively higher, minibus taxis provide a faster means of travel, allowing passengers to reach their destinations more quickly compared to larger bus systems.

4.3.4 Summary

Upon evaluating the overall affordability of public transportation modes in Addis Ababa by utilizing monthly expenditure and Armstrong's affordability threshold values, it was discovered that more than 25% of passengers were spending more than 10% of their monthly earnings on transportation, indicating that the transportation system is unaffordable. Additionally, survey results and actual tariff comparisons revealed that minibus taxis were the least affordable mode of transportation, whereas Anbesa bus and Sheger bus were the most affordable options.

In conclusion, this study demonstrates the usefulness of regression analysis in understanding the complex interplay of various factors that impact transportation performance. The results suggest that while minibus taxis offer faster travel times, they may not be financially viable for all commuters. The affordability of other modes of transport is mainly influenced by their tariff affordability. This study can serve as a valuable reference for policymakers and transportation authorities in developing effective strategies to enhance transportation performance and promote equitable accessibility.

4.4 Safety Performance Evaluation

The leading safety performance measures were collected, and statistical analysis was conducted using the one-way analysis of variance (ANOVA). On the other hand, the lagging safety performance measures were based on data obtained from the Addis Ababa Traffic Management Agency (AATMA), which was analyzed based on the number of fatalities and injuries per mode and per 10,000 vehicles, as outlined in the national safety plan procedure.

4.4.1 Leading Safety Performance Analysis

The present study investigates the driving behavior, safety precautions availability, door closing signal availability, and seat belt usage of the five modes of transportation in the urban setting. Table 4.12 present the result.

Table 4-12 Safety Performance Indicator Coefficients

Indicator	Taxi	Midi bus	Public Service Bus	Anbesa City Bus	Sheger Bus
Driving behavior	0.205	0.359	0.370	0.372	0.377
Seat belt	0.374	0.315	0.401	0.277	0.304
Safety precaution	0.424	0.465	0.438	0.428	0.432
Door closing signal	0.357	0.383	0.387	0.403	0.405

The analysis revealed that minibus taxi drivers exhibited the lowest coefficient for driving behavior, suggesting a tendency towards aggressive driving behaviors such as continuous weaving, swerving, and speeding. In contrast, Sheger bus, Anbesa bus, and Public Service bus drivers had higher coefficients for driving behavior, indicating a more cautious driving approach.

In terms of seat belt usage, the Public Service bus, Taxi, and Midi bus had the highest coefficient, indicating a higher likelihood of drivers and passengers wearing seat belts. On the other hand, the Anbesa bus and Sheger bus had the lowest coefficient for seat belt usage, suggesting a lower adherence to proper seat belt practices. These findings are consistent with a study conducted by Semegnew Takele in 2022, which reported that midi bus and larger bus drivers had a lower rate of proper seat belt usage compared to minibus taxi drivers.

4.4.1.1 Overall Leading Safety Performance Analysis

The overall leading safety performance of public transport groups presented in Table 4.13.

Table 4-13 Overall Leading Safety Performance

	N	Mean	Std. Deviation	Std. Error	95% CI Lower Bound	95% CI Upper Bound	Minimum	Maximum
Taxi	400	1.756	.62311	.03116	1.6956	1.8181	1.00	4.75
Midi-bus	400	1.871	.65823	.03291	1.8072	1.9366	1.00	4.00
Public Service Bus	400	2.490	.74680	.03734	2.4172	2.5640	1.00	4.75
Anbesa Bus	400	2.282	.69157	.03458	2.2145	2.3505	1.00	4.75
Sheger Bus	400	2.450	.70622	.03531	2.3806	2.5194	1.00	4.75
Total	2000	2.170	.74902	.01675	2.1375	2.2032	1.00	4.75

From Table 4.13, minibus taxi has the lowest safety performance with a value of 1.75, followed by midi-bus with a mean value of 1.87. In contrast, the public service bus, Sheger bus, and Anbesa city bus have mean safety performance values of 2.49, 2.45, and 2.28, respectively. These results indicate differences in safety performance among the evaluated modes of transportation.

To determine whether this difference is statistically significant or not, a one-way analysis of variance (ANOVA) test was conducted. The test involved formulating a null hypothesis (H0) and an alternate hypothesis (H1).

- The null hypothesis states that there is no significant difference in the overall leading safety performance level among the five groups, and it will be accepted if the p-value is greater than the predetermined significance level (α=0.05).

- The alternate hypothesis states that at least one of the groups has a different overall leading safety performance level, and it will be accepted if the p- value is less than the predetermined significance level (α=0.05).

The results of the one-way analysis of variance (ANOVA) test are presented in the following table.

Table 4-14 Analysis of Variance (ANOVA) Table

	Sum of Squares	df	Mean Square	F	P-value
Between Groups	181.363	4	45.341	96.214	.000
Within Groups	940.145	1995	.471		
Total	1121.507	1999			

The one-way analysis of variance (ANOVA) table indicates a significant difference in the safety performance among the groups, with a p-value below 0.05. However, the table does not specify the particular groups that differ from each other. To determine the specific differences, a post-hoc multiple comparison analysis is conducted, and the results are presented in Table 4.15.

Table 4-15 Post hoc Multiple Comparison Result

(I) modes		Mean Difference (I-J)	Std. Error	P-value	95% Confidence Interval	
					Lower Bound	Upper Bound
Midi-bus	Minibus Taxi	.11500	.04854	.004	-.0175	.2475
	Public Service Bus	-.61875	.04854	.000	-.7513	-.4862
	Anbesa City Bus	-.41063	.04854	.000	-.5432	-.2781
	Sheger Bus	-.57813	.04854	.000	-.7107	-.4456
Minibus Taxi	Midi-bus	-.11500	.04854	.004	-.2475	.0175
	Public Service Bus	-.73375	.04854	.000	-.8663	-.6012
	Anbesa City Bus	-.52563	.04854	.000	-.6582	-.3931
	Sheger Bus	-.69313	.04854	.000	-.8257	-.5606
Public Service Bus	Midi-bus	.61875	.04854	.000	.4862	.7513
	Minibus Taxi	.73375	.04854	.000	.6012	.8663
	Anbesa City Bus	.20812	.04854	.053	.0756	.3407
	Sheger Bus	.04062	.04854	.919	-.0919	.1732
Anbesa City Bus	Midi-bus	.41063	.04854	.000	.2781	.5432
	Minibus Taxi	.52563	.04854	.000	.3931	.6582
	Public Service Bus	-.20812	.04854	.053	-.3407	-.0756
	Sheger Bus	-.16750	.04854	.065	-.3000	-.0350
Sheger Bus	Midi-bus	.57813	.04854	.000	.4456	.7107
	Minibus Taxi	.69313	.04854	.000	.5606	.8257
	Public Service Bus	-.04062	.04854	.919	-.1732	.0919
	Anbesa City Bus	.16750	.04854	.065	.0350	.3000

Based on this analysis, the p-value for the combination of the public service bus, Sheger bus, and Anbesa bus is greater than 0.05, indicating no significant difference in safety performance. However, for the other combinations, a significant difference is observed. To provide a visual representation of these results, a mean plot is presented in Figure 4.5 below.
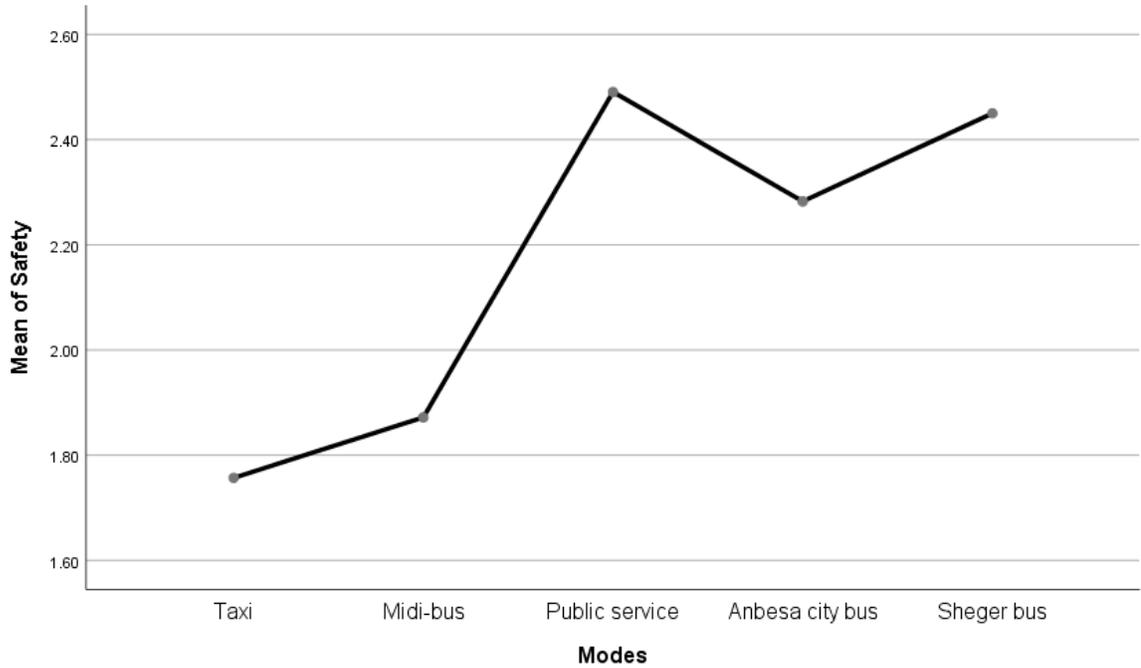
Figure 4-5 Means Plot for Public Transport Safety Performance

The means plot revealed that public service buses demonstrate the highest level of leading safety performance among the transportation modes, followed by Sheger mass transportation and Anbesa city buses. On the other hand, minibus taxis exhibited the lowest leading safety performance. Additionally, midi-buses also displayed poor leading safety performance, indicating that they are in suboptimal condition and may have a higher risk of being involved in accidents.

4.4.2 Overall Lagging Safety Performance Analysis

Based on the report published by the Addis Ababa Traffic Management Agency in 2013, a total of 400 fatalities and 337 injury crashes were documented. Table 4.16 provides a concise overview of the distribution of fatal and injury victims based on road users and gender.

Table 4-16 Death and Injury by Gender and Road Users

		Fatalities in Percent	Injury in Percent
Gender	Male	86.5	74.75
	Female	13.5	25.25
	Total	100	100
Road users	Pedestrians	83.5	67.35
	Passengers	7.75	19.24
	Drivers	7.25	13.41
	Motorcyclists	1.5	_

Based on the available data, it is evident that a significant gender disparity exists among fatal crash victims, with men comprising three-quarters of the total fatalities. In terms of road user type, pedestrians were the most vulnerable, representing the largest proportion of fatalities at 83.5%. When considering injury crashes, pedestrians also accounted for the majority of accidents, comprising 67.37% of the total, followed closely by passengers.

Deaths by Causal Vehicles

The analysis of the 2013 crash report data revealed that heavy trucks and minibus taxis were the most commonly responsible for accidents, representing 20.25% and 16.75% of incidents, respectively. Other automobiles were also identified as significant contributor to crashes.

Figure 4.6 provides a visual representation of the distribution of fatalities based on vehicular types.
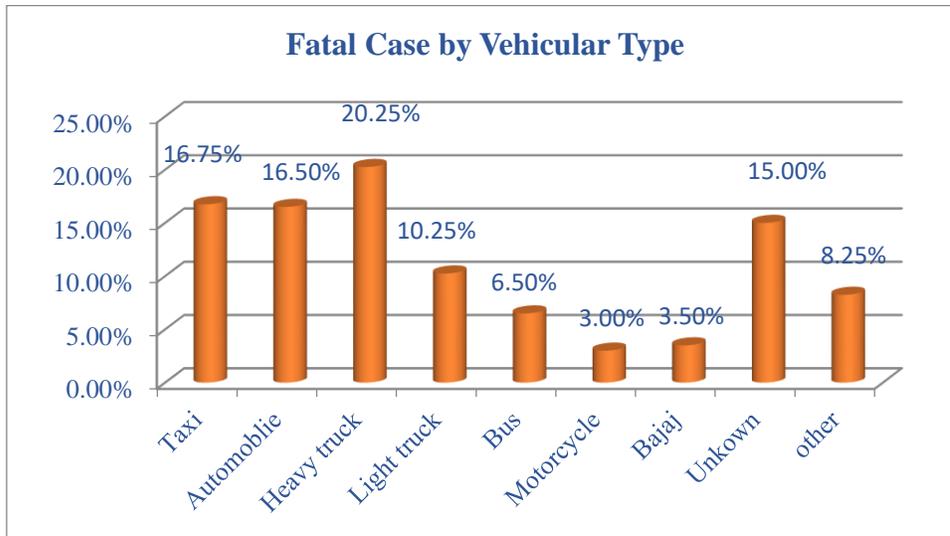
Figure 4-6 Death by Vehicular Type

The data indicate that minibus taxis exhibited a significantly higher involvement in fatal crashes compared to the combined involvement of public buses. Minibus taxis were found to have more than 2.5 times greater fatal crash involvement than public buses. This difference suggests that minibus taxis have a relatively lower level of safety performance when compared to other modes of public transport.

