ANALYSIS OF TRANSPORTATION MODE CHOICE OF THE PASSENGERS USING MULTINOMIAL LOGIT MODEL FOR WORK AND SCHOOL TRIPS: A CASE STUDY IN HAWASSA CITY

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ADVISORS' APPROVAL SHEET

This is to certify that the thesis entitled **" Analysis Of Transportation Mode Choice Of The Passengers using Multinomial Logit Model For Work And School Trips: A Case Study In Hawassa City"** Submitted in partial fulfillment of the requirements for the degree of **Master's** with specialization in **Road and Transport Engineering,** the Graduate Program of the **Department of Civil Engineering,** and has been carried out by **YESHITLA DENEKE** (ID. No. **PGRo/023/10),** under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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We, the undersigned, members of the Board of Examiners of the final open defense by **YESHITLA DENEKE,** have read and evaluated his thesis entitled: **" Analysis Of Transportation Mode Choice Of The Passengers Using Multinomial Logit Model For Work And School Trips: A Case Study In Hawassa City"** and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree.

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DECLARATION

I, the undersigned, declare that this thesis proposal entitled: **"Analysis Of Transportation Mode Choice Of The Passengers Using Multinomial Logit Model For Work And School Trips: A Case Study In Hawassa City "** is my original work, and has not been presented by any other person for an award of a degree in this or any other University, and all sources of material used for this thesis proposal have to be duly acknowledged.

Candidate:

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ABBREVIATIONS

AM income	Average Monthly income
INVTT	In vehicle travel time
MLM	Multinomial logit model
OVTT	Out of the vehicle travel time
RII	Relative importance index
TC	Travel cost
UTMS	Urban transport model system

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ABSTRACT

The urbanization and urban sprawl of the city are becoming expanded in Ethiopia. People migrated to urban centers like Hawassa city in order to work, trade, and learn. Due to this, the transportation planners and engineers are always encountering a problem on how to provide adequate transportation services and facilities within the city because of the various mode choice behavior of the travelers. Hence, this study focused on identifying factors affecting mode choice behavior, analyzing the work and school trip makers' mode choice behavior in Hawassa city using the Multinomial Logit Model by determining and forecasting the current and future mode share respectively. The transport modeling process as a travel demand forecasting tool used in the analysis of probable market shares of different motorized modes. The model developed with questionnaires distributed for this purpose by using workplace and school survey in the seven sub-cities of the Hawassa city. The primary data, like total waiting time were collected through site investigation at different major station of the city. Likewise, the secondary data like travel cost within each station gathered from the Hawassa City Road and Transportation Bureau. SPSS Software was used to process data for a Multinomial Logit Model (MNL) and to explain the travel patterns and mode choice of employees and students. The model was made with mode used in a trip as dependent variable and out of the vehicle travel time, in vehicle travel time, travel cost, income and comfort as an independent variables. Results indicated that the factors that significantly affect the choice of transport modes were average monthly income, in-vehicle travel time, out of the vehicle travel time, total travel cost and comfort during journey. The prediction level of the developed model was 79.5% for the employees and 82.9% for the students. The employee's current probabilities of the modal split for city bus, damas, Bajaj and motorcycle were 28.83%, 25.4%, 6.2% and 39.58% while for the students were 35.92%, 29.74%, 19.79% and 14.53% respectively. The validation and verification of the developed model was done by testing the reasonableness of the sign of the parameters and by examining it with the three fundamental properties of the MLM. The estimations of the model might also be valuable to policy-makers and transport planners, who can estimate possibilities for various modes and determine the impact of unique policy modifications on the need for trip makers.

Keywords: Modal split, mode choice, multinomial logit model, work and school trips

1. INTRODUCTION

1.1. Background

Urbanization has been one of the dominant contemporary processes as a growing share of the global population lives in cities. Transportation in urban areas is highly complex because of the modes involved, the multitude of origins and destinations, and the amount and variety of traffic. Moreover, rapid and expanded urbanization occurring around the world involves an increased numbers of trips in urban areas. Traditionally, the focus of urban transportation has been on passengers as cities were viewed as locations of utmost human interactions with intricate traffic patterns which is linked to commuting, commercial transactions and leisure/cultural activities (Rodrigues et al., 2009).

In the urban world, cities have always been the engines of economic development and the centers of industry and commerce (Brockerhoff, 2000). According to Rodrigue et al. (2009), cities or locations having a high level of accumulation and concentration of economic activities, and there are complex spatial structures that are supported by transport systems. However, nowadays transport becomes one of the most important, but also hardest-to-solve, problems of modern-day cities. Nevertheless, an efficient and effective urban transportation system is a means to both promoting urban development and providing adequate access and mobility to the urban dwellers (Kwakye et al., 1997). Therefore, urban transportation planning is considered as an important activity to promote mobility and national growth process (Dibakar, 2010).

Transport model can be defined as a simplified representation of the real world usually implemented in computer software, which describes the impact of transport decisions and plays an important role in supporting transportation planning. One of the major roles of transportation modelling is to forecast travel demand based on changes in the transportation system. There are different types of models that have been developed to create actual travel patterns of people and existing demand conditions. The models are used to predict changes in travel pattern and utilization of the transportation system in response to changes in land-use, demographics and socioeconomic conditions (Saad and William, 1995).

Travel demand forecasting is a process used in transportation planning to predict future demand of a transportation facility. The transportation planning process has four basic steps that are trip generation, trip distribution, mode choice, and travel assignment. Trip generation estimates the number of potential trips starting or ending in a given area. Trip distribution associates origin and destination for each trip generated. Mode choice analyzes how the trips are split between available modes of transportation based on the attractiveness of each mode. Finally, travel assignment estimates volumes on different links of the transportation network (Sadi, 2012).

The targeted group were employees and students in different sub-cities of the Hawassa city with their different mode choice behavior. Work and school trips are the centers of the focus of urban transportation planning and policy analysis because congestion in peak hours in the urban transportation network (Saad and William, 1995). One of the important aspects of transportation modeling is to predict trip maker's mode choice behaviors. It involves a specific aspect of human behaviors dedicated to choice decisions. With a model, as a simplified representation of a part of reality provides a better understanding and interpreting these complex systems.

The selected mode of travel by the individual for a home-to-work trip or home-to-school trip involved a complex decision-making process (Dibakar, 2010). It could be influenced by the different attributes of the person and the characteristics of the urban transport systems such as age, income, comfort, travel time and travel cost. So, to deal with this, the questionnaires were provided based on those factors affecting mode choice behavior of the employed people and students. In addition, to have an exact approximation of travel time and vehicle waiting time at the major road segments and stations, the site observation and stopwatch with format sheet were used to collect the necessary raw data in the study area. A Multinomial logit model using SPSS Software was used to analysis the raw data.

The developed mode choice model capable of predicting modal shares of different modes of transport, including both private and public transport vehicles. The models describe preferences and choice in terms of probabilities of choosing each alternative and can predict the current individual mode choice behavior as well as for the particular future.

1.2. Statement of the problem

The lack of a sufficient application of the transportation planning process in developing cities, such as Ethiopia, leads to deficiency in adopting the correct transport policies to lessen the transportation problems resulting from urbanization and rapid increase of population in the cities (Mekonnen, 2010). As a result, non-motorized modes of transport; walking and bicycling have become decreased in Hawassa city due to the increasing introduction of Bajaj (three-wheelers) as a dominant mode of public transport (Nuriye, 2015).

The prevalence of poor quality of services in the Hawassa cities makes the road transport passengers of the nation dissatisfied (Deneke and Mebratu, 2016). To meet the increasing travel demand without aggravating the congestion issues, there should be a need for increasing usage of high occupancy modes in addition to encourage the use of non-motorized modes (either, biking and walking). This could not be undertaken without understanding the travelers' needs and preference for using the modes (Nuriye, 2015).

Transport service providers request unfair prices, particularly on peak-times (mostly around 8 am in the morning, during mid-day, around 5 pm and after 8 pm. During these periods, there is high mobility of people in Hawassa city. These tight periods obliged people to pay an unnecessary price which would be arbitrarily set by transport operators (Degwale et al, 2018). Incase service providers sometimes also have not a mindset of serving the people while doing their business they create a short time shortage of getting transportation by stopping to give regular service and obliged people to serve by contract. This is special problem with Bajaj modes nowadays in Hawassa city at the peak hours.

Moreover, Hawassa city is one of the fast growing cities in Ethiopia. In particular, it is attracting investors and become one of the prominent locations of industries. As industries and other opportunities expand, the population increases in a cities in order to have work opportunities in Hawassa Industry Park, to serve as a labor at the different construction sites and other sectors. As the population increases, there would be more completion which needs an increase in mobility. An ability to move from place to place with comfort, reasonable cost, and the desired period is one of the major factors affecting the competency of an individual (Degwale et al, 2018).

1.3. Objectives

1.3.1. General Objectives

The main objective of the research study is to analyze the transportation mode choice of passengers using the multinomial logit model for work and school trips.

1.3.2. Specific Objectives

- To assess the major factors affecting the mode choice of the employees and students for work and school trips from shifting one mode to another mode of transportation.
- To analyze and develop the multinomial logit model for mode choice behavior of travelers in the study area.
- To validate and verify developed model by predicting future modal share and by determining the current share for transportation modes in the study area.

1.4. Research questions

1. What are the major factors affecting the mode choice of employed people or college student for work/school trips from shifting one mode to the other mode?
2. Which multinomial logit mode choice model that can be applied in the study area?
3. How to validate and verify developed model by predicting future modal share and by determining the current share for transportation modes in the study area?

1.5. Significance of the study

This study may be helpful to find mode choice behavior of the work and school trips by identifying the factors affecting mode choice of the city. In addition, the study might predict the current and future probable market share of the transportation mode by developing MLM for the city.

1.6. Scope and limitation of the Research

The scope of this study was the home-based-work trips for the employees and home-based-school trips for the college students in the Hawassa city. The study did not include trips other than work and school trips, such as social and recreational trips.

2. LITERATURE REVIEW

2.1. Introduction

The essential concepts combined with literature review of a related researches presented within this chapter. These includes the following : Mode choice modelling, Overview and historical development of the passenger mode choice model, Aggregate and disaggregate mode choice modelling, Modal split mode choice model and its type, Logit model, Binary logit models, Multinomial logit models, Model Estimation techniques, Methods of testing the validation of the model and Verification of the multinomial logit model Revealed and Stated preference survey, Overview and historical development of the passenger mode choice model , previous studies of passenger travel mode choice modeling in other countries and in Ethiopia.

2.2. Urban transportation planning process

The goal of urban transportation planning is to develop a plan for an efficient, balanced transportation system in an urban area and to promote a desirable pattern of human activities. While the process has been standardized to some extent, each study must nevertheless acquire and manage a massive amount of information about the specific region with which it is concerned. It is undertaken at many levels from strategic planning to project level planning at different geographic scales in any urban area (Sadi, 2012).