Injuries by Causal Vehicles

The findings from the analysis reveal that among public transport vehicles, minibus taxis were identified as the most common vehicle type at fault in injury crashes, comprising 23.44% of the reported cases. In contrast, large public buses accounted for a significantly lower proportion of injury crash cases, representing only 2.97% of the total. Figure 4.7 visually presents the distribution of injuries by vehicle type.
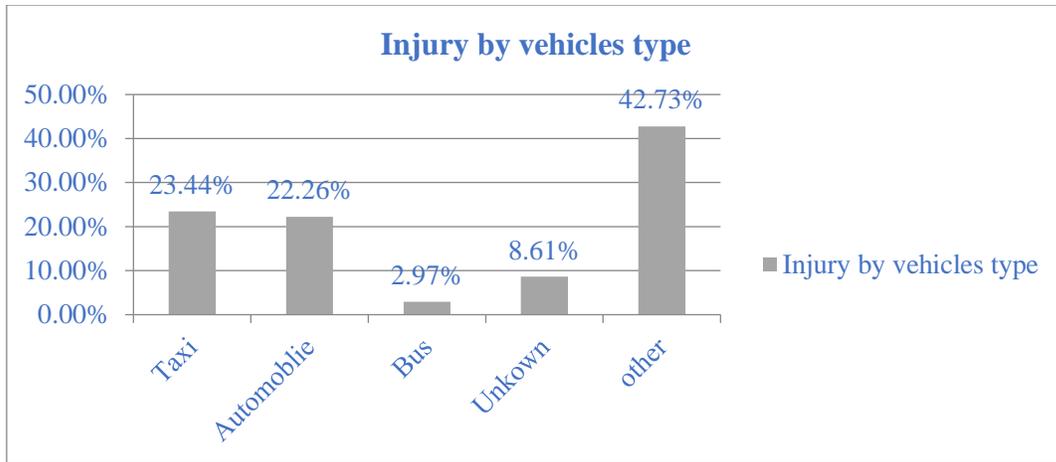
Figure 4-7 Injury by Vehicles Type

Minibus taxis were found to have more than 7.5 times the injury crash involvement of public buses. This substantial difference highlights the relatively higher risk associated with minibus taxis in terms of injury crash incidents when compared to public buses.

4.4.2.1 Comparing Lagging Safety Performance

Lagging safety performance was evaluated by using a number of fatalities and injury per mode and 10,000 vehicles as stated in the national safety plan manual. Table 4.17 and 4.18 present the result.

Table 4-17 Reportable Fatalities by Mode.

Modes of transport	Number of Fleet	Number of fatalities	Number of reportable deaths by mode	Fatalities per 10,000 vehicles
Minibus (Taxi)	7679	67	0.008725094	87.2509441
Midi bus	750	5	0.006666667	66.6666667
Public Service	151	1	0.006622517	66.2251656
Anbesa Bus	589	2	0.003395586	33.9558574
Sheger Bus	329	2	0.006079027	60.7902736

Based on the data presented in Table 4.17, minibus taxis have a higher fatality rate compared to other transportation modes, with 87.25 fatalities per 10,000 vehicles. This rate is significantly higher than other modes. Midi-buses follow as the second-most hazardous mode, with a fatality rate of 66.667 per 10,000 vehicles. Additionally, minibus taxis and midi-buses have the highest incidence of injuries, with 0.010 and 0.008 reportable injuries per mode, respectively, according to the analysis.

Table 4-18 Reportable Injuries by Mode.

Modes of transport	Fleet number of the mode	Number of injuries	Number of reportable injuries by mode
Taxi	7679	79	0.010287798
Midi bus	750	6	0.008
Public Service	151	1	0.006622517
Anbesa Bus	589	2	0.003395586
Sheger Bus	329	2	0.006079027

The findings of this study highlight the need for targeted interventions to improve the safety of minibus taxis. These interventions may include driver training programs, vehicle maintenance programs, and improved safety regulations. The results also suggest the need for further research to investigate the factors contributing to the higher fatal or injury crash involvement of minibus taxis compared to large public buses. Future studies may consider the impact of driver behavior, vehicle design, and road infrastructure on injury crash involvement among public transport vehicles.

4.4.3 Summary

This study employs a combination of leading and lagging safety performance evaluation methods to conduct a comprehensive analysis of the safety performance of different modes of public transportation. The findings from the leading indicators indicate that the taxi sector exhibits the poorest safety performance, indicating a higher likelihood of accidents. These results align with the outcomes derived from the lagging safety performance evaluation and the Addis Ababa Annual Road Safety Report.

According to the Addis Ababa Annual Road Safety Report for 2018, minibus taxis accounted for 27% of fatal crashes and 31% of injury crashes, followed by automobiles. Similarly, the lagging performance evaluation results indicate that taxis accounted for 16.75% of fatal cases, with 87.25 fatalities per 10,000 vehicles. This highlights the cause-and-effect relationship between leading and lagging safety performance measures, where higher-leading performers tend to have lower involvement in lagging outcomes such as accidents, fatalities, and injuries.

In conclusion, measuring safety performance plays a crucial role in addressing safety issues within transportation systems. It aids in reducing harmful safety outcomes by enhancing our understanding and measurement of hazards and risks associated with such outcomes. Moreover, it informs the development of effective policies, procedures, and practices, facilitating continuous improvement and a better understanding of detrimental safety outcomes, such as fatalities.

4.5   Security Performance Evaluation

This section presents an evaluation and comparison of five modes of public transport with respect to their security performance by utilizing three indicators: availability of security staff, availability of CCTV or other surveillance systems, and not being afraid of becoming a victim. Before that, factor analysis was performed to ensure these indicators are appropriate for grouping under the security performance in the case of Addis Ababa. After that regression analysis was performed to identify the coefficients of these indicators.

4.5.1   Security Performance Analysis

This section undertakes an evaluation of five modes of public transport with respect to three security performance indicators and Table 4.19 displays the indicator coefficients for each mode of transport.

Table 4-19 Security Performance Indicator Coefficient

	Security Performance indicator coefficient				
Indicators	Taxi	Midi bus	Public Service Bus	Anbesa Bus	Sheger Bus
Availability of security staff	0.441	0.412	0.379	0.470	0.439
Availability of CCTV or other surveillance systems	0.354	0.419	0.553	0.462	0.594
Not being afraid of becoming a victim	0.686	0.590	0.527	0.349	0.491

Based on the results, minibus taxis exhibit the highest coefficient in terms of lacking fear of victimization, despite possessing the lowest coefficient for the availability of surveillance systems. Conversely, Sheger and Anbesa city buses demonstrate higher coefficients for the availability of surveillance systems, yet lower coefficients for the absence of fear of victimization.

The most notable disparity is observed in the coefficient on the absence of fear of victimization between minibus taxis and Anbesa city buses, with a gap of 0.689 to 0.349.

4.5.2 Overall security Performance Analysis

Table 4.20 presents the security performance of the selected modes of transport based on three performance indicators.

Table 4-20 Public Transport Security performance descriptive result

	N	Mean	Std. Deviation	Std. Error	95% CI		Minim um	Maxim um
					Lower Bound	Upper Bound		
Minibus Taxi	400	1.697	.58229	.0291	1.64	1.7547	1.00	4.00
Midi Bus	400	1.485	.53539	.0267	1.43	1.5384	1.00	3.67
Public Service Bus	400	2.303	.78607	.0393	2.22	2.3806	1.00	4.67
Anbesa City Bus	400	2.350	.90990	.0455	2.26	2.4394	1.00	5.00
Sheger Bus	400	2.235	.72984	.0364	2.16	2.3071	1.00	5.00
Total	2000	2.014	.80301	.0179	1.97	2.0496	1.00	5.00

The result indicates that Anbesa city buses and public service buses have the highest mean security values of 2.35 and 2.30, respectively. On the other hand, the midi-buses and minibus taxis had the least performance by having mean security values of 1.48 and 1.69, respectively.

To determine whether the observed differences in mean security are statistically significant or not, a one-way analysis of variance (ANOVA) is performed. The first step in conducting an ANOVA is to formulate a hypothesis.

Hypothesis

- The null hypothesis (H0) states that there is no significant difference in security performance level among the groups.
- The alternate hypothesis (H1) asserts that at least one of the mean-security values of the modes is different.

The significance level for this analysis is set at $\alpha=0.05$. The null hypothesis will be accepted if the p-value is greater than α, indicating that the observed differences in mean security values are not statistically significant. On the other hand, if the p-value is less than α, the alternate hypothesis will be accepted, indicating that there is a statistically significant difference in security performance level among the groups.

Table 4-21 One-way Analysis of Variance (ANOVA)

	Sum of Squares	Df	Mean Square	F	p-value
Between Groups	249.921	4	62.480	119.960	.000
Within Groups	1039.080	1995	.521		
Total	1289.001	1999			

According to the outcome of the one-way analysis of variance (ANOVA), the p-value is lower than 0.05. This implies that there is a noteworthy difference in the security performance levels among the modes. Consequently, when the ANOVA's p-value is statistically significant, it is necessary to perform post hoc multiple comparisons among the groups. Table 4.22 present the post-hoc multiple comparison results.

Table 4-22 Post hoc Multiple Comparison Result

(I) modes		Mean Difference (I-J)	Std. Error	P-value	95% CI Lower Bound	95% CI Upper Bound
Taxi	Midi Bus	.21169	.05103	.000	.0724	.3510
	Public Service Bus	-.60585	.05103	.000	-.7452	-.4665
	Anbesa City Bus	-.65251	.05103	.000	-.7918	-.5132
	Sheger Bus	-.53792	.05103	.000	-.6772	-.3986
Midi Bus	Taxi	-.21169	.05103	.000	-.3510	-.0724
	Public Service Bus	-.81754	.05103	.000	-.9569	-.6782
	Anbesa City Bus	-.86419	.05103	.000	-1.0035	-.7249
	Sheger Bus	-.74960	.05103	.000	-.8889	-.6103
Public Service Bus	Taxi	.60585	.05103	.000	.4665	.7452
	Midi Bus	.81754	.05103	.000	.6782	.9569
	Anbesa City Bus	-.04666	.05103	.891	-.1860	.0927
	Sheger Bus	.06794	.05103	.672	-.0714	.2073
Anbesa City Bus	Taxi	.65251	.05103	.000	.5132	.7918
	Midi Bus	.86419	.05103	.000	.7249	1.0035
	Public Service Bus	.04666	.05103	.891	-.0927	.1860
	Sheger Bus	.11459	.05103	.163	-.0247	.2539
Sheger Bus	Taxi	.53792	.05103	.000	.3986	.6772
	Midi Bus	.74960	.05103	.000	.6103	.8889
	Public Service Bus	-.06794	.05103	.672	-.2073	.0714
	Anbesa City Bus	-.11459	.05103	.163	-.2539	.0247

The mean difference is significant at the 0.05 level. *

Based on the post hoc test outcomes, the obtained p-value is lower than 0.05 for the comparison of performance levels between minibus taxis and midi buses with other modes, indicating statistical significance.

Conversely, the results indicate a lack of significant difference in the security performance of public service buses compared to Anbesa city buses and Sheger buses. Thus, it can be concluded that there is no significant distinction between public service buses, Anbesa city buses, and Sheger buses in terms of security performance.
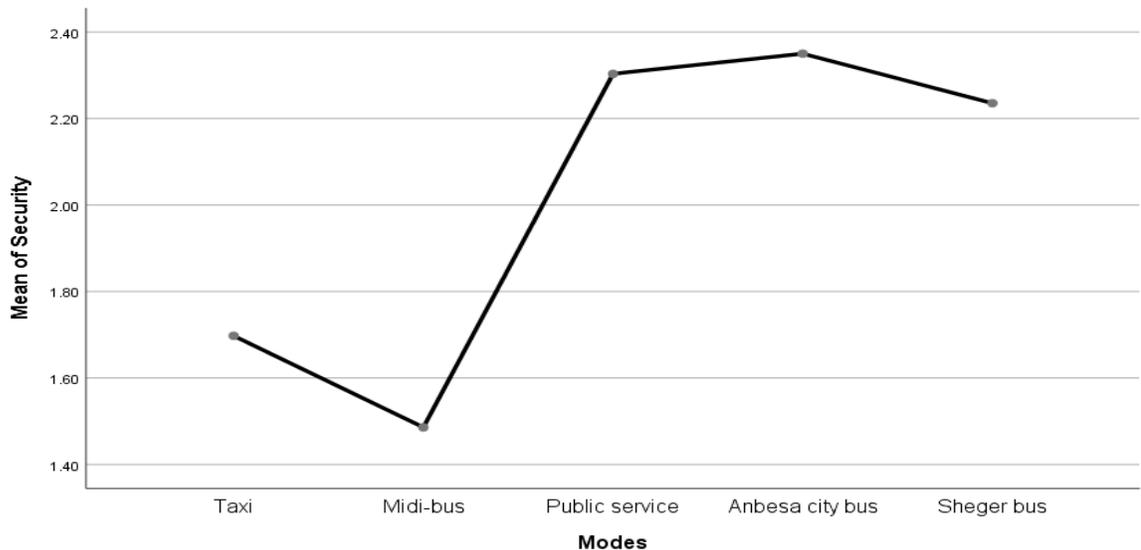
Figure 4-8 Means Plot for Security Performance of Public Transport

The mean plot presented in Figure 4.8 reveals that the midi-bus is the lowest performer in terms of security, followed by the minibus taxi. In contrast, Anbesa city buses and public service buses are the highest performers, followed by Sheger mass transit.

4.5.3 Summary

This section presents a comparison of the security performance of different modes of public transport using analysis of variance (ANOVA) as a statistical tool. The results indicate that public service buses have the highest level of security performance, while midi buses have the lowest. These findings suggest that there may be significant differences in the security measures implemented across different modes of public transport.

One possible implication of this study is that policymakers and transport operators may want to consider prioritizing security measures for modes of public transport that have been found to be less secure, such as midi buses. This could include measures such as increased surveillance, better training for drivers and staff, and improved communication channels for reporting security incidents.

4.6 Summary

This study evaluated five public transportation modes in Addis Ababa, focusing on comfort, affordability, safety, and security. The findings revealed significant insights:

- In terms of comfort, taxis provided space for passengers, while Anbesa buses had limited space availability due to high passenger loading. Taxis achieved an overall Level of Service D, whereas Anbesa buses scored a Level F. Regarding noise levels, public service buses had the highest subjective and objective sound levels performance rating, indicating a quieter environment for passengers.

- The study highlighted the overall unaffordability of the transportation system in Addis Ababa, with a significant portion of passengers spending more than 10% of their monthly earnings on transportation. Minibus taxis were identified as the least affordable option, while the Anbesa bus and Sheger bus were the most economically accessible choices. In terms of safety, taxis demonstrated poorer safety performance based on leading indicators, suggesting a higher likelihood of accidents. This was supported by lagging safety performance analysis and the Addis Ababa Annual Road Safety Report, which highlighted taxis' involvement in a significant number of fatal and injury crashes.

- In terms of security, public service buses displayed the highest level of security performance, while midi buses exhibited the lowest. This implies variations in security measures implemented across different modes of transport.

Policymakers and transport operators are advised to prioritize security enhancements for less secure modes, including increased surveillance and improved training for drivers and staff.

In conclusion, this study emphasizes the importance of considering multiple factors in evaluating transportation performance. It provides valuable insights for policymakers and transportation authorities to develop strategies that enhance comfort, affordability, safety, and security in public transportation. By addressing these aspects, the aim is to improve passenger satisfaction, increase ridership, and support the development of sustainable and efficient transportation systems in Addis Ababa.

CHAPTER FIVE

5. COMMUTER MODE CHOICE PREFERENCE ANALYSIS

5.1 Introduction

This study has aimed to explore the mode choice behavior of commuters with respect to public transport attributes in the context of Addis Ababa. To achieve this goal, the study employs multinomial logistic regression. Through this analytical approach, we can gain valuable insights into how demographic and trip-related variables impact the decision-making process of public transport users, thus providing critical information for policymakers looking to enhance public transportation services in Addis Ababa.

5.2 Modal Choice Preference Model

Research on commuter mode choice preferences has commonly used demographic and trip-related variables to understand individual travel behavior. For instance, a study conducted in Hong Kong by Lo in 2005 found that age, gender, and education level, as well as trip-related variables such as travel time and trip purpose, were significant factors in influencing transit users. Similarly, a study conducted in Tehran by Zabihi in 2012 found that demographic variables such as age, gender, and income level, as well as trip-related variables such as travel time and trip purpose, were significant in determining mode choice preference decision. By inferring number of studies, this research considers the following variables as a relevant for studying commuter mode choice preference in Addis Ababa.

Table 5-1 Independent Variables for Commuter Preference Model

Variable	Label	Data Type
Sex	SEX	Nominal
Age	AGE	Ordinal
Monthly Income	MI	Ordinal
Education Level	EDUL	Ordinal
Marriage Status	MRG	Nominal
Trip Purpose	TP	Nominal
Frequently used Mode	FUM	Nominal
Trip Per Week	TPW	Ordinal

To ensure accurate estimation, it's important to note that the independent variables should not be highly correlated with one another. To verify this, a correlation matrix is conducted and presented in the **Appendices Part E: Correlation Matrix of The Independent Variables**.

In this analysis correlation coefficient value is less than 0.7, indicating the absence of a significant correlation among the independent variables. The result inferred that the independent variables are sufficiently independent, meaning they provide distinct information to the model. This independence enables the model to accurately determine the unique effects of each independent variable on the dependent variable.

After selecting the relevant independent variables and checking their correlation, a comprehensive model has been developed to understand how commuters prioritized the public transport attributes when they made mode choice decision. This will ultimately lead to more effective policy decisions and improvements in public transportation services.

5.2.1 Multinomial Logistic Regression Result

In multinomial logistic regression, the selection of the base category or reference group is a crucial step, as it profoundly influences the interpretation of the coefficients and odds ratios. Typically, the choice of the base category is grounded in either theoretical or practical considerations. One approach involves designating the most prevalent or extensive category as the base group, while another involves assessing the impact of the reference group on the interpretation of the results. Ultimately, the selection of the base category is a weighty decision that can significantly shape the understanding and analysis of the results obtained. Base category used for this multinomial logistic regression model is presented in **Appendices Part F: Reference Category for Multinomial Logistic Regression Model.**

A combination of various variables is employed to derive the most suitable model fit. The initial model incorporates two demographic and two trip characteristics parameters, specifically gender, monthly income, frequently used mode and trip frequency. Building upon the first model, the second model includes additional variables, namely age and trip purpose. Lastly, the third model encompasses a range of variables, including gender, age, monthly income, education level, marital status, frequently used mode, trip frequency, and trip purpose. The coefficients and significance levels corresponding to these models are detailed in **Appendices Part G: Parameter Estimates.**

5.3 Model Selection

To ascertain the optimal multinomial logistic regression model among the three alternatives, a range of techniques can be employed. These include model comparison, cross-validation, and assessment of predictive accuracy. The essential goodness of fit statistics, such as deviance, AIC, and Pseudo R-Square, can serve as comparative measures for evaluating the models. Typically, the model with the lowest AIC or the highest Pseudo R-Square, is deemed superior. An alternative criterion for model selection is based on predictive accuracy, where the model exhibiting the highest accuracy is considered the most favorable. For comprehensive details, **Appendix Part: H: The Goodness of Fit Measures present the result**.

In this specific scenario, it is clear that model three outperforms the other two models in terms of classification accuracy percentage, AIC, and Pseudo R-Square values. This is due to the added variables having a significant improvement in the model's fit. Therefore, the third model is selected for further interpretation. The selected model is presented in Table 5.2.

Table 5-2 Final Selected Model

Parameter Estimates									
	Affordability			Safety			Security		
Dependent [a]	B	Exp(B)	Sig.	B	Exp(B)	Sig.	B	Exp(B)	Sig.
Intercept	-2.653		0.061	-2.830		0.052	-0.845		0.600
[SEX=Male]	0.631	1.879	0.068	0.036	1.037	0.915	-0.349	0.705	0.036
[SEX=Female]	0[b]			0[b]			0b		
[MI=Below 3,000 Birr]	3.640	38.090	0.015	-0.214	0.808	0.846	3.385	29.506	0.002
[MI=3000-50000 Birr]	2.198	9.010	0.060	-0.700	0.497	0.318	1.500	4.482	0.115
[MI=5000-10,000Bir]	1.547	4.696	0.171	-0.671	0.511	0.258	1.552	4.719	0.072
[MI=10,000-20,000 Birr]	0.457	1.580	0.691	-1.751	0.174	0.006	0.691	1.996	0.434
[MI=More Than 20,000]	0b			0b			0b		
FUM=Midi bus	1.649	5.202	0.008	1.903	6.705	0.002	-0.718	0.488	0.355
FUM=PSETSE	1.447	4.251	0.003	1.437	4.209	0.005	-0.087	0.917	0.859
FUM=ACBE	1.846	6.334	0.001	2.189	8.924	0.000	-1.059	0.347	0.153
FUM=SMTE	2.397	10.985	0.000	2.067	7.901	0.000	0.232	1.261	0.618
FUM=Taxi	0[b]			0[b]			0b		
TPW=2 days per week	-1.427	0.240	0.253	-0.703	0.495	0.594	-0.247	0.781	0.787
TPW=3 days per week	0.742	2.099	0.384	0.960	2.612	0.331	0.847	2.333	0.384
TPW=4 days per week	2.273	9.704	0.019	2.115	8.291	0.054	1.614	5.023	0.154

TPW=5 days per week	0.274	1.316	0.684	0.950	2.586	0.245	0.546	1.726	0.457
TPW=6 days per week	0.200	1.221	0.77	1.270	3.561	0.114	-0.227	0.797	0.757
TPW=7 days per week	0.007	1.007	0.992	1.267	3.550	0.116	0.308	1.361	0.668
TPW=1 day per week	0			0b			0b		
AGE=18 -24 years	2.097	8.139	0.101	0.081	1.084	0.965	-0.083	0.920	0.962
AGE=25-34 years	2.122	8.350	0.094	0.204	1.226	0.047	0.267	1.306	0.824
AGE=35-44 years	2.071	7.934	0.127	0.737	2.090	0.618	0.344	1.411	0.775
AGE=45-54 years	1.671	5.317	0.269	1.038	2.824	0.046	0.890	2.436	0.045
AGE=More than 55 years old	2.722	15.211	0.092	1.101	3.007	0.416	0.565	1.760	0.658
AGE= Below 18 years old	0b			0b			0b		
EDUL=Diploma	-0.461	0.631	0.682	-0.590	0.554	0.622	-0.268	0.765	0.799
EDUL=Degree	-0.750	0.472	0.505	-0.894	0.409	0.049	0.553	1.738	0.619
EDUL=Masters and Above	-0.266	0.766	0.824	-0.398	0.672	0.034	1.549	4.706	0.188
EDUL=Primary and Secondary	0b			0b			0b		
[MRG=Single]	-0.213	0.808	0.603	-0.122	0.885	0.047	0.090	1.094	0.825
[MRG=Married]	0b			0b			0b		
[TP=School Trip]	1.413	4.108	0.104	0.874	2.396	0.288	1.828	6.224	0.120

[TP=Recreational Trip]	0.940	2.561	0.322	0.491	1.634	0.593	1.497	4.470	0.227
[TP=Other Trip]	0.407	1.503	0.701	1.148	3.153	0.267	0.851	2.343	0.541
[TP=Work Trip]	0b			0					

a. The reference category is Comfort.

b. This parameter is set to zero because it is redundant.