2.2.1. Classical four-step urban transportation model

There are four stages of the urban transportation planning system which are tripped generation, trip distribution, modal split and trip assignment (Rosenbaum and Koenig, 1997). Those models are simplified representation of reality which can be used to explore the consequences of particular policies or strategies and deliberately simplified in order to keep them manageable and avoid irrelevant detail while hopefully encapsulating the important features of the system of interest (Sadi, 2012).

The Urban Transport Model System (UTMS) often referred as the four-step model is commonly used to predict the flows on the links of a particular transportation network as a function of the land-use activity system that generates the travel (Sadi, 2012). The model consists of four elementary stages, where each stages addresses: how many travel movements will be made, where will they go, by what mode the travel be carried out, and what route will be taken (Ortuzar & Willumsen, 2002). The details of these four stages of the transportation is as follows:

2.2.1.1. Trip Generation

The aim of the trip generation is predicting the total number of trips generated by and attracted to each zone of the study area. As Ortuzar and Willumsen (2002) have demonstrated that common trip generation patterns on the basis of following standard trip purposes: Work trips, Educational trips, Shopping trips and other trips (social, recreational, medical, bureaucratic trips etc.)

The analytical technique commonly used to develop the trip generation patterns of a study area is multiple linear regressions. In this technique, the dependent output variable is assumed to have a linear dependence on the independent input variables, which may or may not influence the trip generation, as shown in (Equation 2.1).

$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \ldots + BkXk + E$.. (Equation 2.1)

Where,

$\beta_{0,\ 1,\ 2 \ldots K}$ are coefficients of regression;

$X_{0,\ 1,\ 2 \ldots K}$ are independent input variables;

Y is dependent input variable;

E is error in estimating the output variable.

2.2.1.2. Trip Distribution

The trip distribution tends to provide a standard pattern of trip making by linking the trip ends with the origins. The trip distribution model is essentially a destination choice model and generates a trip table, for each trip purpose utilized in the model as a function of activity-system attributes and network attributes. This trip table commonly known as Origin-Destination Matrix (O-D Matrix), provides a comprehensive illustration of the number of trips generated between different zones of the study area. There are different traffic distribution algorithms for forecasting the future O-D matrix which are growth factor methods, gravity model, the entropy-maximizing approach, and the proportional approach (Qrtuzar and Willumsen, 2002).

2.2.1.3. Modal Split

Mode choice predicts the number of trips from each origin to each destination that will use each mode of transportation. Modal split has considerable implications for transportation policy, particularly in large metropolitan areas. The issue of selecting the most appropriate travelling mode has always been a critical issue in travel behavioral modeling, since it tells an individual about the most efficient travelling mode available. Therefore, it is vital to develop and use models that are receptive to those attributes of travel that influence a certain individual's choice of mode. The quantification of this interaction in terms of mathematical relationships is known as modal split and the travel demand models are referred to as modal split or mode choice models. Hence, the modal split assists a transport planner to assess the impact of each urban element on mode choice and permits testing and evaluation of various transportation schemes. (Qrtuzar and Willumsen, 2002).

2.2.1.4. Trip Assignment

Trip assignment is the last stage of the four-step model, dealing with the allocation of a given set of trip interchanges to a specific transport network. It always estimate the traffic volumes and the corresponding travel times or costs on each link of the transportation system by the help of inter-zonal or intra-zonal trip movements which determined by trip generation and distribution and the travel behavior of the individuals which determined by modal split. The proportion of vehicles using each route between a particular origin-destination pair depends upon a number of attributes and the alternative routes including travel time, distance, number of stops / signals, aesthetic appeal etc. But travel time is the attribute most commonly considered in network assignment models. There are different traffic assignment algorithms which are: All-or-Nothing assignment (AON), War drop's user Equilibrium assignment, Method of successive averages and stochastic user-equilibrium assignment (Qrtuzar and Willumsen, 2002).

Patriksson (1994) presented a list of useful purposes of trip assignment in context with transport planning such as assessing the deficiencies in the existing transportation system of the study area, evaluating the effects of limited improvements and extensions to the existing transportation systems and developing construction priorities for the existing transportation system of the study area.

2.3. Factors influencing passenger mode choice behavior

Dibakar (2010) stated that there are many different factor influencing passenger mode choice behavior in many different ways. Some of these are described below.

i) Hard and soft factors

Hard factors are normally found in the traditional travel mode choice models that are based on maximization of utility. Examples of hard factors are traveling time, waiting time and ticket price (fare). Soft factors are things like comfort, services and information. Soft factors may also be psychological, for example flexibility, ease of orientation etc.

ii) Internal and external factors

Factors that control choice of travel mode can also be divided into internal and external factors. Internal factors include attitudes, socio-economic and demographic factors, habits and perceived level of control. External factors include such things as traveling time and the cost of the journey.

iii) Subjective and objective factors

The objective factors are normally based on objective measures and are easy to measure and quantify. The alternative's so-called hard standard factors such as traveling time, fare etc. as well as soft standard factors such as comfort, information etc. are grouped as objective factors. The objective factors also include socio-economic factors such as gender and age, and also trip-related factors such as purpose. Examples of other objective factors are weather, topography, security and environment. Whereas, Subjective factors include valuations of the alternative's characteristics, attitudes and lifestyle. These factors are based on the individual's perception and are often more difficult to quantify.

Ortuzar and Willumsen (2004) has presented the factors influencing mode choice into three groups and a good mode choice model should include the most important of these factors. These factors are presented as follows.

a) Characteristics of the trip maker:-Car availability and/or ownership, Possession of a driving license, Household structure (young couple, couples with children, retired, singles, etc.)

Income, further the decisions made elsewhere, for example the need to use a car at work, take children to school, etc.

b) Characteristics of the journey:- The trip purpose; for example, the journey to work is normally easier to undertake by public transport than other journeys because of its regularity and the adjustment possible in the long run and time of the day when the journey is undertaken.

c) Characteristics of the transport facility:-Relative travel time, in-vehicle travel time, waiting and walking travel time by each mode, Relative monetary costs (fares, fuel and direct costs) availability and cost of parking.

d) Qualitative factors: - which are less easy to measure, such as: Comfort and convenience; Reliability and regularity; Protection, security.

2.4. Mode choice modelling

2.4.1. Overview and historical development of the passenger mode choice model

As Sadi (2012) stated that model developed by Adam is one of the modal split models to be advised for the transport planners. Since mid-1960's many mode choice models for intercity travelers were calibrated and used for prediction in various environments. Traditionally aggregate models are used in dealing with the travel choice behavior of individual travelers: however the aggregate models have the limitation of forecasting and estimating of travel choice with aggregated zonal data.

The inability of aggregate data to explain the travelers' behavior led to propose another group of models called disaggregate models. These models require the data that describes the behavior of an individual's characteristics and attitudes towards the travel services provided by each mode.

Disaggregate travel demand models represent a recent innovation in travel forecasting procedure. The earliest research into disaggregate mode choice models was done by Sadi (2012). The pioneering efforts were made during the period 1967-1969 used a binary mode choice modeling with automobile as a base mode. Pioneers in this early age of disaggregate modeling include, Quarmby (1967) used discriminate analysis and Stopher (1969) used regression and subsequently Logit analysis.

However it was found from the market research that besides the socioeconomic and mode related characteristics and individual evaluates his choice depending upon the level of service provided by the alternatives. This led to incorporation of factors such as comfort, convenience, privacy and other mode related attitudinal indicators in the models. One of the earliest efforts in this field was done by Ackoff as stated in Sadi (2012). His effort was pioneering in considering psychological factors in mode choice.

2.4.2. Aggregate and disaggregate mode choice modelling

Modeling of mode choice can be approached in two ways: aggregate and disaggregate modeling. Mode choice models have received a lot of attention by the transportation research community and have been studied extensively.

Aggregate mode choice models have the limitation of forecasting and estimating of mode choice with aggregated zonal data. They also have limitations in treating policy questions. Moreover, these models are subject to serious biases and errors owing to their reliance on aggregate travel data rather than records of individual choice (Dibakar, 2012).

Disaggregate mode choice models tend to present the travel behavior of the individuals when provided with a discrete set of travelling alternatives. It widely used as it describe individual characteristics in a much better way compared to aggregate models that depend on zonal characteristics.

Disaggregate mode choice models have substantial advantages over the aggregate models for predicting the consequences of transportation policy measures that affect mode choice. The advantages and useful proprieties of disaggregate models have presented by (Ortuzar and Willumsen, 2002 and Koppel and Bhat, 2006) as follows:

Prediction ability: **-** Empirical evidence indicates that disaggregate mode choice models have the ability to simulate the phenomenon under study and to produce reliable forecasts for future planning purposes.

The behavior aspect: **-** Disaggregate models are based on the observable behavior of individual decision-makers. Therefore, statistically, they are efficient in extracting the maximum possible information through the averaging procedure.

Moreover, as they stated disaggregate approach explains why an individual makes a particular choice given her/his circumstances and is, therefore, better able to reflect changes in choice behavior due to changes in individual characteristics and attributes of alternatives. The aggregate approach, on the other hand, rests primarily on statistical associations among relevant variables at a level other than that of the decision maker; as a result, it is unable to provide accurate and reliable estimates of the change in choice behavior due to changes in service or in the population.

2.4.3. Modal split mode choice model and its type

The significance of the transportation model as a planning tool is particularly important due to the extent and diverse characteristics of transportation systems as well as the complexity of people's travel behavior. Modeling travel behavior is a key aspect of demand analysis (Ben-Akiva and Bierlaire, 1999). Mode choice behavior of the travelers has traditionally played a central role in transportation modeling research and applications (Portoghese et al., 2009).

Mode choice analysis is the third step in the four-step transportation forecasting model. Many different urban areas in the world are plague by a continuing increase in traffic congestion resulting in motorist frustration, longer travel times, lost productivity, increased accidents and automobile insurance rates, more fuel consumption, increased freight transportation costs, and deterioration in air quality. Due to these serious consequences of traffic congestion, urban areas forced to examining and implementing Transportation Congestion Management (TCM) and Transportation System Management (TSM) policies. So, the urban travel mode choice models used to evaluate the effectiveness of TCM policies in shifting single-occupancy vehicle users to vehicle modes (Lawton, 1989).

Mode choice model represents the decisions that consumers make when confronted with alternative modal choices. These decisions are made on the basis of the terms upon which the different travel modes are offered, includes the travel times, costs and other level-of-service attributes of the competing alternative traveling modes, in addition to relevant socio-economic and land use characteristics (Sadi, 2012).

A mode choice model is divided into binary and multinomial choice models depending on the number traveling modes, if the choice set consists of two traveling modes, or two sets of travelling modes, a binary modal split model can be applied. Contrarily, multinomial modal split models can be selected for larger choices sets (figure 2.1).