5.4 Model Interpretations and Policy Implications

Gender

Gender has been coded as 1 for Female and 0 for Male, with Female as the base category. In Table 5.1, the estimated probabilities for gender show that security has a negative sign and a significant effect, while Affordability and Safety have a positive sign but are statistically insignificant with respect to the reference group, comfort. This suggests that female travelers are more concerned about security aspects of a mode. Specifically, being male decreases the odds ratio of selecting a secure mode of transport over a comfortable one by 0.705 times compared to being female, representing a reduction of 30%. This effect is statistically significant with a p-value less than 0.05.

In summary, when holding other variables constant, the odds of a male participant selecting a secure mode of transport over a comfortable one is 0.705 times or 30% lower than that of a female participant. This finding has significant implications for transportation policies and planning.

Age

The results indicate that age has a significant impact on the selection of transportation modes based on safety and security aspects. However, the same cannot be said for affordability. As the age of the participant increases, the odds of selecting a safe and secure mode of transport over a comfortable one also increases. For example, when compared to the base category of age below 18, passengers in the age group of 25-34 are 1.226 times more likely to select a safe mode of transport over a comfortable one. Similarly, the odds ratio for the age group of 45-55 selecting safe mode over comfortable are 2.84 times higher than the age group below 18, after controlling for other variables. Moreover, among the respondents who prioritize security, those aged between 45-54 years have a 2.43 times higher odds ratio of selecting a security attribute rather than comfort as compared to those classified under 18 years old.

In essence, the results indicate that holding other factors steady, as individuals grow older; they are more prone to opt for safer and more dependable transportation methods. Notably, this trend is statistically meaningful.

Marital Status

When controlling for other variables, the likelihood of a single participant choosing safety over comfort is 11.5% lower than the odds ratio of a married individual. This finding is statistically significant, as indicated by a p-value below 0.05. Thus, it can be inferred that being married is associated with a higher prioritization of safety over comfort, compared to being single.

Education Level

It can be inferred that an individual's education level plays a crucial role in their modal choice preference with respect to the safety attribute of mass transit. With other variables held constant, the odds of an individual with a higher education level prioritizing safety over comfort are 1.64 times greater than those of an individual with a lower educational level. This finding indicates that education level has a substantial influence on the safety considerations of mass transit.

Monthly Income

The model has found that monthly income does not have a statistically significant impact on the commuter safety considerations. However, for both affordable and security outcomes, monthly income have observed a significant impact with p values less than 0.05. When comparing participants with less than 3000-birr monthly income to those with a monthly income higher than 20000 birrs, the odds of selecting affordable mode of transport instead of comfortable mode is 38.090 times greater, and the odds of selecting secured mode instead of comfortable mode are 29.506 times greater.

While holding all other variables constant, the odds of an individual with less than 3000-birr monthly income selecting affordable mode of transport instead of secured mode are 1.29 times the odds of someone in the higher income group (monthly income greater than 20,000 birr). Overall, as income increases, the odds of participants selecting comfort over affordable or secured modes of transport increase.

Trip Per Week

Although a weekly trip frequency may not show statistical significance in most cases, an increase in the number of trips taken by a passenger tends to lead them towards opting for an affordable mode of transportation rather than a comfortable one. This implies that passengers who take more trips per week are more likely to choose affordable transportation options when compared to comfortable ones.

To illustrate this point, consider a passenger who takes four trips per week. This passenger is 9.633 times more likely to choose affordable transportation over comfortable transportation than a passenger who only takes one trip per week. Similarly, a passenger who takes four trips per week is 4.63 times more likely to choose affordable transportation over comfortable transportation than a passenger who takes three trips per week. Moreover, passengers who take many trips per week tend to prioritize safety over comfort when choosing a mode of transportation. For instance, a passenger who takes five trips per week is 2.63 times more likely to choose a safe transportation option over a comfortable one than a passenger who takes only one trip per week.

Trip Purpose

The findings indicate that the odds of passengers intending to go to school selecting affordable modes over comfortable modes are 4.108 times greater than the odds of those intending to go on a work trip. This suggests that passengers going to school are more likely to prioritize affordability over comfort when selecting a mode of transportation.

When controlling for other variables, we also found that the odds ratio for someone who intends to go to recreational areas choosing affordable modes over comfortable modes is 0.243 times the odds of someone on a work trip. This indicates that passengers going to recreational areas are less likely to choose affordable modes over comfortable ones compared to those going on work trips.

Additionally, the model found that the odds ratio of a commuter who plans to go to a recreational area selecting secured modes rather than comfortable ones is 0.162 times the odds of a passenger on a work trip. This represents an 83% reduction in the odds of selecting secured modes over comfortable ones. This suggests that commuters going to recreational areas are more likely to prioritize comfort over security when selecting a mode of transportation. Finally, passengers intending to go to other places have 0.397 times the odds of selecting secured modes over comfortable modes compared to those on a work trip. This finding suggests that passengers going to other places are less likely to prioritize security over comfort when selecting a mode of transportation.

Frequently Used Mode

The model reveals that the "frequently used mode" variable does not have a significant impact on the odds of voting for security over comfort, while it is a significant predictor of affordability and safety. Specifically, individuals who frequently use midi-bus have about 5.188 times higher odds of selecting affordable mode over comfortable mode as compared to those who frequently taxi user, and individuals who frequently use public service have about 4.246 times higher odds of selecting affordable mode than comfortable as compared to frequent taxi users. Additionally, frequent users of Anbesa city bus and Sheger mass transport have even higher odds of selecting affordable mode over comfortable mode, with odds ratios of 6.370 and 11.002, respectively as compared to frequent taxi users. All of these effects are statistically significant, with p-values ranging from 0.001 to 0.009.

Regarding safety, individuals who frequently use midi-bus, public service, Anbesa city bus, and Sheger mass transport have significantly higher odds of selecting safe mode over comfortable modes as compared to frequent taxi users, with odds ratios of 6.628, 4.154, 9.013, and 7.775, respectively. All of these effects are statistically significant, with p-values less than 0.05. Therefore, these results suggest that frequent use of certain modes of transport can significantly predict individuals' affordability and safety preferences, while having no significant impact on their security preferences.

5.5 Summary

In summary, the analysis shows that gender, age, trip purpose, marital status, education level, and monthly income have a significant impact on the mode choice preference decisions. Being male reduces the odds of selecting a secure mode of transport over a comfortable one compared to being female. As individuals grow older, they are more likely to opt for safer and more dependable transportation modes. Passengers intending to go to school have a higher likelihood of selecting affordable modes over comfortable modes than those on a work trip. Being married is associated with a higher prioritization of safety over comfort compared to being single. Individuals with a higher education level are more likely to prioritize safety over comfort in mass transit mode selection. Monthly income has a significant impact on affordable and secure mode choice, but not on safety. Finally, the frequently used mode variable is a significant predictor of affordability and safety, but not security. These findings have significant implications for transportation policies and planning.

The model results can be used by policymakers to develop policies and interventions that promote affordable, safe and secure transportation for all individuals. Specifically, the findings on age, trip purpose, marital status, education level, and monthly income can inform the development of targeted policies to address the unique transportation needs of different demographic groups.

For instance, policies could be developed to encourage younger individuals to prioritize safety when choosing a mode of transportation, and to promote safer modes of transportation for individuals who prioritize safety and security.

The findings also suggest that affordable modes of transportation are more likely to be selected by individuals who frequently use midi-bus, public service, Anbesa city bus, and Sheger mass transport. This information can be used to develop policies that focus on improving the affordability of transportation for these groups. Similarly, policies could be developed to promote education and awareness among individuals with lower education levels to help them prioritize safety when choosing a mode of transportation.

Finally, the findings on monthly income suggest that policies to improve the affordability and security of transportation should be targeted towards individuals with lower monthly incomes, as they are more likely to prioritize affordability and security when choosing a mode of transportation. Policies could include subsidies or discounts for low-income individuals to make safe and secure transportation more accessible and affordable for them. Overall, these findings can be used by policymakers to develop targeted policies and interventions that promote safe and secure transportation for all individuals, particularly those who are more vulnerable to the negative impacts of unsafe and insecure transportation.

CHAPTER SIX

6. CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The purpose of this study was to evaluate and compare the performance of various modes of public transport in Addis Ababa in terms of comfortability, affordability, safety, and security, while also examining how commuters prioritize these attributes when selecting a mode of transport. To achieve this, the study utilized a combination of subjective and objective performance evaluation measures, as well as leading and lagging safety performance evaluation measures. Despite its contributions to the understanding of mass transit in Addis Ababa, this study is not without limitations. The study only examined five modes of transportation, rather than all modes, and relied solely on subjective data to assess security performance due to a lack of objective data. Additionally, the study was conducted before the implementation of the new transportation tariff, which may have influenced affordability performance. These limitations could potentially introduce biases and confounding factors that may have affected the results. Therefore, for future study by addressing those issues the findings would be profoundly sound. Overall, this study contributes to our understanding of the performance of the available mode of mass transit and highlights how commuter's demographic and trip characteristic impacted the mode preference decisions, and the result summarized as follow.

- This study highlights the importance of utilizing both subjective and objective performance evaluation methods to obtain a comprehensive understanding of the quality of service offered to passengers. By doing so, transit operators can identify areas for improvement and ultimately increase ridership. The study revealed that minibus taxis performed well in terms of comfort, while public service buses had low noise levels. However, the Anbesa bus had a poor Level of Service value, indicating a need for improvement in service frequency and vehicle quality.

Overall, this study emphasizes the need for ongoing evaluation and improvement of public transportation services to meet the expectations and requirements of passengers.

- The study highlights the issue of unaffordable public transportation in Addis Ababa, with more than 25% of passengers spending over 10% of their income on transportation fees. The analysis reveals that taxis are the least affordable mode of transportation, while Anbesa bus and Sheger bus are the most affordable options. The findings can be instrumental in informing policymakers and transportation authorities in formulating effective strategies to improve transportation performance and enhance equitable accessibility for all commuters.

- This thesis highlights the importance of leading indicators in safety management, which help to identify and mitigate potential hazards before occur. The result indicates poor leading safety performance of the taxi sector, with an increased likelihood of accidents. Therefore, prioritizing leading indicators can help organizations enhance their safety performance and adopt a proactive approach to safety management.

- This thesis section also compares the security performance of different modes of public transport using ANOVA. Public service buses have the highest security performance, while midi buses have the least. Policymakers and transport operators should prioritize security measures for less secure modes of transport. Robust security measures enhance passenger safety and confidence, leading to increased ridership and support for public transport systems.

- The study provides insights into commuters'' preferences for different attributes of public transportation systems and highlights the strengths and weaknesses of various systems. Policymakers and transportation planners can use these insights to design policies and infrastructure that improve public transport and enhance customers'

satisfaction. However, further analysis may be necessary to fully understand the underlying factors influencing passenger behavior.

- The multinomial logistic model also revealed that gender, age, trip purpose, marital status, education level, and monthly income significantly affect commuter mode preferences decisions. The results suggest that policymakers can use these findings to develop targeted policies and interventions that promote safe and secure transportation for all individuals, especially those who are more vulnerable. For example, policies could focus on promoting safer modes of transportation for individuals who prioritize safety and security and increasing affordability for those who frequently use specific modes of transportation. Additionally, policies could promote education and awareness among individuals with lower education levels to help them prioritize safety when choosing a mode of transportation. Overall, these findings have significant implications for transportation policies and planning.

6.2 Recommendation

Effective public transportation is critical for the travel industry to attract new passengers and benefit the public by increasing transportation effectiveness, decreasing pollution, progressing local and national economies, and promoting social inclusion. Particularly after the COVID-19 outbreak, to make public transport an appealing and everyday option for residents, cities ought to plan their administrations appropriately and overcome physical and social obstructions. So that, qualities of public transport services that impact mode choice behavior for instance, comfortability, reliability, frequency, accessibility, convenience, affordability, and security are weighted more. Be that as it may, this study ponders, as it were, the comfort, affordability, safety, and security of mass transit. In this manner, to improve its engaging quality, these fundamental components that impact the mode choice of the traveler should be improved.

- Transit operators should utilize both subjective and objective performance evaluation methods to obtain a comprehensive understanding of the quality of service offered to passengers. This will help them identify areas for improvement and ultimately increase ridership.

- The study recommends that to improve the attractiveness and effectiveness of public transportation, service providers should focus on improving safety, comfort, security, and affordability performance. The study identifies the minibus taxi as the most dangerous and expensive mode of transportation and recommends that service providers should divert additional funds to improve these critical services, such as affordability and safety, to attract new passengers. The midi-bus is also identified as having the worst safety and comfort performance, while public service bus transportation is the least objectionable, but its avoidance is primarily motivated by its comfort and safety. The study also identifies the Anbesa City Bus as the best performer in terms of affordability, but its lack of usage is due to its poor comfort and safety performance.

- Policymakers and transportation authorities should formulate effective strategies to improve transportation performance and enhance equitable accessibility for all commuters, particularly for the low-income population.

- Transportation organizations should prioritize leading indicators in safety management to identify and mitigate potential hazards before incidents occur. This will help them enhance their safety performance and adopt a proactive approach to safety management.

- Policymakers and transport operators should prioritize security measures for less secure modes of transport to enhance passenger safety and confidence, leading to increased ridership and support for public transport systems.

- Policymakers should use the findings of the multinomial logistic model to develop targeted policies and interventions that promote safe and secure transportation for all individuals, especially those who are more vulnerable. Policies could focus on promoting safer modes of transportation for individuals who prioritize safety and security and increasing affordability for those who frequently large bus users. Additionally, policies could promote education and awareness among individuals with lower education levels to help them prioritize safety when choosing a mode of transportation.

In common, these discoveries are vital since, in a progressively competitive transport environment, it is fundamental to know the key components that go into the decision-making preparation of major transport clients and their mode of travel determination. These discoveries, in specific, give experimental bolster for the idea that travel execution is foremost critical to calculating mode determination and throughput assurance from the viewpoint of travelers. It is, in this manner, basic that transport administrators and policymakers grant the best need to move forward their general level of execution relative to other variables to draw in more travelers to utilize their modes.

The discoveries of this study are also intriguing to transport directors since the qualities and shortcomings of the modes can be distinguished. With this understanding, the means of transport may have a superior position and define methodologies to pick up competitive preferences. In this way, on the off chance that any of the transit's modes point to outperforming their competitors, they must endeavor to be more competitive within the critical criteria.

6.3 Future Study

As a recommendation for future studies, it is suggested that Modal Split models should be created to include a more comprehensive set of variables, including factors related to comfort, affordability, safety, and security, in addition to other relevant characteristics. This would enable transportation planners and policymakers to evaluate the potential impacts of different transportation policies, interventions, and infrastructure investments on travel behavior more effectively.

Furthermore, it is recommended that sensitivity analysis be conducted on these models to determine the extent to which different attributes influence mode choice. This would provide insights into which variables are most significant and help decision-makers prioritize interventions that are likely to be most effective in achieving their goals. By improving Modal Split models in this way, policymakers can better predict travel behavior and make informed decisions that improve transportation outcomes for all users.

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APPENDICES

Part A: Questionnaire

A1: English version Questionnaire

Dear participant:

My Name is Shambel Assefa. I am presently pursuing a Master of Science Degree in Civil and Environmental Engineering under Road and Transport Engineering at Addis Ababa University Institute of Technology, School of Graduate Studies.

This questionnaire aims to study the performance of Public Transport in terms of comfort, fare, safety, and security in Addis Ababa. Please answer all questions where possible. All the information gathered will be kept strictly confidential and will be used only for academic research and analysis without mentioning the names of the individuals involved.

Thank you in advance for your time and kind cooperation.

General Direction

Please mark your response by putting "√" mark in the space provided that most explain your feeling.

Remark

No need of writing your name.

Yours Faithfully

Shambel Assefa Esheti

(Mobile. +251914462745 or email <assefashambel@gmail.com>)

Supervised by:

Dr. Bikila Teklu

Addis Ababa, Ethiopia

Part one: Demographic Information

1. Sex   Male ☐   Female   ☐

2. In which category is your age?

Below 18 years   ☐   18-24 years   ☐   25-34 years   ☐   35-44 years   ☐

45-54 years   ☐   55-64 years   ☐   65 years or older   ☐

3. Income level

Less than 3,000 Birr   ☐ 3,000 Birr up to 5,000 Birr   ☐ 5,000 Birr up to 10,000Birr
☐

10,000Birr up to 20,000   ☐   More than 20,000Birr   ☐

4. Your level of formal education

Primary or secondary school   ☐   Diploma ☐   Degree   ☐   Masters and above ☐

5. Marriage status

Married   ☐   Single   ☐   Divorced ☐   widow // widower   ☐

Part Two: Trip maker characteristics

1. For what purpose do you take the trip?

To go to School   ☐   to go to work   ☐   to go to recreational area ☐   to go to other
☐

2. Which modes of Public Transport do you use frequently?

Mini bus (Taxi) ☐   Midi Bus   ☐ Public service ☐   Alliance bus ☐   Anbesa
bus   ☐   LRT   ☐   Walking   ☐   others   ☐

3. How often do you use public transport such as Taxi, bus or LRT?

1 day per week   ☐   2 days per week   ☐   3 days per week ☐   4 days per week   ☐

5 days per week   ☐   6 days per week   ☐   7 days per week ☐

4. How much do you pay for the trip you make per day? _____

Part Three: Performance Evaluation

Listed below are descriptive parameters about public transport performance indicators for comfort, fare, safety, and security measures in public transport modes. Rate each mode of transport according to its performance by using parameters as reference.

Parameter	Modes	v. poor	Poor	Moderate	Good	V. good
1. Cleanliness of Vehicle	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					
2. Probability of getting Seats	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					
3. Seats Comfort like availability of enough space for leg movement	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					
4. Sound level in the transport service	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					
5. Driving behaviors like, weaving, swerving, speeding,	Taxi					
	Midi Bus					
	Public service					

driving too slowly, and other situations	Anbesa bus					
	Sheger Bus					
6. In-vehicle trip information (Announcement of next stops using screens or audio).	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					
7. The transport service well-lit and at an adequate temperature. (Ventilation and temperature in general air conditioning on the system.	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					
8. Available space for each traveler, i.e., how crowded the vehicle is?	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					
9. Travel Time taken to complete the journey (the modes provide short travel time rated as very good	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					
10.Transport price affordability (tickets cost)	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					
	Taxi					
	Midi Bus					

11. Availability of seat belt and Anchored seating for the children	Public service					
	Anbesa bus					
	Sheger Bus					
12. Availability of Security staff like police	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					
13. Availability of Additional safety precautions like Fire extinguishers, in case of fire	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					
14. Availability of Door closing' signals like Lit before doors begin to close	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					
15. Availability of security products like CCTV inside transport service	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					
16. Not afraid of being pickpocket	Taxi					
	Midi Bus					
	Public service					
	Anbesa bus					
	Sheger Bus					

Part four: About mode choice characteristics

1. Which public transport do you avoid using mostly?

Taxi ☐   Midi Bus ☐   Public service ☐

Anbesa bus ☐   Alliance Bus ☐

2. What is the reason behind avoiding the transport means you selected above?

Taxi	Alliance Bus	Anbesa bus	Midi Bus	Public service
Uncomfortable ☐	Uncomfortable ☐	Uncomfortable ☐	Uncomfortable ☐	Uncomfortable ☐
Unaffordable ☐	Unaffordable ☐	Unaffordable ☐	Unaffordable ☐	Unaffordable ☐
Unsafe and unprotected ☐	Unsafe and unprotected ☐	Unsafe and unprotected ☐	Unsafe and unprotected ☐	Unsafe and unprotected ☐

3. Prioritize or order the following public transport performance indicator parameter used when you choose your transport modes
    a. Comfort
    b. Fare
    c. Safety
    d. Security

A2: Amharic Version Questionnaire

መጠይቅ

ዉድ ተሳታፊ:

ሻምበል አሰፋ እባላለሁ አሁን በአዲስ አበባ ዩኒቨርሲቲ የቴክኖሎጂ ኢንስቲትዩት የድህረ ምረቃ ትምህርት ቤት በሲቪል እና አካባቢ ጥበቃ ምህንድስና ት/ት ክፍል በመንገድ እና ትራንስፖርት ምህንድስና የማስተርስ ዲግሪዬን እየተከታተልኩ ነው::

ይህ መጠይቅ በአዲስ አበባ ውስጥ ካለው ምቾት፣ ታሪፍ፣ እና ደህንነት አንፃር የህዝብ መጓጓዣ አፈጻጸምን ለማጥናት ያለም ነው:: እባክዎን በተቻለ መጠን ሁሉንም ጥያቄዎች ይመልሱ:: ሁሉም የተሰበሰቡ መረጃዎች በጥብቅ ሚስጥራዊ ይሆናሉ እና የተሳተፉትን ግለሰቦች ስም ሳይጠቅሱ ለአካዳሚክ ጥናትና ምርምር ብቻ ጥቅም ላይ ይውላሉ ::

ስለ ጊዜዎ እና ደግ ትብብርዎ አስቀድሜ አመሰግናለሁ::

አጠቃላይ አቅጣጫ

እባክዎን ስሜትዎን በጣም በሚያብራራ ቦታ ላይ "√" ምልክት በማድረግ ምላሽዎን ያስቀምጡ::

አስተያየት

ስምዎን መጻፍ አያስፈልግም

አመሰግናለሁ

ሻምበል አሰፋ እሸቴ

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አማካሪ

ዶ/ር. ቢቂላ ተክሉ

ክፍል አንድ: የሥነ ሀዝብ መረጃ

1.1 ፆታ

ወንድ ☐   ሴት ☐

1.2 እድሜዎ በየትኛዉ ምድብ ነዉ?

ከ 18 አመት በታች   ☐   ከ 18 እስከ 24 አመት   ☐   ከ 25 እስከ 34 አመት ☐

ከ 35 እስከ 44 አመት   ☐   ከ45 እስከ 54 አመት   ☐   ከ 55 እስከ 64 አመት ☐

ከ 65 አመት ወይም በላይ   ☐

1.3 የወር ገቢዎ መጠን

ከ 3,000 ብር በታች   ☐   ከ 3,000 እስከ5,000 ብር   ☐   ከ5,000 እስከ 10,000 ብር   ☐

ከ 10,000እስከ20,000 ብር   ☐   ከ20,000 ብር በላይ   ☐

1.4 የትምህርት ደረጃ

አንደኛ ወይም ሁለተኛ ደረጃ   ☐   ዲፕሎማ   ☐   ድግሪ   ☐

ሁለተኛ ድግሪ ወይም በላይ   ☐

1.5 የጋብቻ ሁኔታ

ያገባ   ☐   ያላገባ ☐   የተፋታ   ☐   ባል /ሚስት የሞተበት/ ባት   ☐

ክፍል ሁለት: የጉዞ ሁኔታ

2.1 ለምን አላማ ይጓዛሉ?

ወደ ትምህርት ቤት   ☐   ወደ ሥራ   ☐   ወደ መዝናኛ ቦታ   ☐   ወደ ሴላ   ☐

2.2 የትኞቹን የሀዝብ ማመላለሻ ዘዴዎች በተደጋጋሚ ይጠቀማሉ?

ታክሲ ☐ መካከለኛ አዉቶብስ ☐ የህዝብ አዉቶብስ ☐ ሸገር አዉቶብስ ☐

አንበሳ አዉቶብስ ☐ ሌሎች ☐

2.3 የሀዝብ መጓጓዣ ለምን ያህል ጊዜ ይጠቀማሉ?