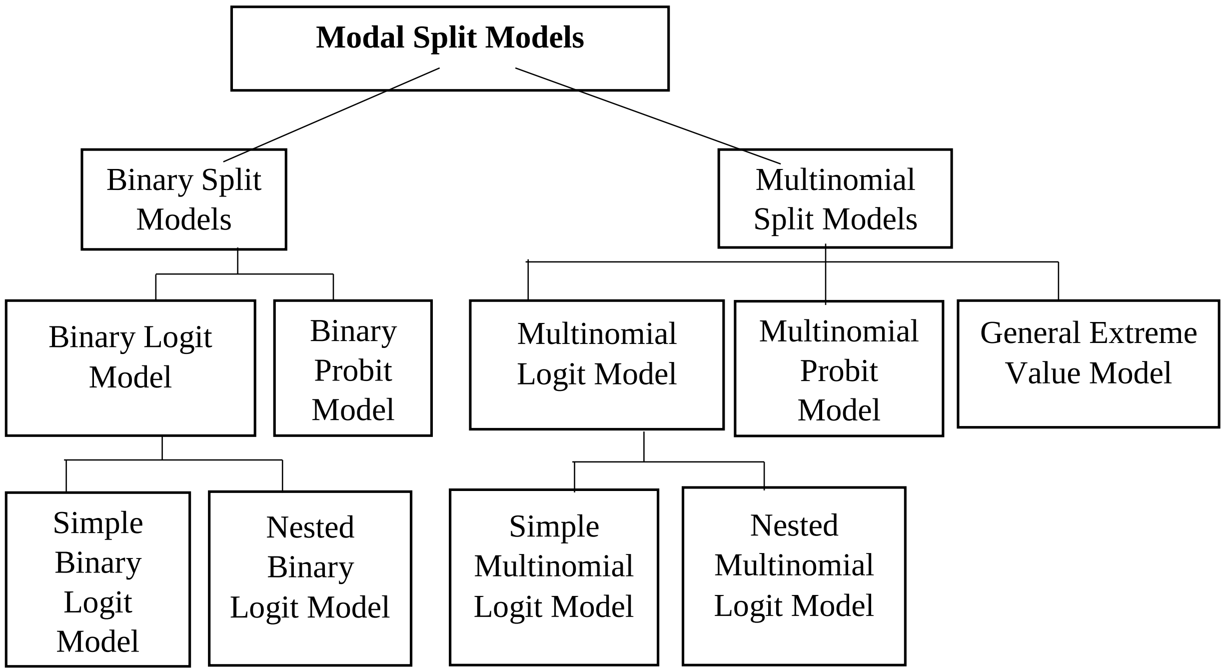

Figure 2.1. Classification of mode choice models *(Source: (Sadi, 2012))*

There are three different types of models depends upon the functional form of the error term distribution: - They are Logit model, probit model and General extreme value model. In this case we going to review only for the logit model.

2.4.4. Logit model

The mathematical framework of logit models is based on the theory of utility maximization. As (Sadi, 2012) stated there are three specific assumptions of the structure of logit model.

1. The error components are extreme-value (or Gumbel) distributed: - indicates that all the utilities associated with the travelling modes should be considered as a linear sum of attributes and have same scale parameter which allows the addition or removal of an alternative from the choice set without affecting the structure or parameters of the model.

2. The error components are identically and independently distributed across alternatives.

3. The error components are identically and independently distributed across observations.

Those assumptions serve as the main postulates of the structure of logit models. In first assumption Gumbel distributed indicates that all the utilities associated to the travelling modes should be considered as a linear sum of attributes and have the same scale parameter (Sadi, 2012). The last two assumptions are normally grouped together to be referred to as Independence of Irrelevant Alternatives (IIA) simply meaning that all the travel modes used in modelling the travel behaviour are independent of each other.

Logit models are the most commonly used modal split models in the area of transportation planning, since they possess the ability to model complex travel behaviors of any population with simple mathematical techniques and because of its simplicity and easy interpretation of results, it has comparatively reasonable accuracy (Sadi, 2012).

The mathematical framework of the logit models is based on the theory of utility maximization (Sadi, 2012). The technique is explained in detail by (Hensher and Johnson, 1981). Briefly, the utility function for the logit model has the following form.

The utility by an individual n from mode j, Vjn, is derived as a linear function of the explanatory variables as follows:

$$Vjn = \beta_{oj}+\beta_{1j}X_{1n}+\beta_{2j}X_{2n}+\ldots\ldots\ldots\ldots+\beta_{nj}X_{qn}\ldots\ldots\ldots\ldots \text{(Equation 2.2)}$$

Where:

Boj is the alternative specific constant for mode j;

β1j, β2j- βnj is the coefficients associated with explanatory variables;

X1n, X2n........, Xqn is the explanatory variables for individual n; and

q The number of the explanatory variables included in model.

Logit models are generally classified into two main categories, namely binary and multinomial logit models.

2.4.4.1. Binary logit models

It is capable of modeling with two discrete choices only, i.e. Car and Public transport. The individual has only two possible alternatives for selection. An example of a binary logit model in (Figure 2.2), where the choice set contains car and public transport as two competing alternatives.

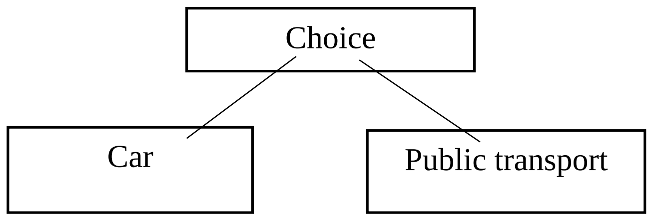

Figure 2.2. Example of a Simple Binary Logit Model (Source: (Sadi, 2012))

As discussed previously, an individual, when faced with a set of various discrete alternatives, always select the one that yields maximum utility. In the case of binary choice models, the main assumption is that the individual has only two alternatives to be chosen. Therefore, the binary choice models can be classified as a special case of multinomial choice models in which the set of available alternatives contains two members.

For binary logit models, the basic equation, ignoring the attributes of the individual and considering the individual has only two alternatives i and j, is given as:

$$Pi= \frac{\exp(Vi)}{\exp(Vi)+\exp(Vj)} \text{ or } pi= \frac{1}{1+\exp(Vj-Vi)} \text{ And, } Pj = 1- pi \text{.................. (Equation 2.3)}$$

Where,

Vi is the utility function associated to alternative i;

Vj is the utility function associated to alternative j;

Pi is the probability that alternative i will be selected; and

Pj is the probability that alternative j will be selected.

This is the detailed mathematical explanation, theoretical framework and statistical estimation techniques of binary logit models can be found in Sadi (2012).

2.4.4.2. Multinomial logit models

The MLM is widely used in a variety of transport related mode choice behavior. It is particularly attractive in a modelling scenarios due to the nature that it is linked to the decision-making behavior via maximizing or minimizing the utility (Li, 2011). It can be derived from binary logit model to deal with more than two modes or simply a larger set of alternatives.

MLM are categorized into simple and nested logit models, based on the characteristic of the available travelling alternatives in the choice set. Simple MNL assume that all of the alternatives are independent and each should be analyzed separately and the (figure 2.3) shows the example of the simple MNM.

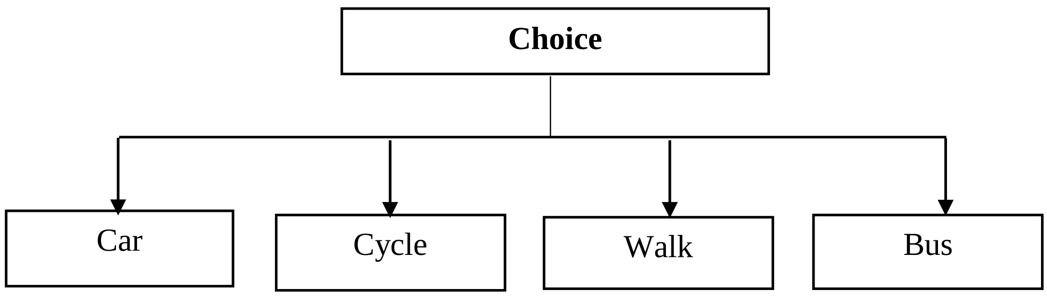

Figure 2.3. Example of simple multinomial logit model (Source: (Sadi, 2012))

The nested logit model is based on the assumption that some of the alternatives share common components in their random error terms and it is decomposed into a portion associated with each alternative and a portion associated with groups of alternatives as shown in (Figure 2.4).

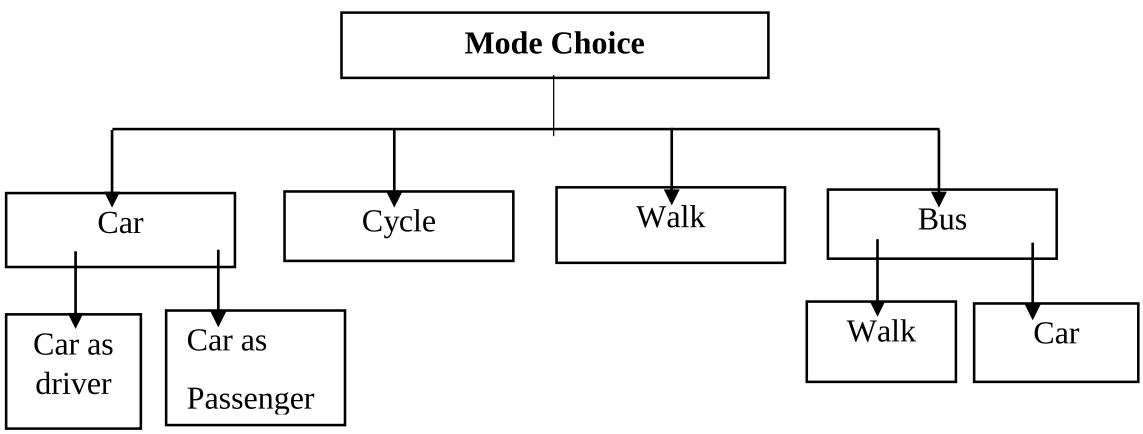

Figure 2.4. example of nested multinomial logit model (Source: (Sadi, 2012))

MNL are the simplest and most practical discrete choice models because of the ease with which they estimate the modal split of a study area. They are based on extreme value distribution and follow a strict assumption that all the disturbance terms are independent and identically distributed (Dibakar, 2012).

The basic equation of the model is given as:

Pn = exp (Vn)/$\sum_{m\varepsilon M} exp(Vm)$.. (Equation 2.4)

Where,

Vn is the utility of mode n

Vm is the utility of any mode

Pn is the probability that the individual selects mode and the probable of the modal share For the future; and

M is the set of all available travelling modes

2.5. Model Estimation techniques

Logit model development consists of formulating model specifications and estimating numerical values of the parameters for the various attributes specified in each utility function by fitting the models to the observed choice data. The critical elements of this process become the selection of a preferred specification based on statistical measures and judgment.

There are two model estimation techniques which are maximum likelihood and least squares method but due to higher application of maximum likelihood method, it is preferred over the least square method.

2.5.1. Maximum Likelihood method

The method of maximum likelihood is the most commonly used for determining the estimators in logit models. Its estimators are the values of the parameters for which the observed sample is most likely to have occurred (Sadi, 2012).