በሳምንት አንድ ቀን ☐ በሳምንት ሁለት ቀን ☐ በሳምንት ሶስት ቀን ☐

በሳምንት አራት ቀን ☐ በሳምንት አምስት ቀን ☐ በሳምንት ስድስት ቀን ☐

በሳምንት ሰባት ቀን ☐

2.4 **በቀን ለሚያደርጉት ጉዞ ምን ያህል ይከፍላሉ?**

_____

ክፍል ስስት:

ከዚህ በታች የተዘረዘሩት ስለ ህዝብ መጓጓዣ አፈጻጸም አመላካቾች ለምችት፣ ለክፍያ፣ ለደህንነት እና ለደህንነት እርምጃዎች በሕዝብ መጓጓዣ ዘዴዎች ገላጭ መለኪያዎች ናቸው። መለኪያዎችን እንደ ማጣቀሻ በመጠቀም እያንዳንዱን የመጓጓዣ ዘዴ እንደ አፈፃፀሙ ደረጃ ይስጡ።

መለኪያ	የመጓጓዣ ዘዴዎች	በጣም ዝቅ ያለ	ዝቅ ያለ	መጠነኛ	ጥሩ	በጣም ጥሩ
3.1 የተሻከርካሪ ንፅህና	ታክሲ					
	መካከለኛ አዉቶብስ (ሀይገር)					
	ፐብሊክ ሰርቪስ					
	አንበሳ አዉቶብስ					
	ሸገር አዉቶብስ					
3.2 መቀመጫዎች የማግኘት ዕድል	ታክሲ					
	መካከለኛ አዉቶብስ (ሀይገር)					
	ፐብሊክ ሰርቪስ					

	አንበሳ አዉቶብስ					
	ሸገር አዉቶብስ					
3.3 መቀመጫዎች ልክ እንደ እግር እንቅስቃሴ በቂ ቦታ እንደ መገኘት ያጸናኑ	ታክሲ					
	መካከለኛ አዉቶብስ (ሀይገር)					
	ፐብሊክ ሰርቪስ					
	አንበሳ አዉቶብስ					
	ሸገር አዉቶብስ					
3.4. በመንንዣ አገልግሎት ዉስጥ የድምፅ ደረጃ (እንደ ንዝረት፣ ከፍተኛ ድምፅ፣	ታክሲ					
	መካከለኛ አዉቶብስ (ሀይገር)					
	ፐብሊክ ሰርቪስ					
	አንበሳ አዉቶብስ					
	ሸገር አዉቶብስ					
	ቀላል ባቡር					
3.5 የማሽከርከር ባህሪ፣ መወዛወዝ፣ በፍጥነት ማሽከርከር፣ በጣም በዝግታ መንዳት እና ሌሎች ሁኔታዎች	ታክሲ					
	መካከለኛ አዉቶብስ (ሀይገር)					
	ፐብሊክ ሰርቪስ					
	አንበሳ አዉቶብስ					
	ሸገር አዉቶብስ					
3.6 በተሽከርካሪ ዉስጥ የጉዞ መረጃ (ስክሪን ወይም አዲዮን በመጠቀም ቀጣይ ማቆሚያዎች ማስታወቂያ)	ታክሲ					
	መካከለኛ አዉቶብስ (ሀይገር)					
	ፐብሊክ ሰርቪስ					
	አንበሳ አዉቶብስ					
	ሸገር አዉቶብስ					
3.7 የመንንዣ አገልግሎት በቂ ብርሃን እና በቂ አየር መኖር (የአየር ማናፈሻ እና የሙቀት መጠን አጠባበቅ፣ የአየር ማቀዝቀዣ በሲስተሙ ላይ መኖር) የአየር ምቹነት	ታክሲ					
	መካከለኛ አዉቶብስ (ሀይገር)					
	ፐብሊክ ሰርቪስ					
	አንበሳ አዉቶብስ					
	ሸገር አዉቶብስ					
3.8 ለእየንዳነዱ ተጓዢ ያለዉ ክፍት ቦታ ፡ ማለትም	ታክሲ					
	መካከለኛ አዉቶብስ (ሀይገር)					
	ፐብሊክ ሰርቪስ					
	አንበሳ አዉቶብስ					

መጓጓዣያዉ ምን ያህል የተጨናነቀ ነዉ	ሽገር አዉቶብስ						
3.9 ጉዞዉን ለማጠናቀቅ የሚፈጀዉ ጊዜ	ታክሲ						
	መካከለኛ አዉቶብስ (ሀይገር)						
	ፐብሊክ ሰርቪስ						
	አንበሳ አዉቶብስ						
	ሽገር አዉቶብስ						
3.10 የመጓጓዣ ዋጋ ተመጣጣኝነት (የቲኬቶች ዋጋ)	ታክሲ						
	መካከለኛ አዉቶብስ (ሀይገር)						
	ፐብሊክ ሰርቪስ						
	አንበሳ አዉቶብስ						
	ሽገር አዉቶብስ						
3.11 የመቀመጫ ቀበቶች እና ለህጻናት የተገጠመ መቀመጫ መኖር	ታክሲ						
	መካከለኛ አዉቶብስ (ሀይገር)						
	ፐብሊክ ሰርቪስ						
	አንበሳ አዉቶብስ						
	ሽገር አዉቶብስ						
3.12 እንደ ፖሊስ ያሉ የደህንነት ሰራተኞች መገኘት	ታክሲ						
	መካከለኛ አዉቶብስ (ሀይገር)						
	ፐብሊክ ሰርቪስ						
	አንበሳ አዉቶብስ						
	ሽገር አዉቶብስ						
3.13 በእሳት ጊዜ እንደ እሳት ማጥፊያ ያሉ ተጨማሪ የደህንነት ጥንቃቄዎች መገኘት	ታክሲ						
	መካከለኛ አዉቶብስ (ሀይገር)						
	ፐብሊክ ሰርቪስ						
	አንበሳ አዉቶብስ						
	ሽገር አዉቶብስ						
3.14 በሮች መዘጋት ከመጀመራቸው በፊት የበር መዝጊያ ምልክቶች መገኘት	ታክሲ						
	መካከለኛ አዉቶብስ (ሀይገር)						
	ፐብሊክ ሰርቪስ						
	አንበሳ አዉቶብስ						
	ሽገር አዉቶብስ						

3.15 እንደ CCTV (የደህንነት መጠበቂያዎች) በመጓጓዣ አገልግሎት ውስጥ መገኘት	ታክሲ				
	መካከለኛ አዉቶብስ (ሀይገር)				
	ፐብሊክ ሰርቪስ				
	አንበሳ አዉቶብስ				
	ሸገር አዉቶብስ				
3.16 ለዝርፊያ/ስርቆት የመጋለጥ እድል	ታክሲ				
	መካከለኛ አዉቶብስ (ሀይገር)				
	ፐብሊክ ሰርቪስ				
	አንበሳ አዉቶብስ				
	ሸገር አዉቶብስ				

ክፍል አራት: ስለ መጓጓዣ ሁነታ ምርጫ ባህሪያት

4.1 የትኛውን የህዝብ መጓጓዣ በብዛት ከመጠቀም ይቆጠባሉ

ታክሲ ☐   መካከለኛ አዉቶብስ (ሀይገር) ☐   ፐብሊክ ሰርቪስ ☐

አንበሳ አዉቶብስ ☐   ሸገር አዉቶብስ ☐   ቀላል ባቡር ☐

4.2 ከላይ ከተዘረዘሩት የመጓጓዣ አይነቶች ዉስጥ በብዛት ያልመለጣችሁበት ምክንያታችሁ ምንድን ነዉ?

ታክሲ	መካከለኛ አዉቶብስ (ሀይገር)	ፐብሊክ ሰርቪስ	አንበሳ አዉቶብስ	ሸገር አዉቶብስ
ምቹ አለመሆኑ ☐	ምቹ አለመሆኑ ☐	ምቹ አለመሆኑ ☐	ምቹ አለመሆኑ ☐	ምቹ አለመሆኑ ☐
ተመጣጣኝ ያልሆነ ክፍያ ☐	ተመጣጣኝ ያልሆነ ክፍያ ☐	ተመጣጣኝ ያልሆነ ክፍያ ☐	ተመጣጣኝ ያልሆነ ክፍያ ☐	ተመጣጣኝ ያልሆነ ክፍያ ☐

ደህንነቱ	ደህንነቱ	ደህንነቱ	ደህንነቱ	ደህንነቱ
ያልተጠበቀ ☐	ያልተጠበቀ ☐	ያልተጠበቀ ☐	ያልተጠበቀ ☐	ያልተጠበቀ ☐

4.3 ከሚከተሉት የህዝብ መጓጓዣ አፈጻጸም አመልካች ዝርዝሮች መካከል የመጓጓዣ ዘዴዎችን በሚመርጡበት ጊዜ ቅድሚያ የምትሰጡትን የህዝብ ማመላለሻ አፈጻጸም አመልካች በቅደም ተከተል አስቀምጡ

ሀ. ምቾት

ለ. የመጓጓዣ ታሪፍ

ሐ. የአደጋ ደህንነት

መ. ደህንነት/ጥበቃ

Part B: Parametric Test Assumption Result

Part B1: Comfort Performance data

Descriptive Analysis Result for Public Transport Comfort Performance

Modes		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Comfort	Taxi	400	100.0%	0	0.0%	400	100.0%
	Midi-bus	400	100.0%	0	0.0%	400	100.0%
	PSETSE	400	100.0%	0	0.0%	400	100.0%
	ACBE	400	100.0%	0	0.0%	400	100.0%
	SMTE	400	100.0%	0	0.0%	400	100.0%

Skewness and Z value

Modes	Skewness	Std. Error	z value
Taxi	-0.127	0.122	1.040983607
Midi -Bus	0.196	0.122	1.606557377
PSETSE	0.180	0.122	1.46348191
Anbesa bus	0.204	0.122	1.672131148
Sheger bus	0.043	0.123	0.346840737

Kurtosis and Z value

Modes	Kurtosis	Std. Error	z value
Taxi	-0.239	0.243	-0.9776
Midi -Bus	-0.036	0.243	-0.148913
PSTS	-0.140	0.243	-0.573234
Anbesa bus	-0.260	0.243	-1.063991
Sheger bus	-0.263	0.243	-1.072165

The z-values for skewness and kurtosis in the preceding table fall within the range of -1.96 and 1.96, indicating that the data is normally distributed.

	Tests of Normality						
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Modes		Statistic	df	P-value	Statistic	df	P-value
Comfort	Taxi	0.075	400	0.056	0.986	400	0.061
	Midi bus	0.065	400	0.063	0.982	400	0.053
	Public service	0.053	400	0.077	0.991	400	0.070
	Anbesa city bus	0.068	400	0.088	0.989	400	0.074
	Sheger bus	0.051	400	0.074	0.990	400	0.079

P- value is greater than 0.05; This implies that the data are normally distributed. Therefore, we can opt for parametric test.

Part B2: Affordability Performance data

Descriptive Analysis Result for Public Transport Affordability Performance

		Valid Cases		Missing Cases		Total Cases	
		N	Percent	N	Percent	N	Percent
Fare	Taxi	400	100.0%	0	0.0%	400	100.0%
	Midi-bus	400	100.0%	0	0.0%	400	100.0%
	PSETSE	400	100.0%	0	0.0%	400	100.0%
	ACBE	400	100.0%	0	0.0%	400	100.0%
	SMTE	400	100.0%	0	0.0%	400	100.0%

Skewness Test Result

Modes	Skewness	Std. Error	z value
Taxi	0.168	0.122	1.374917
Midi-bus	0.222	0.122	1.819945
PSETSE	-0.153	0.122	-1.25419
ACBE	-0.159	0.122	-1.30403
SMTE	-0.129	0.122	-1.05465

Kurtosis Test Result

Modes	Kurtosis	Std. Error	z value
Taxi	0.103	0.243	0.42397
Midi-bus	-0.374	0.243	-1.53522
PSETSE	-0.146	0.243	-0.59976
ACBE	0.149	0.243	0.611792
SMTE	0.250	0.243	1.026448

The z-values for skewness and kurtosis in the preceding table fall within the range of -1.96 and 1.96, indicating that the data is normally distributed.

Tests of Normality

Modes		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	P-value	Statistic	df	P-value
Fare	Taxi	0.299	400	0.061	0.825	400	0.066
	Midi-bus	0.183	400	0.053	0.901	400	0.063
	PSETSE	0.199	400	0.070	0.896	400	0.077
	ACBE	0.281	400	0.074	0.837	400	0.088
	SMTE	0.280	400	0.079	0.839	400	0.074

P- value is greater than 0.05; This implies that the data are normally distributed. Therefore, we can opt for parametric test.

Part B3: Safety Performance data

Descriptive Analysis Result for Public Transport Safety performance

Case Processing Summary							
		Valid Cases		Missing Cases		Total Cases	
		N	Percent	N	Percent	N	Percent
Safety	Taxi	400	100.0%	0	0.0%	400	100.0%
	Midi-bus	400	100.0%	0	0.0%	400	100.0%
	PSETSE	400	100.0%	0	0.0%	400	100.0%
	ACBE	400	100.0%	0	0.0%	400	100.0%
	SMTE	400	100.0%	0	0.0%	400	100.0%

Skewness Test Result

Modes	Skewness	Std. Error	z value
Taxi	0.185	0.122	1.51836
Midi -Bus	0.056	0.122	0.457796
PSETSE	0.208	0.122	1.706512
Anbesa bus	0.187	0.122	1.532997
Sheger bus	0.135	0.122	1.107694

Kurtosis Test Result

Modes	Kurtosis	Std. Error	z value
Taxi	0.135	0.243	0.554101
Midi -Bus	0.202	0.243	0.830879
PSETSE	-0.254	0.243	-1.04367
Anbesa bus	-0.280	0.243	-1.1495
Sheger bus	-0.369	0.243	-1.51448

The z-values for skewness and kurtosis in the preceding table fall within the range of -1.96 and 1.96, indicating that the data is normally distributed.

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Modes		Statistic	df	p-value	Statistic	df	p-value
Safety	Midi-bus	0.111	400	0.054	0.939	400	0.065
	Taxi	0.142	400	0.067	0.911	400	0.055
	PSETSE	0.092	400	0.052	0.982	400	0.076
	ACBE	0.106	400	0.053	0.975	400	0.073
	SMTE	0.079	400	0.063	0.982	400	0.059

P- value is greater than 0.05; This implies that the data are normally distributed. Therefore, we can opt for parametric test.

Part B4: Security Performance data

Descriptive Analysis Result for Public Transport Security performance

Case Processing Summary

		Valid Cases		Missing Cases		Total Cases	
		N	Percent	N	Percent	N	Percent
Security	Taxi	400	100.0%	0	0.0%	400	100.0%
	Midi-bus	400	100.0%	0	0.0%	400	100.0%
	PSETSE	400	100.0%	0	0.0%	400	100.0%
	ACBE	400	100.0%	0	0.0%	400	100.0%
	SMTE	400	100.0%	0	0.0%	400	100.0%

Skewness Test Result

Modes	Skewness	Std. Error	z value
Taxi	0.125	0.122	1.023156
Midi -Bus	0.125	0.122	1.021388
PSETSE	0.232	0.122	1.899701
Anbesa bus	0.195	0.122	1.595902
Sheger bus	0.176	0.122	1.44022

Kurtosis Test Result

Modes	Kurtosis	Std. Error	z value
Taxi	0.187	0.243	0.769257
Midi -Bus	0.369	0.243	1.517316
PSETSE	-0.185	0.243	-0.76093
Anbesa bus	-0.365	0.243	-1.49972
Sheger bus	0.144	0.243	0.59157

The z-values for skewness and kurtosis in the preceding table fall within the range of -1.96 and 1.96, indicating that the data is normally distributed.

Tests of Normality

Modes		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Security	Taxi	0.139	400	0.058	0.910	400	0.058
	Midi-bus	0.205	400	0.054	0.831	400	0.059
	PSETSE	0.100	400	0.065	0.967	400	0.067
	ACBE	0.087	400	0.075	0.956	400	0.057
	SMTE	0.137	400	0.053	0.961	400	0.051

P- value is greater than 0.05; This implies that the data are normally distributed. Therefore, we can opt for parametric test.

Part C: Anbesa City Bus Tariff

	ANBESSA CITY BUS SERVISE ENTERPISE ROUTE, DISTANC AND FEAR/tariff		
Route	**Origin-Destination**	**k/m**	**new 2012 tariff**
1	MENILKSEQUARE - KARALO --ABA KIROSE	**16.7**	**6**
2	KORE MEKANISSA - MEXICO-----ADDIS KETEMA	**11.1**	**4**
3	AYER TENA - TORHAYLOCH- MENELIK SQUAR	**10.8**	**4**
4	KALITI - GOTERA--- ADDIS KETEMA	**19.4**	**7**
5	KORE MEKANISSA MEXICO - MENELIK SQUAR	**12.7**	**4**
6	KERA -MEXICO -- SEMEN GEBEYA SQUAR	**9.9**	**3**
7	MEGENAGNA - LEGEDADI -- ALELTU	**49**	**20**
8	KECHENE - SEMENHOTEL-- ADDIS KETEMA	**9.4**	**3**
9	BOLE BRASS CLINIC -KASANCHESE----- PIASSA	**10.5**	**4**
10	KOTEBE COLLEGE - MEGENAGA-- PIASSA	**12.7**	**4**
11	KOLFE EFOYETA - GIYORGESE-- MENELIK HOSPITAL	**10**	**3**
12	GURARA FERENSAY KELA -6KILO-- ADDIS KETEMA	**9.9**	**3**
13	ITALY EMBASSY - 6KILP-- ADDIS KETEMA	**9.9**	**3**
14	BOLY BULBULA - MENELIK SQUAR	**12.3**	**4**
15	MEGENAGNA - 4KILO--- ADDIS KETEMA	**10.4**	**4**
16	KIDANIMIHRET - GIYORGESE-- ADDIS KETEMA	**7.9**	**3**
17	KUSQUM - 6KILO-- ADDIS KETEMA	**9.1**	**3**
18	KERANIYO - 18MAZORIYA-- ADDIS KETEMA	**7.3**	**2**
19	SANSUSI - WINGATE-- PIASSA	**12.8**	**4**
20	DIL BER - RUFALE-- ADDIS KETEMA	**8.6**	**3**
21	FELIDORO - FETNO DERASH--ADDIS KETEMA	**8.6**	**3**
22	SUMMIT - MEGENAGA-- LEGEHAR	**14.3**	**5**
23	LAMBERET - 6KILO-- ADDIS KETEMA	**12**	**4**

For the purpose of sample: Here is presented only 23 routes out of 126 service routes

Factor Loadings				
	Component			
	1	2	3	4
Q15			0.725	
Q11	0.695			
Q14			0.585	
Q13	0.563			
Q9				0.531
Q2		0.759		
Q7		0.719		
Q8				0.693
Q16			0.766	
Q4		0.522		
Q10	0.338			
Q5		0.851		
Q6		0.355		
Q3		0.375		
Q12	0.421			
Q1		0.491		

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 9 iterations.

Note: Q1 -Q16 are the question listed in the questionnaire: link to Part A: Questionnaire

In Exploratory Factor Analysis (EFA), eigenvalues are utilized to determine the number of factors to retain. In EFA, factors with eigenvalues greater than 1 are typically retained, as this indicates that the factor accounts for more variance than would be expected by chance alone. The result reveal that sixteen factors are grouped under four components; namely comfort, affordability, safety, and security class.

Part E: Correlation Matrix of The Independent Variables

	Sex	Age	Income level	Education level	Marriage Status	Trip Purpose	Frequently used Mode	Trip Frequency (Trip per week)
Sex	1							
Age	-0.166	1						
Income level	-0.094	0.463	1					
Education level	-0.125	0.397	0.417	1				
Marriage Status	0.064	0.157	0.221	0.053	1			
Trip Purpose	-0.097	0.358	0.361	0.394	0.277	1		
Frequently used Mode	0.092	0.134	0.110	0.165	0.031	0.045	1	
Trip frequency (Trip per week)	-0.117	-0.043	0.078	-0.001	-0.003	-0.074	-0.124	1

Part F: Reference Category for Multinomial Logistic Regression Model

		N	Marginal Percentage	Remark
Case Processing Summary				
Mode choice determinate factor): Dependent Variable	Comfort	125	31.4%	Reference group
	Affordability	106	26.6%	
	Safety	88	21.9%	
	Security	81	20.1%	
SEX	Male	236	59.0%	
	Female	164	41.0%	Base category
MI (Monthly Income)	Below 3000	68	17.1%	
	3000-5000	76	19.1%	
	5000-10000	142	35.4%	
	10000-20000	90	22.4%	
	More than 20000	24	6.0%	Base category
Frequently used mode (FUM)	Midi bus	32	8.0%	
	Public Service Bus	68	16.8%	
	Anbesa City Bus	49	12.3%	
	Sheger Bus	92	22.9%	
	Taxi	159	39.9%	Base category
Trip made per week (TPW)	2 days per week	15	3.8%	
	3 days per week	26	6.5%	
	4 days per week	22	5.5%	
	5 days per week	120	30.2%	
	6 days per week	100	25.2%	
	7 days per week	87	21.9%	
	1 days per week	27	6.8%	Base category
AGE	18-24	81	20.4%	
	25-34	192	48.0%	
	35-44	45	11.3%	

	45-54	22	5.5%	
	55-65	12	3.0%	
	Below 18	48	11.8%	Base category
Education level (EDUL)	Diploma	50	12.6%	
	Degree	236	59.3%	
	Masters and above	65	16.1%	
	Primary or Secondary School	49	12.1%	Base category
Marriage Status (MRG)	Single	268	67.1%	
	Married	132	32.9%	Base category
Trip purpose (TP)	School	93	23.4%	
	Recreational area	15	3.5%	
	Another place	32	7.8%	
	Work	260	65.3%	Base category
Valid		400	100.0%	
Missing		0		
Total		400		

The selection of the base category or reference group is a crucial step, as it profoundly influences the interpretation of the coefficients and odds ratios. Therefore, the interpretation should be in accordance with these base categories.

Part G: Parameter Estimates									
		Model 3			Model 2			Model 1	
MCDF[a]	B	Sig.	Exp(B)	B	Sig.	Exp(B)	B	Sig.	Exp(B)
Affor dabili ty	Intercept	2.65	0.006		-2.975	0.025		-1.53	0.04	
	[SEX=.Male]	0.63	0.068	1.879	0.5812	0.088	1.78	0.523	0.10	1.687
	[SEX=Female]	0b			0b			0b		
	Monthly income =Below 3,000]	-1.18	0.162	0.306	-1.305	0.115	0.27	-0.02	0.96	0.980
	Monthly income =3000-5000	-1.83	0.033	0.159	-1.969	0.018	0.13	-0.47	0.32	0.621
	Monthly income =5000-10000	-2.92	0.002	0.054	-3.0683	0.001	0.04 64	-1.39	0.00 9	0.248
	Monthly income 10,000-20,000	-3.48	0.013	0.031	-3.5773	0.009	0.02 79	-2.07	0.07	0.125
	Monthly income =more than 20,000	0b			0b			0b		
	Frequently used mode: midi bus	1.64	0.008	5.202	1.5832	0.010	4.87	1.377	0.01	3.964316
	Public Service Bus	1.44	0.003	4.251	1.5077	0.002	4.51	1.426	0.00	4.162503
	Anbesa City Bus	1.84	0.001	6.334	1.9177	0.000	6.80	1.943	0.00	6.980152

Sheger Bus	2.39	0.000	10.985	2.3619	0.000	10.6	2.281	0.00	9.785852
Minibus Taxi	0[b]			0b			0b		
Two Trips per week	-1.42	0.254	0.241	-1.388	0.260	0.24 9	-1.51	0.22	0.219805
Three Trips per week	0.72	0.386	2.050	0.7396	0.368	2.09	0.981	0.21	2.666011
Four Trips per week	2.26	0.019	9.602	2.1578	0.024	8.65	1.880	0.03	6.555500
Five Trips per week	0.28	0.682	1.319	0.3257	0.626	1.38	0.577	0.34	1.781485
Six Trips per week	0.21	0.764	1.228	0.2589	0.701	1.29	0.373	0.54	1.452646
Seven Trips per week	0.01	0.989	1.009	-0.017	0.981	0.98	0.230	0.72	1.258234
One Trip per week	0[b]			0b			0b		
Age between 18-24	2.09	0.101	8.139	1.6591	0.090	5.26			
Age between 25-34	2.12	0.094	8.350	1.7743	0.065	5.89			
Age between 35-44	2.07	0.127	7.934	1.8478	0.089	6.35			
Age between 45-54	1.67	0.269	5.317	1.5619	0.211	4.78			
Age older than 55	2.72	0.092	15.211	2.6394	0.045	14.4			
Age below 18	0[b]			0b					
Education level Diploma	-0.46	0.682	0.631						
Education level: Degree	-0.75	0.505	0.472						
Education level: masters and above	-0.26	0.824	0.766						