This method requires a sample of individual decision-makers along with the data regarding the travelling mode chosen and the attributes of that particular mode. The basic equation of the method, that involves the maximization of the likelihood function, is given as:

L = $\prod_{m=1}^{M} P(tm, m)$ .... (Equation 2.5)

Where,

L is the likelihood the model assigns to the vector of available alternatives

M is the total number of available alternatives.

m is the alternative present in the set of available alternatives.

tm is the mode observed to be chosen in alternative m; and

$P(tm, m)$ is the probability for choosing alternative m.

In Maximum Likelihood Estimation Theory the steps the steps followed as follows:

1. Developing a joint probability density function of the observed sample, called the likelihood function,

2. Estimating parameter values which maximize the likelihood function.

2.5.2. Least-Squares

The method of least-squares is widely used in the case of linear regression for determining the coefficients of equation and it can be stated as, the least square estimators are the values that minimize the sum of squared differences between the observed and expected values of the observations (Sadi, 2012).

The coefficients of regression are estimated by the basic objective function F which is given by equation (2.6) below.

$$F = \min \sum E^2 = \min \sum (\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + B_k X_k - Y)^2 \quad \text{.................... (Equation 2.6)}$$

The desired coefficients are estimated by taking (k+1) derivatives of equation (2.6) and solving for (k+1) unknowns. This method is usually called the Ordinary Least-Squares (OLS). Generally, the least-squares estimators are unbiased under very general assumptions and it should be noted that the least square method works consistently and efficiently for linear models only (Hashemolhosseini et al., 2002) and (Thissen et al., 2004).

2.6. Methods of testing the validation of the model

2.6.1. Checking signs of parameters

There are informal tests are designed to examine the reasonableness of the results of estimated parameters. The most common estimation results to assess the signs of the estimated parameters with theory, intuition and judgment based on the expected impact of the corresponding variables (Essam & Sadi, 2013). For example, it is logical for signs of travel time and travel cost parameters to be negative because the utility of modes will decrease with an increase of travel time and travel cost.

Over all goodness of fit measures Rho-squared value (ρ2); this is similar to the R2 measure for linear regression models and it can be used to describe the overall goodness of fit of the model. The value of rho-squared measurements lie between 0 and 1. A value of zero implies that the model is not perfect; whereas, a value of one implies a perfect model; that is, every choice is predicted correctly (Koppelman & Bhat, 2006).

The $\rho_0\, 2 = 1 - (LL(\beta) / LL(0))$; measures how explanatory the model is relative to a model with all the parameters zero where LL(β) is the log likelihood of the estimated model or the model at convergence and LL(0) is the log likelihood when all the parameters are zero. Whereas $\rho_c\, 2 = 1 - ((\beta)/ (c))$; measures how the estimated model explains the preference of modes relative to the constants only or intercept model. LL(c) is the log likelihood of the constants only model (Ali, 2018).

2.6.2. Tests for the individual parameters

The null hypothesis in most software packages are that the parameter is equal to zero. In cox regression, too, Wald statistics is used to test the null hypothesis that a parameter is zero by measuring the statistical significance of the parameter, with the following equation (2.7).

$Wald\ statistic = \beta / S.E$.. (Equation 2.7)

Where β is the covariate regression coefficient estimated value and S.E is the standard error associated with the parameter. SPSS results in a P-value for the null hypothesis that the parameter is zero. For 95% confidence level, if the P-value is less than 0.05, the null hypothesis is rejected which means that the estimated covariate significantly improves the fit model. P-values greater than 0.05, provided 95% of level of confidence, imply that the variable does not contribute significantly to the explanatory power of the model and can be considered for exclusion (Essam and Sadi, 2013).

2.6.3. Log likelihood ratio test

The likelihood ratio test is used to compare two models provided that one is the restricted version of the other by formulating a test statistics. If all the restrictions that distinguish between the restricted and unrestricted models are valid, it is expected for the difference in log-likelihood values at convergence of the two models to be small. If some or all of the restrictions are invalid, the difference in log-likelihood values of the two models will be sufficiently large to reject the hypothesis (Koppelman & Bhat, 2006). The test statistics is; $\chi\ 2 = -2 * (LLR - LLU)$ Where, LLR is the log likelihood of the restricted model at convergence and LLu is the log likelihood of the unrestricted model at convergence (Ali, 2018).

2.7. Verification of the multinomial logit model

Koppelman and Bhat (2006) stated that the developed model of the multinomial logit model has three important properties. So, the verification of the model is checked by either it fit those three properties of the MLM or not. This important properties of the MLM is discussed as follows:

1. Its sigmoid or S shape,

2. Dependence of the alternative choice probabilities on the differences in the systematic utility or it is called the equivalent differences property and,

3. Independence of the ratio of the choice probabilities of any pair of alternatives from the attributes and availability of other alternatives.

2.7.1. The Sigmoid or S shape of Multinomial Logit Probabilities

The S shape of the MNL illustrated the probability of choosing alternatives. The S-shape limits the probability range between zero when the utility of alternatives is very low, relative to other alternatives, and one when the utility of alternatives is very high, relative to other alternatives. This function has very gradual slope at extreme values of alternative utility, relative to the other alternatives, and is much steeper when its utility reaches a value such that its choice probability is close to one-half. This implies that if the representative utility of one alternative is very low or very high, compared with the others, a small increase in the utility of this alternative will not substantially affect its probability of being chosen. The point at which an increase in the representative utility of an alternative has the greatest effect on its probability of being chosen (i.e., the point of maximum slope along the curve) is when its representative. Utility is equivalent to the combined utility of the other alternatives. When this is true, a small increase in the utility of one alternative can 'tip the balance' and induce a large increase in the probability of the alternative being chosen (Train, 1998).

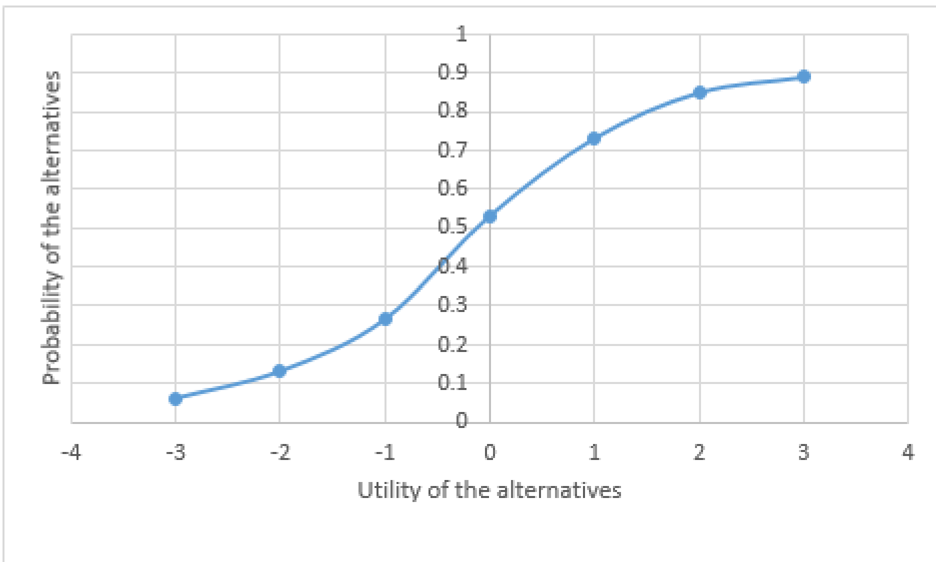

Figure 2.5. S-shape of the MLM probabilities (source:(Koppelman and Bhat,2006))

2.7.2. The Equivalent Differences Property

A fundamental property of the multinomial logit and other choice models is that the choice probabilities of the alternatives depend only on the differences in the systematic utilities of different alternatives and not their actual values. This can be illustrated in two ways. First, the choice probability equations are unchanged if the same incremental value, say α, is added to the utility of each alternative.

$$\Pr(\mathrm{i}) = \frac{\exp(Vi)}{\exp(i)+\exp(j)+\exp(k)} \quad \text{......................................} \text{ (Equation 2.8)}$$

Where, i is the alternative for which the probabilities are being computed.

Adding α to the systematic components of i, j and k gives.

$$\Pr(i) = \frac{\exp(Vi)}{\exp(i+\alpha)+\exp(j+\alpha)+\exp(k+\alpha)} \text{ .... (Equation 2.9)}$$

Which has the same probability as before is α was added to each of the utilities. This result applies to any value of α (Koppelman and Bhat, 2006).

2.7.3. Independence of Irrelevant Alternatives Property

One of the most widely discussed aspects of the multinomial logit model is its independence from irrelevant alternatives (IIA) property. The IIA property states that for any individual, the ratio of the probabilities of choosing two alternatives is independent of the presence or attributes of any other alternative. The premise is that other alternatives are irrelevant to the decision of choosing between the two alternatives in the pair. To illustrate this, multinomial logit model for the choice is as mentioned below.

$$\Pr(i) = \frac{\exp(Vi)}{\exp(i)+\exp(j)+\exp(k)} \text{ .... (Equation 2.10)}$$

$$\Pr(j) = \frac{\exp(Vj)}{\exp(i)+\exp(j)+\exp(k)} \text{ .... (Equation 2.11)}$$

$$\Pr(k) = \frac{\exp(Vk)}{\exp(i)+\exp(j)+\exp(k)} \text{ .... (Equation 2.12)}$$

The ratios of each pair of probabilities and exponential of the utility function is equal:

$$\frac{p(i)}{p(j)} = \frac{exp\ (Vi)}{exp\ (Vj)} \text{ .... (Equation 2.13)}$$

$$\frac{p(i)}{p(k)} = \frac{exp\ (Vi)}{exp\ (Vk)} \text{ .... (Equation 2.14)}$$

$$\frac{p(j)}{p(k)} = \frac{exp\ (Vj)}{exp\ (Vk)} \text{ .... (Equation 2.15)}$$

The IIA property has some important ramifications in the formulation, estimation and use of multinomial logit models. The independence of irrelevant alternatives property allows the addition or removal of an alternative from the choice set without affecting the structure or parameters of the model. The flexibility of applying the model to cases with different choice sets has a number of advantages.

First, the model can be estimated and applied in cases where different members of the population (and sample) face different sets of alternatives. Second, this property simplifies the estimation of the parameters in the multinomial logit model. Third, this property is advantageous when applying a model to the prediction of choice probabilities for a new alternative. On the other hand, the IIA property may not properly reflect the behavioral relationships among groups of alternatives. That is, other alternatives may not be irrelevant to the ratio of probabilities between a pair of alternatives. In some cases, this will result in erroneous predictions of choice probabilities (Koppelman and Bhat, 2006).

2.8. Revealed and Stated preference survey

These two techniques are used a complementary tools to elicit the preferences of the decision because many researchers have attempted to model travel demand and travelers' behavior using revealed and stated preference survey data. They conveniently provide data for the development of disaggregate travel forecasting models.

Revealed preference and stated preference studies each have their advantages and disadvantages. According to Swait et al. (1994) the main advantage of using a revealed preference study is that it can represent current market situations better than stated preference studies whereas stated preference studies are less constrained than revealed preference studies and allow us to look at potential changes.

In revealed preference studies, the choices that are made by respondents are known outcomes, although they are dependent on the respondent's perceptions of attribute levels, which may or may not be accurate but stated preference studies allow us to examine how decision-making varies as different types of attribute profiles and levels are considered (Sadi, 2012).

Stated preference techniques were originally popularized by the work of Sadi (2012) who demonstrated how researchers could examine trip maker's answers to hypothetical combination of attribute levels for travel modes.

The stated preference techniques allow the deficiencies of revealed preference data to be overcome by testing hypothetical transport alternatives. This technique becomes an attractive option in transportation modeling since it presents the decision-makers choice and behavioral pattern under different hypothetical scenarios. Many researchers use this technique to understand the unpredictable behavior of decision-makers under conditions that are new or hypothetical (Sadi, 2012).

2.9. Previous studies of passenger travel mode choice modelling in other countries

There are many studies have been applied around the world in the area of transportation travel mode choice modeling. The studies aimed at developing a discrete choice model that fits with the study area. In this research some studies presented in the cities of developed and developing countries in order to benefit in developing a suitable mode choice for our country.

Al-Ahmadi developed intercity mode choice models for Saudi Arabia. These models indicated that in-vehicle travel time, out of pocket cost, number of family members travelling together, monthly income, travel distance, nationality of traveler, and number of cars owned by family played the major role in decision related to intercity mode choice **(**Sadi, 2012).

Developed mode choice model for work trip for Calicut city. The attributes Age, gender, income, time and cost are proved to be the significant factors that influence the mode usage of the employees, and the model of employee's mode choice formulated in this study is also convincible. This work trip is essentially an attempt to identify the various variables that influences the mode choice behaviours of employees. The investigation was conducted through a comprehensive analysis of geographic, transportation, and personal statistics, principally with the aid of the logit model (Tushara et.al, 2013).

The empirical utility functions for car and bus as follow:**-**

V (CAR) = –5.213 – 0.211(TT) + 0.166(TC) + 2.689 (INC) – 2.131(AGE=0) – 2.311 (AGE=1)

V (BUS) = –0.512 +0.319 (TT) – 0.438 (T.C) +2.44 (WT) – 3.179(TW) + 2.700 (GEN=0)

Results of the multinomial logit model analysis demonstrated that these five factors (age, gender, income time and cost) were strongly related to considerations of the employees of their travel. The sign of each coefficient generated in the MNL model is convincible and consistent with the hypothesis. In terms of the hypothesis the mode choice of workers affected mainly by time and cost.

Khan estimated various nested logit models for different trip length and trip purpose using data from stated preference survey. A unique computer assisted personal interviewing instruments was designed using motorized and non-motorized travelling modes in the SP choice set. Additionally a unique set of access modes for bus on bus way was also generating hypothetical modes such as secure park and ride facilities and kiss and ride drop-off zones. He found from the final model estimation that the travel behavior forecasted for regional trip makers is considering different from that for local trip makers. The regional travelers for work were found not to perceive the non- motorized modes as valid alternatives to car, possibly due to longer trip length. The value of time determined for local work trip makers was 16.5 A$/hr was also found to be higher than that of regional work trip makers (Sadi, 2012).

Adjaka **a**nalyzed the factors that influence parents' decision in choosing transportation modes for school children in district of Colombia. Multinomial logistic regression was used to predict the share between choice modes. The factors that found to be most significant included distance home to school, student's grade, school's encouragement of walking and biking and walking fun for school children (Sadi, 2012).

Almasri analyzed the factors that affect travel choice of shared taxi versus bus for Palestinian university student trips. The results of this study indicated that factors that are significantly affecting the mode choice of students are family income divided by family size, weighted travel time, out of vehicle travel time divided by distance and cost divided by natural logarithm of income. The results also show that the age and gender variables are statistically insignificant and it could be dropped from the model (Sadi, 2012).

Sadi (2012**)** stated that travel time, ratio of fare over personal income, frequency of service, age, average monthly family income, and distance have an effect on the mode choice decision of employed people as they are statistically significant at the 95 % confidence level while the gender variable has no effect on the mode choice decision as it is statistically insignificant even at 90% confidence level.

The utility functions for the model can be written as follows:

Up-car = – 0.1294(TT) – 227.50729 (Tc/PINC)

US-taxi = 1.0773 – 0.1294(TT) – 227.5072 (Tc/PINC) – 1.06260 (OWTM)

U-taxi = -0.5826 – 0.1294 (TT) – 227.5072 (Tc/PINC)

U-motorcycle = 4.9794 – 0.1294 (TT) – 227.5072 (Tc/PINC) – 0.0021(FINC)

U-bicycle = – 15.3013 – 0.1294 (TT) – 227.5072 (Tc/PINC) + 0.3979(AGE)

U-walking = 7.366 – 0.1294 (TT) – 227.5072 (Tc/PINC) – 0.001(FINC) – 2.16 (DIST)

Where TT for the travel time, TC for the travel cost, DIST for distance, FINC for family income.

2.10. Previous studies of transportation mode choice modeling in Ethiopia

Modal split model used in the urban transport study for the Addis Ababa, 2005: the Ethiopian Road Authority (ERA), under assistance from the World Bank, has undertaken an urban transport study as a project entitled ''Urban Transport Study and Preparation of Pilot for Addis Ababa."

This study assumes that the first choice between walk and vehicular modes is influenced by the economic status of the household. Moreover, mathematical models were developed in order to assess the relationship between the choice of vehicular modes/walk and the economic status (i.e. income) of households. In which after the study the result shows that with the increase in income, the tendency towards vehicular modes increases. Which, they have found to be more prominent in the case of work purpose trips.

For public transport users, the study considered two facilities, Namely, Anbesa Bus service and Minibus as available competing modes and a Logit model was developed in order to assess the choice behavior between Anbesa City Bus service and Minibus service based on the generalized cost of travel by these services. The generalized cost component includes in vehicle travel time, access time, waiting time, out-of-pocket cost, reliability, comfort and convenience etc. And finally the model was calibrated for the observed data for the two competing modes Anbesa city bus and Minibus for work, education and other trip purposes.

Mengistu (2015) developed Logit Model for School and Work Trip Mode Choice on Railway Route Corridor. A mode choice model was developed for both employees and students and the variables which is found significant for the case of employees are work type (Government, private, self-employee), out of vehicle time, travel time and income. For the case of Light Rail Transit system the interest to shift from existing modes for both employees and students are mainly from Higer and Anbesa bus users followed by taxi, then she concluded that almost there is no interest to shift from private car users.

Sample size calculation for logistic regression is a complex problem, but based on the work of Peduzzi et al. (1996) the following guideline for a minimum number of cases to be included in the study was determined. Let p be the smallest of the proportions of negative or positive cases in the population and k the number of covariates (independent variables), then the minimum number of cases to include was:

N=10K/P, Assuming a proportion of positive cases of 0.5(50 %).

Ali (2018) The models indicated that for the situation in which BRT is included in the choice set of trip makers, to increase the utility of the modes, decreasing a unit in-vehicle travel time has more effect than decreasing a unit out of vehicle travel time. The sample size he used according to the Glenn which is used to determine the sample size in different research areas with Population sizes greater than 100,000 (Glenn, 1992).

$n = Z^2 * p\ (1-p)/e^2$

Where; n is the minimum sample size, Z is the z-score for desired level of confidence, p is the estimated proportion of an attribute that is present in the population, and e is the desired level of precision. For 95% level of confidence Z = 1.96, maximum variability p = 0.5 and e = 5% level of precision or sampling error, the minimum sample size is calculated to be 385.

It is also apparent that the in-vehicle travel time and total travel cost has similar effects on the

Utility of the modes.

UBRT = – 0.100 * **IVTT** – 0.045 * **OVTT**– 0.104 * **TTC**

ULBUS = – 1.919 – 0.100 $*$ **IVTT** – 0.045 $*$ $\boldsymbol{OVTT}$ – 0.104 $*$ **TTC**

$\text{UTAXI} = -\ 2.040 - 0.100 * \boldsymbol{IVTT} - 0.045 * \boldsymbol{OVTT} - 0.104 * \textbf{TTC}$

$\text{UPC} = 2.073 - 0.100 * \boldsymbol{IVTT} - 0.045 * \boldsymbol{OVTT} - 0.104 * \textbf{TTC}$

According to the above formulated stated preference of modes, the decrease in in-vehicle travel time and travel cost of a particular mode apparently increases the preference of the mode. Since their magnitudes are more or less similar, a unit decrease of in-vehicle travel time has a similar impact on the increase of the utility of the model as the impact in a decrease of a unit of the total travel cost of the mode. This can be applied in the fare structure and the arrival frequency design of the BRT system, which is under design and installation now.

Megersa Akewak (2018), Assess for the passengers mode choice in Addis Ababa: A case of Mexico square-Hayahulet and Megenagna –Hayat route. He try to determine mode choice of the public transportation namely Light rail transit, Anbesa city bus and Mini bus taxi. He takes a minibus as a reference category. The model he developed was for the Light rail transit and Anbesa city bus.

Utility of the modes:

Light rail transit = 1.963+0.12(EGDEST) – 0.398(DOS) +0.810(SEX)

Anbesa city bus = –2.33+0.005(EGDEST)–1.516(POT=4) +0.745(RELIABILITY)

3. MATERIAL AND METHODS

3.1. Introduction

The steps followed in order to achieve the objective of the study, and it presents the researcher how to collect data and investigate the research problem. They include description of the study area, the transportation system of Hawassa city, research design, theoretical framework for research methods, modeling, methods used to calculate mode attribute values, the relative importance index and the rank of the factors that affect the mode, design of questionnaires, target group, study period, study of variables, data collection tools and method, sampling generation methods, sample size determination and data analysis.

3.2. Description of the Study Area

Hawassa city located in the Sidama Zone, 273 km south of Addis Ababa and well known in well-connected road networks with heterogeneous traffic system. Based on the Hawassa central statistics population census, the current population of Hawassa city is 406,148 inhabitants, of whom 208,799 were males and 195,349 females in its eight sub cities in a city. Of those 8 sub city, Hawella Tulla has had the highest population with a total of 141,058 inhabitants, followed by Tabor with 74,057 and Menaheria with 41,645 inhabitants.