	Education level: Primary	0[b]								
	Marriage: Single	-0.21	0.603	0.808						
	Marriage: Married	0[b]								
	School Trip	1.41	0.104	4.108	1.4479	0.092	4.45			
	Recreational Trip	0.94	0.322	2.561	0.9391	0.316	2.58			
	Other Trip	0.40	0.701	1.503	0.4928	0.634	1.63			
	Work Trip	0[b]			0b					
Safety	Intercept	-2.83	0.052		-2.811	0.042		-2.03	0.02	
	SEX=.Male	0.04	0.915	1.037	0.0391	0.906	1.04	0.119	0.71	1.126356
	SEX=Female	0[b]			0b			0b		
	Monthly income =Below 3,000]	-0.51	0.602	0.601	-0.715	0.437	0.48	-0.59	0.29	0.552449
	Monthly income	-0.46	0.637	0.630	-0.676	0.454	0.52	-0.21	0.67	0.808780
	=3000-5000	-1.55	0.136	0.212	-1.761	0.066	0.17	-1.23	0.02	0.292206
	Monthly income	0.19	0.857	1.219	-0.017	0.986	0.98	0.450	0.51	1.567659
	=5000-10000	0[b]			0b			0b		
	Monthly income	1.90	0.002	6.705	1.9037	0.002	6.71	1.663	0.00	5.275828
	10,000-20,000	1.43	0.005	4.209	1.5282	0.002	4.61	1.491	0.00	4.442281
	Monthly income =more than 20,000	2.19	0.000	8.924	2.2255	0.000	9.27	2.175	0.00	8.803609
	Frequently used mode: midi bus	2.07	0.000	7.901	2.0488	0.000	7.76	1.977	0.00	7.217838

Public Service Bus	0[b]			0b			0b		
Anbesa City Bus	-0.72	0.582	0.484	-0.756	0.563	0.47	-0.83	0.51	0.433975
Sheger Bus	0.87	0.367	2.408	0.8980	0.355	2.46	1.044	0.26	2.840133
Minibus Taxi	2.18	0.045	8.854	2.0963	0.051	8.14	1.858	0.06	6.411818
Two Trips per week	0.93	0.256	2.532	0.8953	0.271	2.48	0.866	0.24	2.377025
Three Trips per week	1.25	0.119	3.503	1.2992	0.104	3.66	1.181	0.10	3.258721
Four Trips per week	1.25	0.120	3.498	1.2215	0.128	3.39	1.106	0.13	3.022671
Five Trips per week	0[b]			0b			0b		
Six Trips per week	0.20	0.876	1.226	-0.388	0.710	0.68			
Seven Trips per week	1.08	0.416	2.824	0.497	0.615	1.64			
One Trip per week	1.10	0.416	3.007	0.6104	0.573	1.84			
Age between 18-24	0.73	0.618	2.090	0.2369	0.844	1.27			
Age between 25-34	0.08	0.965	1.084	-0.396	0.806	0.67			
Age between 35-44	0[b]			0b					
Age between 45-54	-0.59	0.622	0.554						
Age older than 55	-0.89	0.459	0.409						
Age below 18	-0.39	0.754	0.672						
Education level Diploma	0[b]								
Education level: Degree	0.08	0.830	1.091						

	Education level: masters and above	0^b								
	Education level: Primary	0.87	0.288	2.396	0.8877	0.277	2.43			
	Marriage: Single	0.49	0.593	1.634	0.5246	0.564	1.69			
	Marriage: Married	1.18	0.267	3.153	1.1969	0.238	3.39			
	School Trip	0^b			0^b					
Security	Intercept	-0.84	0.600		-0.728	0.623		0.627	0.36	
	[SEX=.Male]	-0.34	0.306	0.705	-0.372	0.262	0.69	-0.49	0.17	0.644933
	[SEX=Female]	0^b			0b			0b		
	Monthly income =Below 3,000]	-2.14	0.014	0.117	-2.133	0.013	0.11	-1.38	0.01	0.262460
	Monthly income	-2.09	0.015	0.123	-1.829	0.027	0.15	-0.96	0.03	0.382279
	=3000-5000	-2.96	0.001	0.052	-2.538	0.004	0.07	-1.67	0.00	0.192670
	Monthly income	-3.65	0.002	0.026	-3.205	0.004	0.04	-2.22	0.01	0.108391
	=5000-10000	0^b			0b			0b		
	Monthly income	-0.78	0.355	0.488	-0.777	0.309	0.46	-0.97	0.20	0.391859
	10,000-20,000	-0.08	0.859	0.917	-0.091	0.848	0.93	-0.16	0.73	0.851306
	Monthly income =more than 20,000	-1.09	0.153	0.347	-1.076	0.144	0.34	-1.03	0.15	0.356047
	Frequently used mode: midi bus	0.23	0.618	1.261	0.2138	0.641	1.28	0.167	0.70	1.181640
	Public Service Bus	0^b			0b			0b		

Anbesa City Bus	-0.26	0.775	0.770	-0.212	0.812	0.81	-0.09	0.91	0.914000
Sheger Bus	0.79	0.420	2.157	0.6040	0.520	1.89	0.645	0.47	1.906886
Minibus Taxi	1.61	0.154	5.007	1.3387	0.221	3.81	1.222	0.22	3.395664
Two Trips per week	0.59	0.471	1.698	0.4256	0.550	1.53	0.796	0.23	2.216291
Three Trips per week	-0.24	0.743	0.786	-0.369	0.603	0.69	-0.13	0.84	0.877816
Four Trips per week	0.29	0.684	1.339	0.2156	0.758	1.24	0.410	0.52	1.507464
Five Trips per week	0[b]			0b			0b		
Six Trips per week	0.34	0.775	1.411	0.8093	0.385	2.26			
Seven Trips per week	0.27	0.824	1.306	0.6793	0.474	1.97			
One Trip per week	0.56	0.658	1.760	1.1570	0.272	3.18			
Age between 18-24	0.89	0.523	2.436	1.3169	0.270	3.73			
Age between 25-34	-0.08	0.962	0.920	0.3872	0.801	1.47			
Age between 35-44	0[b]			0b					
Age between 45-54	-0.28	0.799	0.765						
Age older than 55	0.55	0.619	1.738						
Age below 18	1.59	0.188	4.706						
Education level Diploma	0[b]								
Education level: Degree	-0.12	0.769	0.886						
Education level: masters and above	0[b]								

Education level: Primary	1.82	0.120	6.224	1.7875	0.122	5.97			
Marriage: Single	1.49	0.227	4.470	1.3662	0.261	3.92			
Marriage: Married	0.85	0.541	2.343	0.4442	0.742	1.55			
School Trip	0[b]			0b					

a. The reference category is Comfort.

b. This parameter is set to zero because it is redundant.

Part: H: The Goodness of Fit Measures

Goodness of fit measures are essential statistical tools that are used to assess the degree to which a statistical model fits a given set of observed data. In the context of multinomial logistic regression, the following goodness of fit measures can be employed to evaluate the performance of the model.

1. **Deviance**

In SPSS, the deviance goodness of fit measure is reported as a chi-square value and its associated p-value. The chi-square value represents the difference between the observed data and the predicted values of the model, and the p-value indicates the probability of obtaining a chi-square value as extreme as the one observed, assuming that the model is a good fit for the data. To compare the deviance values of different models in SPSS, we can compare their chi-square values. The model with the lowest chi-square value is considered the best fit for the data. However, it is important to note that the p-value should also be taken into consideration. A low p-value (typically less than 0.05) indicates that the model is a good fit for the data, while a high p-value suggests that the model may not be a good fit.

The Deviance Table

Model	Deviance		
	Chi-Square	df	Sig.
Model 1	750.950	111	0.004
Model 2	646.32	699	0.003
Model 3	148.4	811	0.001

In this particular case, model three has the lowest chi-square value with a p-value less than 0.05. Therefore, we can conclude that model three is the best model compared to the other two models based on deviance value.

2. Pseudo R-Square

This measure is used to evaluate how well the model fits the data relative to a null model. It measures the proportion of the variance in the dependent variable that is explained by the independent variables in the model, relative to the variance in the dependent variable in the null model. In the context of multinomial logistic regression (MNL), there are several ways to compute a pseudo-R-square measure that assesses the goodness of fit of the model. Three commonly used pseudo-R-square measures are McFadden's R-squared, Cox and Snell's and Nagelkerke R-squared.

To compute McFadden's R-squared, first need to estimate the log-likelihood of the full model (LL1) and the log-likelihood of a baseline model that only includes the intercept (LL0).

The formula for McFadden's R-squared is:

$$R^2_{McFadden} = 1 - \left(\frac{LL1}{LL0}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..Equation\ 6\text{-}1$$

The resulting value ranges from 0 (indicating a very poor fit) to 1 (indicating a perfect fit). Cox and Snell's R-squared, on the other hand, is based on the likelihood function rather than the likelihood ratio test. It is defined as:

$$R^2_{CS} = 1 - \left[\frac{LL1^{\frac{2}{n}}}{LL0^n}\right]\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.Equation\ 6\text{-}2$$

The Nagelkerke R-squared is a measure of the proportion of variance explained by a logistic regression model. It is calculated using the following formula.

$$R^2_{Nagelkerke} = \frac{[1-(\frac{Lnull}{Lmodel})^{(\frac{2}{n})}]}{1-(Lnull(\frac{2}{n})]}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ Equation\ 6\text{-}3$$

Where: Lnull is the log-likelihood of the null model (i.e., a model with only an intercept), Lmodel is the log-likelihood of the full model, and n is the sample size.

Nagelkerke R-squared ranges from 0 to 1, with higher values indicating a better fit of the model to the data.

Pseudo R-square value

Pseudo R-Square	Model 1	Model 2	Model 3
McFadden	0.181	0.171	0.484
Nagelkerke	0.418	0.4	0.571
Cox and Snell	0.391	0.375	0.473
AIC	984.222282	896.3462	716.7475

Generally, higher values of pseudo-R squared indicate a better fit of the model to the data. From the above three models, the third model has the highest R-squares.

3. Classification Accuracy:

The classification accuracy table represents a reliable and widely used approach to assess the performance of a model. This method is designed to gauge the model's ability to accurately classify observations into their respective categories, thereby providing a metric for evaluating its effectiveness. By quantifying the proportion of correctly classified observations, this measure provides valuable insights into the model's accuracy and efficacy.

Classification accuracy of the models

Model 1					
Predicted					
Observed	Comfort	Affordability	Safety	Security	Percent Correct
Comfort	82	28	9	6	65.6%
Affordability	21	67	11	7	63.2%
Safety	23	40	19	6	21.6%
Security	39	21	3	17	21.3%
Overall Percentage	41.4%	39.1%	10.5%	9.0%	46.4%
Model 2					
Predicted					
Observed	Comfort	Affordability	Safety	Security	Percent Correct
Comfort	81	18	14	12	64.80%
Affordability	21	63	15	7	59.40%
Safety	21	33	26	8	29.50%
Security	28	20	5	27	33.80%
Overall Percentage	37.80%	33.60%	15.00%	13.50%	49.40%
Model 3					
Predicted					
Observed	Comfort	Affordability	Safety	Security	Percent Correct
Comfort	85	30	15	17	60.80%
Affordability	25	64	23	11	60.40%
Safety	28	45	32	21	36.80%
Security	40	19	15	30	37.50%
Overall Percentage	44.50%	39.50%	21.30%	19.80%	70.80%

Part I: Likelihood Ratio Test

	Model Fitting Criteria			Likelihood Ratio Tests		
Effect	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	p-value
Intercept	989.463	1336.284	815.463[a]	.000	0	.
SEX	990.919	1325.781	822.919	7.456	3	.0059
AGE	966.884	1241.949	828.884	13.421	18	.046
MI	1003.640	1302.624	853.640	38.177	12	.000
EDUL	982.347	1293.291	826.347	10.884	9	.024
MRG	984.099	1318.961	816.099	.636	3	.488
TP	981.146	1292.089	825.146	9.683	9	.037
FUM	1036.298	1335.282	886.298	70.835	12	.000
TPW	977.196	1252.261	839.196	23.733	18	.0164

Likelihood Ratio Tests

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.