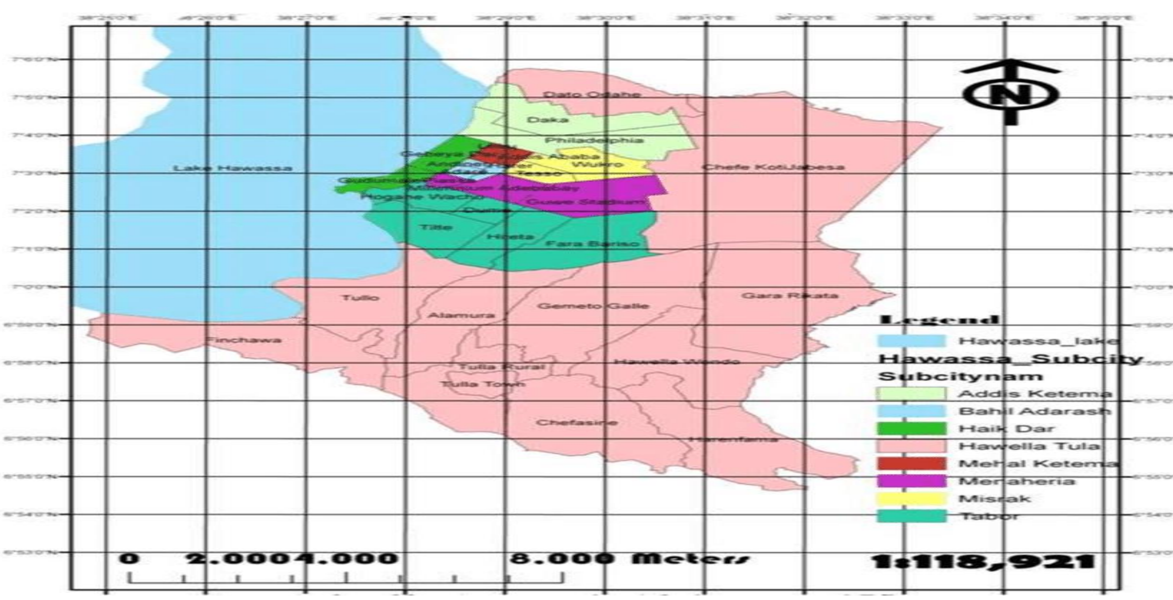

Figure 3.1. Map of the study area (Source: City Administration of Hawassa, (2014))

3.2.1. The transportation system of Hawassa city

The most common transportation means of transportation to move to and within the city is automobile. There are a number of buses and mini-buses that serve as the means of public transportation from different cities in the country. The road is among the first rank in the country in almost all gates of the city. There are also a number of transportation service providers in the city. These include:

City Bus-The city administration started sixty bus service in September 2012. There are four buses to begin with mainly used to give transport service the city's longest routes and the nearby areas. The tariff and the service can be considered to be in better condition. Currently, there is 17 number of the city bus in services.

Taxi-Hawassa city has more than three thousand taxis providing transportation service within a city among about 2750 are Bajaj and 360 minibus mode of the transportation. The common ones are Bajaj and TVS taxis that accommodate three people. These taxis have high mobility, lower tariffs, ease of accessibility and ventilation.

Motor Bike-In now day's motor bikes are becoming popular means of transportations for residents. Most residents with upper middle level income are becoming more and more users of motor bike transportation system. The suitability of the roads, relatively lower priced motor bikes availability and the growing need for faster transportation are contributing for the greater degree of assimilation in motor bikes.

Pedal Bicycle-Before years pedal bicycle was one of the most popular private transportation system. But it now days it is mainly used by high school students. The former dominant private transportation role of pedal bicycle is overtaken by motor bikes and three tyre taxis.

Car Rentals- In case you want to drive within and out of the city, you can contact car rental service providers that are in a position to meet your car demands in the city fairly. The majority of the car rental service providers are providing services for field work and to some extent city tour.

Motor Bike Rental-One of the interesting things in the city is the availability of friendly service provision. Whether you are experienced motor bike user or not, there are motor bike service provider that lets someone experience the city by renting and assisting you to have a motor bike.

Traditional Cart or in Amharic "Gar" -This means transportation was common in Hawassa before some years when there was not asphalt road and the villages were relatively clustered. However, au on the rise in the coverage of asphalt roads, the service is now limited to the areas where formal taxis are not available and in the rear by rural areas. If you want to feel the countryside taste of the city, the city, you can just move to either edge of the city major asphalt road, and you will find cart "Gari' transport in the nearby area.

Boat Trip on the lake-There are a number of Boat trip service providers on the lake. These service providers can be found in Gudumale/Amora Gedel, Lewi resort, Haile Resort and around Tikur Wuha area. The lakes have different carrying capacity, and system. Some have motor system while the others are soley or partialy operated by human labor.

Air transport service-Hawassa has no local nor international standardized airport. However there are some undertakings to improve the level of air field to accommodate air transport. Some air private flight service providers available to provide air service in case of emergencies and for special needs.

Moreover, the city administration of Hawassa announced on Tuesday, Jan 5, 2019, that it is going to introduce Bishoftu buses to provide public transportation service for its residents. The commencement of the service will mark the first public city bus transportation system in the Southern Region. The Metal and Engineering Corporation has signed an agreement with the city to assemble and supply the eight buses by importing spare parts from China. The buses are being assembled by Bishoftu Automotive and Locomotive Industry (BALI), a subsidiary of the Metal and Engineering Corporation (Hawassa city road and transportation burreo, 2019).

3.3. Research design

The research is explanatory type of the research aimed at showing the transport mode choice of students and employees and the factors that determine their mode of the transport. So, in order to analyze the relationship between characteristics and mode choice of the employees and students, a MNL is applied to understand mode usages of these categories. The MNL is the simplest and most popular known discrete choice model. The closed form of the MNL is to estimate (maximum likelihood estimation procedure), interpret and use. The theoretical framework for research methods is as follow in (Figure 3.2).

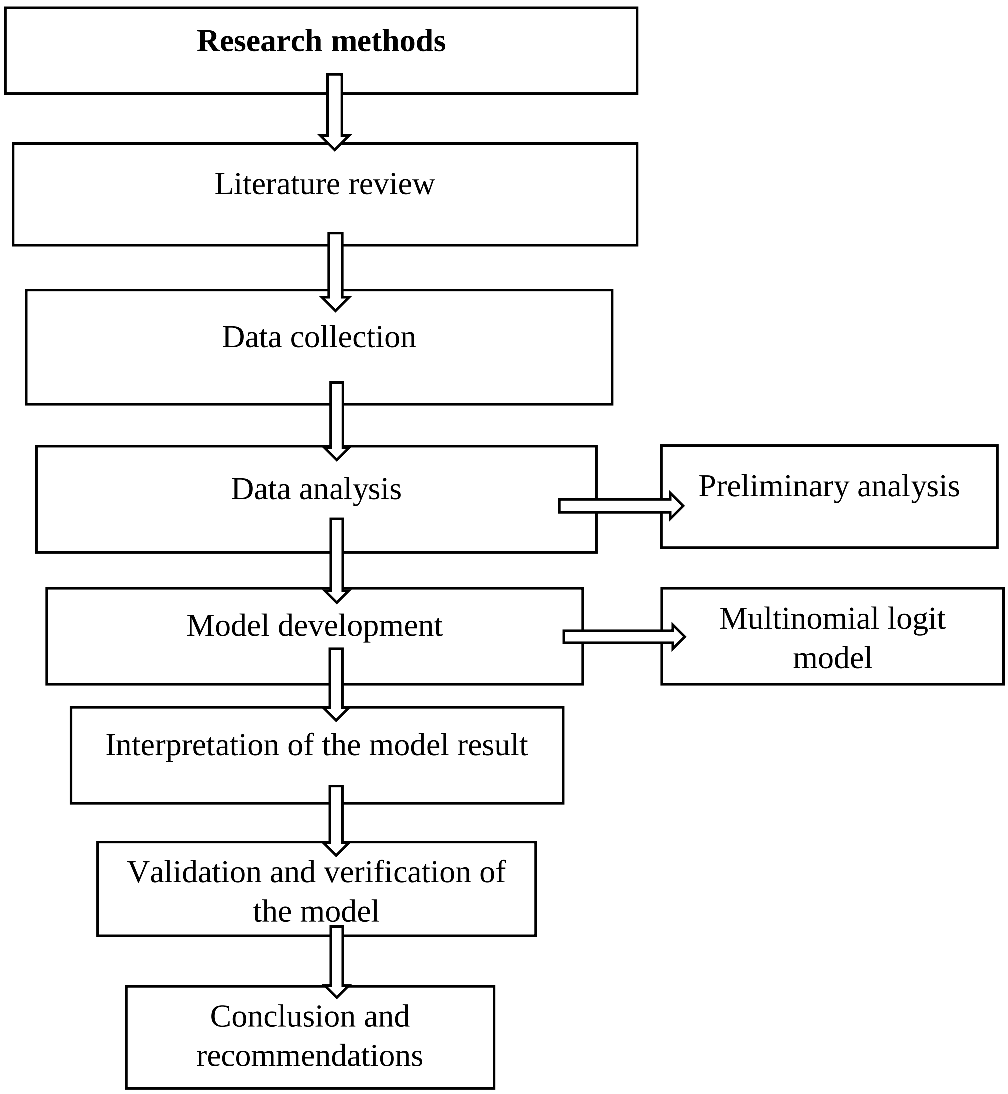

Figure 3.2. Schematics of the Study

3.4. Modeling

In developing this model, the dependent and independent variables were determined. The dependent variables were the mode choice of the transport: walking, bicycle, motorcycle, Bajaj, damas, minibus, city bus and private car.

The designing of the mode choice model needs extensive evaluation of observed data and the efficiency of the whole model system. Distinct requirements for the models have been assessed to identify, which requirements most effectively augment the data for various trip purposes. In the current study, specific parameters were predicted to impact travelers' behavior, when they have different choice of transportation modes. Some of the parameters (such as, travel cost and travel time) are considered to be substantial in literature. These requirements consist of the parameters for employees such as gender, age, sex, marital status, family size, monthly income, travel cost, out of the vehicle travel time, in vehicle travel time and comfort, whereas for the students' gender, age, sex, marital status, family size, monthly income, travel cost, out of the vehicle travel time, in vehicle travel time and educational level.

For the state preference case the data were collected in the way of anyone is interested in choice from the existing mode choice behaviours by considering frequency, travel time and cost.

3.5. Methods used to calculate mode attribute values.

Travel Cost: - Travel cost is a cost incurred by the traveler which out of pocket cost and for Car drive out of pocket cost is calculated by summing fuel cost and operation cost per kilometer. For the bus, minbus, damas and Bajaj their travel cost calculated through formula, the formula was created by regretting travel distance verses travel cost which was collected from the respective respondents.

Hawassa city road and transportation burreo (2018) announced that previous tariff of the Hawassa city is altered due to the increase of the benzene from the 18.07 cents to 18.90 cents in 2010. In case the tariff for the Minbus, Ladas and Bajaj is 0.75 cents/km, 0.75 cents/km and 1.25 cents/km respectively. Therefore the decided tariff for the different length (km) for the transportation mode types Minibus, Damas and Bajaj is as follow in (Table 3.1 and Table 3.2).

Minibus and damas taxi

Table 3.1. Fare structure minibus and Demas taxi tariff

Distance(km)	Cost(birr)
1	0.75
2	1.50
3	2.25
4	3
5	3.75
6	4.50

(Source: Hawassa city road and transportation burreo, (2018))

Bajaj

Table 3.2. Fare structure minbus and Demas taxis tariff

Distance(km)	Cost(birr)
1	1.25
2	2.5
3	3.75
4	4
5	5.25
6	6.50

(Source: Hawassa city road and transportation burreo, (2018))

To get real travel cost of the respondents from their trip experience calculated by adding fuel and maintenance cost in addition to their response in the questionnaires. This is in order to fill if any missed data in their response in the designed questionnaires.

For example: Travel cost calculation of a trip maker who makes an approximated total trip of 44 work trips or school trips per month and whose home is 3 km away from his/her college or organization, whose car with fuel efficiency of 8km/liter uses gasoline fuel and maintenance cost is 400 ETB/month and is given below.

Travel Cost $=$ Fuel Cost + Total Maintenance Cost

$$= (18.90\frac{ETB}{Liter} * 3km\Big/_{8km/Liter}) + (400\frac{ETB}{month}\Big/_{44\ trips/month})$$

= 16.17 ETB/trip

Travel time: - is the component of the out of vehicle travel time, waiting time, and in-vehicle traveling time. The out of vehicle travel time, including time from home to the bus / tax station and then walking time to the working place or the school. The waiting time is the time the travelers lost in the coming vehicle. In-vehicle travel time is the time they lost until the vehicle starts to move plus the time they lost until the drop at the end of the station.

The walking time from home to taxi or bus station, then from the station to their destination and also in-vehicle travel time was collected from the respondents, but the waiting time for the new coming taxi or bus and also the waiting until the taxi leaves the station was obtained from site observation by using a stopwatch and format filling sheet in addition to the respondents.

3.6. The Relative Importance Index and Ranking of the factors that affect the mode

To determine the level of the factors that affect mode choice the Relative Importance Index Technique (RII) was used. The RII used to determine the relative importance of the various factors which affects mode choice behaviours.

The four-point scale ranged from 0 (very low degree effect) to 4 (very high degree effect) is adopted and transformed to relative importance indices (RII) for each factor (Aibinu and Jagboro, 2002).

$$\text{RII} = \frac{4n1+3n2+2n3+1n4+0n5}{4N}$$

Where;

N is the total number of the respondents

n1 is the number of frequency extremely high (very high) significant response

n2 is the number of frequency highly significant response

n3 is the number of frequency moderately significant response

n4 is the number of frequency slightly (low) significant response

n5 is the number of frequency extremely low (very low) significant response i.e. not significant

3.7. Design of Questionnaire

A questionnaires were developed in order to collect the data required for calibrating the mode model for work trips and school trips in Hawassa city. The questionnaire was divided into four parts as can be seen below:

Part one: which includes the social and economic information about the respondents such as gender, age, job, income, family size, ownership of the private car, ownership of a bicycle, etc.

Part two: This focused on the factors that affect the mode choice. The respondents was asked to indicate their perception on the importance of organized factors that affect the choice of transportation mode for work and school trips in Hawassa city.

Part three: This focused on the trip characteristics. For the purpose of this study, the daily trips which constitute homework trip or homeschool trips were included. In this part the information was covered is related to travel behavior of the individual for his/her trips such as (the mode usually used, travel time, travel cost, monthly fuel consumption, and maintenance cost etc.).

Part Four: This was a concern on the hypothetical choice of the respondents. The respondents were asked to rate his/her preferred modes among the following different modes shared taxi (mini bus, damas and Bajaj) and bus.

Case study: Characteristics of the transportation and quality of the transportation services

The characteristics of the transport facility and quality of the transportation service at Aroge Menaheria taxi station, Addisu Menaheria taxi station, Meskel adebabay taxi station, TTC membo station, Atote taxi station and mobile taxi station was determined by site investigation and observation regarding waiting time at the station until the new taxi service come and leave the station, quick, accessible and frequent services and also regarding the specified carrying capacity of the taxis or buses.

3.8. Pilot questionaries'

A pilot survey is a complete run through of the actual survey done over a small set of population in order to the level of credibility of instrument, data coding, and data recording. In this study at least 30 questionnaires were distributed to experts in transportation field and for sample of the population. The objective of this study was to verify and validate the completeness of questionnaire.

3.9. Target group

This research was targeted at the employees and students in Hawassa city.

3.10. Study Period

This research study was carried out within the prescribed time frame as per attached work schedule from June to October 2019.

3.11. Study of variables

3.11.1. Independent variables

For employee are Age, gender, average monthly income, family size, car ownership, travel cost, out of the vehicle travel time, in vehicle travel time and comfort are independent variables which affects the mode choice behavior whereas for the students are Age, gender, average monthly income, travel cost, out of the vehicle travel time, in vehicle travel time, waiting time and comfort.

3.11.2. Dependent variables

Transportation service modes were both motorized and non-motorized types such as City bus, Mini bus, Damas, Bajaj, Motorcycle, Bicycle and Walking.

3.12. Data Collection tools and method

Both Primary and secondary data were used for this research. The primary data was collected through questionnaire which was designed in order to fit the objectives of this study. The data were collected from college's students and governmental employees of the city.

The survey questionnaires were designed to get data on the profile of the students and workers, their choice of mode of transport, the transport costs they incur, their travel time and the related out of vehicle time. In the design of the questionnaire, travel mode, sex, income, marital status, and employment nature were assigned categorical values. For the travel time, travel cost, out of vehicle time and age the questionnaire was designed to collect the number values in the respective unit of measurement.

Data collection was implemented in two steps first pilot survey was used for 30 samples for both workers and students. Then, after some review the adjusted questionaries' distributed and the final data was collected. Secondary data for the research was collected from different agencies and companies in which the datas were available.

Moreover, the case study was used in order to measure the travel time of the passenger who is waiting for the coming vehicle and also until the coming vehicle leaves the station. The stopwatch and format sheet to fill data was used at the station of the city at the peak hour. This was done by observation for how much time passenger waiting for the coming vehicle and to know the duration of the bus/taxi until it has left the station. The major station was selected for the analysis of the vehicle waiting time at the station are Addis Menaheria to TTC warka via Alamura high school, Aroge Menaheria to piazza, Meskel adebabay to Hawassa referral hospital via TTC warka and Mobile to piazza via Arab sefer.

Secondary data was obtained from the Hawassa city road and transportation bureau, which was the travel cost or tariff in a city in each station, the number of each mode of the city.

Travel Survey: The estimation of mode choice models, requires collecting of travel and trip-related (including the actual mode choice of the traveler) survey. These data are generally obtained by surveying a sample of travelers from the population of interest. Koppelman and Bhat (2006) stated that the most common types of surveying methods are a household survey, workplace survey, school survey and intercept surveys. Among them, a workplace and school travel survey were used for this study.

3.13. Sampling generation methods

Sample generation is regarded as a vital step in surveying a sample of respondents from the targeted population. Therefore, it is essential that the sample generated from the research is representative of the characteristics of the population of the study area. Inappropriate sample generation can lead to erroneous modeling results involving biased estimated coefficients and non-representative travel behavior forecasts.

The multistage sampling technique was adopted in the study area. At the first stage by using the cluster sampling method, the study area was divided into a number of smaller non-overlapping areas. In case there is seven Sub-city was selected for study out of eight sub-cities of Hawassa city. The Tulla sub-city in the city is not considered for this study because it is very populated and also it surrounds the Hawassa city, but it is included in Hawassa city. Then after from those sub-cities, the governmental employee's institution and university colleges selected purposively because the travel time being on time at their institution and school is the critical issue for them respectively. Finally, for those selected government institution and colleges the questionnaires distributed randomly by using the simple random sampling method.

3.14. Sample size determination

Sample size calculation for multinomial logistic regression is a complex problem, but based on the work of Peduzzi et al. (1996) the following guideline for a minimum number of cases to include in the study can be suggested.

Let p be the smallest of the proportions of negative or positive cases in the population and k the number of covariates (the number of independent variables), then the minimum number of cases to include is:

$N = 10\ k / p$

For the students case of the college students there were 8 independent variables and in the case of governmental employees there were 9 independent variables. Assuming a proportion of positive cases of 0.5(50 %) for each cases the minimum number of cases required for each group:

For students = $10\ k / p = 10*8/0.5 = 160$ whereas

For employee = $10\ k / p = 10*9/0.5 = 180$, Therefore, the minimum sample size for both students and employees are 340. The seven sub-city of the Hawassa city is as follows.

The sustainable transportation planning for the employees and students are base for all other travelers in the city since school and work trips are very critical in the urban cities due to it is a daily activities than other trips (Koppelman and Bhat, 2006).

Table 3.3. Number of the people in each sub-city of the Hawassa city

item	Name of the sub city	Male	Female	Total
1	Misrak subcity	20,694	18,737	39,431
2	Menaheria sub city	21,307	20,338	41,645
3	Tabor subcity	38,993	35,064	74,057
4	Mehal ketema subcity	12,640	12,245	24,885
5	Addis ketema subcity	15,150	15,146	30,296
6	Haik dar sub city	15,218	14,321	29,539
7	Bahel adarash sub city	12,669	12,568	25,237
	Total	**136,671**	**128,419**	**265,090**

(Source: Hawassa city administration central statistics burreo, (2018))

Table 3.4. Number of the sample size in each sub-city of the Hawassa city

item	Name of the sub city	Total	percentage	Total
1	Misrak subcity	39,431	14.87%	51
2	Menaheria sub city	41,645	15.71%	53
3	Tabor subcity	74,057	27.94%	95
4	Mehal ketema subcity	24,885	9.39%	32
5	Addis ketema subcity	30,296	11.43%	39
6	Haik dar sub city	29,539	11.14%	38
7	Bahel adarash sub city	25,237	9.52%	32
	Total	**265,090**	**100%**	**340**

The employees of the different organization were taken randomly from each sub cities among them Hawassa city road and transportation bureau, SNNPR transportation bureau, municipality of the Hawassa, Hawassa city administration, Hawassa industrial park and Hawassa referral hospital were the major one while for the students different colleges were taken randomly from Hawassa city among them Rift Valley College, Info Link College, Zion College, Beza College, Hawassa TVET College and Pharma health Science College.

3.15. Data analysis

The analysis of the Multinomial Logit Models (MLM) for the work and school trips in the study area enabled the testing's and the estimation of the utility function. The ongoing processes before developing the model the data analysis passes through different statistical tests such model fitting information, goodness of the fit tests, Pseudo r-square, likelihood ratio tests and parameter estimates. The, utility functions were explored and tested in order to determine the "best fit" model specification of the study area.

The data analysis with multinomial logistic regression was undertaken in predicting with the largest score statistic whose significance value is less than a specified value (by default 0.05) is added to the model. All the variables do not add to the analysis if it's significant values larger than 0.05. Those variables chosen by the stepwise forward method have significant changes in -2 log-likelihood which is more reliable than the Wald statistics and also handle the change in -2 log-likelihood if they disagree as to whether a predictor is useful to the model.

Then after, to measure the ability of the model to adequately describe the data goodness of fit analysis is a useful and effective parameter in determining whether the model adequately describes the data or not and also by giving the result of two tests of the null hypothesis that the model adequately fits the data. If the null is true, the Pearson and deviance statistics would have chi-square distributions with the displayed degrees of freedom. If the significance value is small (less than 0.05), then the model was considered a model that does adequately fit the data. This means the goodness of fit statistic indicates a poor fit if the significance value, *p* is less than 0.05 (SPSS, 2010).

Keep in mind that in the linear regression model, pseudo $R^{2,}$ summarizes the proportion of variance in the dependent variable associated with the predictor (independent) variables, with larger R^2 values indicating that more of the variation is explained by the model, to a maximum of 1. For regression models with a categorical dependent variable, it is not possible to compute a single R^2 statistic that has all of the characteristics of R^2 in the linear regression model.

So, in order to approximate or compute the values instead, the following methods are used to estimate the coefficient of determination (Mengistu, 2015)

Cox and Snell's R^2 (Cox and Snell, 1989) is based on the log likelihood for the model compared to the log likelihood for a baseline model. However, with categorical outcomes, it has a theoretical maximum value of less than 1, even for a "perfect" model.

Nagelkerke's R^2 (Nagelkerke's, 1991) is an adjusted version of the Cox & Snell R-square (R^2) that adjusts the scale of the statistic to cover the full range from 0 to 1.

McFadden's R^2 (McFadden, 1974) is another version, based on the log-likelihood kernels for the intercept-only model and the full estimated model.

The ratio of the coefficient to its standard error, squared, equals the Wald statistic. If the significance level of the Wald statistic was found small (less than 0.05), then the parameter was considered useful to the model (SPSS, 2010). The predictors and coefficient values shown in the most appropriate model selected were used by the procedure to make predictions. Here, it should be noted that the meaning of a logistic regression coefficient is not as straightforward as that of a linear regression coefficient. While it is convenient for testing the usefulness of predictors, it is easier to interpret. The value represents the ratio-change in the odds of the event of interest for a one-unit change in the predictor.

In the explanation for parameters signs, parameters with significant negative coefficients were interpreted to decrease the likelihood of that response category with respect to the reference category. Parameters with positive coefficients increase the likelihood of that response category.

The validation and Verification of the developed model checked by either it fit those three properties of the MLM or not. This important properties of the MLM which is its sigmoid or S shape, dependence of the alternative choice probabilities on the differences in the systematic utility or it is called the equivalent differences property and Independence of the ratio of the choice probabilities of any pair of alternatives from the attributes and availability of other alternatives.

4. RESULT AND DISCUSSION

4.1. Introduction

This chapter describes the results of the descriptive analysis of the survey data, factor affecting mode choice behaviours, development of the multinomial logit mode choice model, interpretation, prediction and verification of the developed model. Initially, the analysis done for the employees and then for the students.

4.2. Analysis for the employees

4.2.1. General socio-demographic data presentation

During the collection of the primary data there were 340 questionnaires distributed, of which 180 were for the employed people work trips and 160 for the college students school trips. But the data valid for the analysis were 308 of this 162 was governmental employee and 146 was college students. These data were collected systematically selected work and school trip makers from different governmental organizations and university colleges respectively.

The descriptive statistics on the profile of employees in Table 4.1, which is the demographic profile of employees 162 data collected, whereas 18 samples were missed due to different reason and it used for analysis of the work trips. The socio-economic data included in this study were age, gender, education, level, monthly household income, family size, car ownership and marital status.

The summarized data in Table 4.1 indicated that 69.1% of the sample were men and 30.9% were female. About 43.2% of the trip makers in the sample ranged from age 18-29, 43.89% ranged from age 30-45 and 4.94% was the age above 45. The marital status of the trip makers 53.7% were single and 46.3 were married. The family size of the trip makers were 13% for one family member, 36.4% were in the 2-3 family member and 50.6% of the family member greater than 3. The education level of the 33.3% were diploma, 59.9% were degree and 6.8% were master's degree. It was obvious that 100% of the sample were the governmental employees. The average monthly income level of the trip makers were 28.4% less than 2000, 58.6% range from 2001-5000, 11.1% were ranging from 5001-1000 and 1.9% were greater than 10001.

Table 4.1 Descriptive statistics on the demographic profile of employees

Socio economic attributes	Label	Category	Frequency	Percentage (%)
Gender	1	Male	112	69.1
	2	Female	50	30.9
Age	1	18-29	70	43.2
	2	30-45	84	51.86
	3	> 45+	8	4.94
Marital status	1	Single	87	53.7
	2	Married	75	46.3
Family size	1	1	21	13
	2	2-3	59	36.4
	3	>3	82	50.6
Educational level	1	Diploma	54	33.3
	2	Degree	97	59.9
	3	Master's degree	11	6.8
Occupation		Governmental employee	180	100
Income	1	< 2000	46	28.4
	2	< 2001- 5000	95	58.6
	3	<5001-10000	18	11.1
	4	>10001	3	1.9

4.2.2. The mode chosen by the employees

In addition to the socio-economic profile of the trip makers, the modal share (mode chosen by the employee) of the selected governmental employee of the city is summarized in the Table 4.2 which illustrated the percentage of the modal split chosen by the employees.

The employees were chosen set of modal alternatives such as Walking, Bicycle, Motorcycle, Bajaj, Damas, Minibus, Bus, and Private car. In the study area, Minibus is the most predominantly used modes for work trips followed by Bajaj, Motorcycle, Bus, Lada, and Walking while less than 3 % are selecting for private car and bicycle for their trip purpose.

Table 4.2.The mode chosen by the employees

Types of the mode	Male	Female	Frequency	Percent (%)
Walking	3	2	5	3.1
Bicycle	2	0	2	1.2
Motorcycle	31	3	34	21
Bajaj	20	16	39	24.1
Damas	10	5	12	7.4
Minbus	30	16	46	28.4
Bus	14	8	22	13.6
Private car	2	0	2	1.2
Total	112	50	162	100

The tabular analyzed above revealed preference survey data for quantitative factors which affects mode choice behaviors.

4.3. Factors affecting mode choice behaviour

4.3.1. Revealed preference survey data presentation for qualitative factors which affects mode choice behaviours

For the sake of better understanding of the relationship between the mode of the transport and qualitative factors affecting mode choice of the respondents, results were analyzed with the bar charts performed between the modes of transport that are mostly used by the trip makers and qualitative factors which affecting mode choice behaviour.

4.3.1.1. Relation between the mode of transport and comfort of the seats during journey

The distribution of the transport modes that are usually used by the respondents over the comfort of the seats during the journey of the trip makers in Figure 4.1. As can be seen from it, the comfort of the seats during the journey for the minibus is unsatisfied and even strongly unsatisfied following the Damas and bus. The satisfaction level is satisfied and even strongly satisfied with Bajaj following the bus, Damas, and minibus mode of transportation.

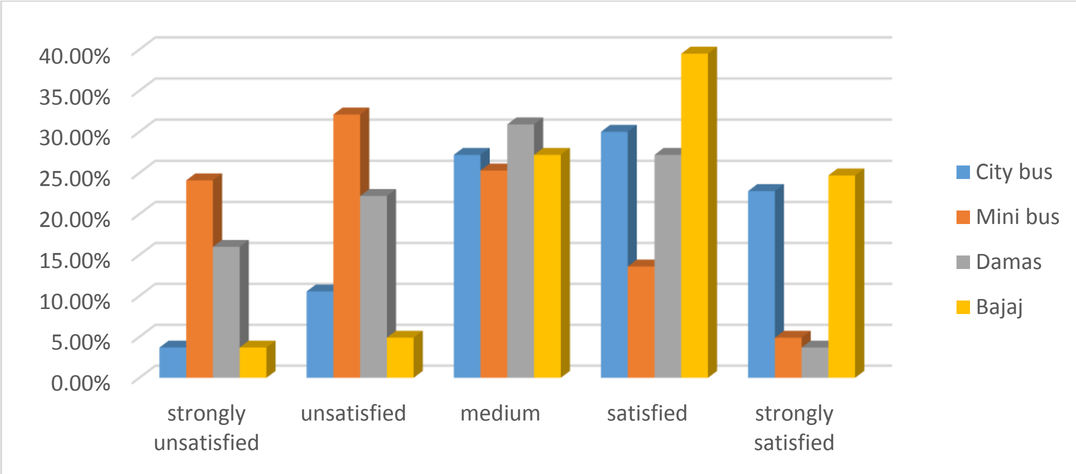

Figure 4.1. Relation between mode of transport and comfort of the seats

4.3.1.2. Relation between the mode of transport and quick, accessible and frequent services

The distribution of the transport modes that are usually used by the respondents over the quick, accessible and frequent services during journey of the trip makers is in Figure 4.2. As can be seen from this figure, quick, accessible and frequent services during journey for the damas and bus is unsatisfied and even strongly unsatisfied following the Bajaj and mini bus. The satisfaction level is satisfied and even strongly satisfied with Bajaj following the bus, damas and mini bus mode of the transportation.

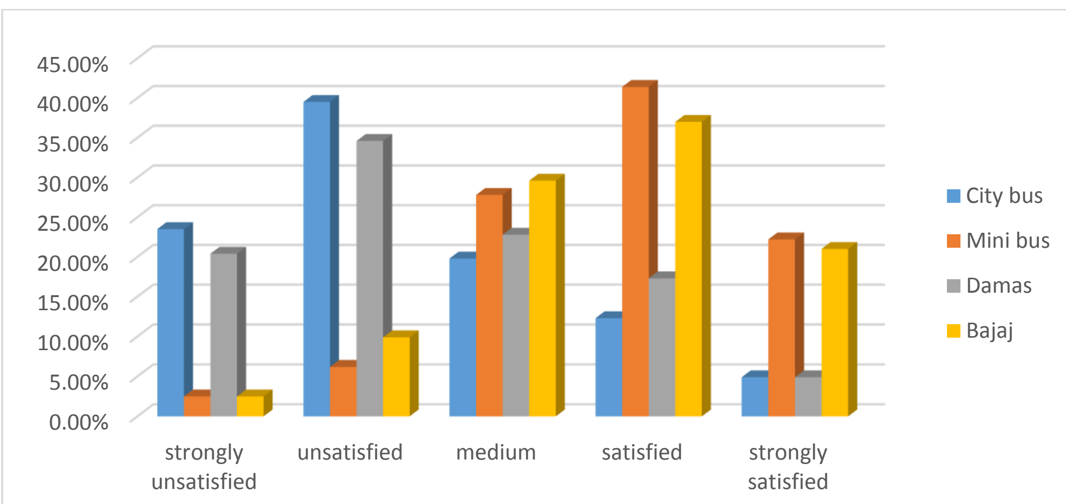

Figure 4.2. Mode of transport and quick, accessible and frequent services

4.3.1.3. Relation between the mode of transport and safety from crime at station

The distribution of the transport modes that are usually used by the respondents over safety from crime at station during journey of the trip makers is in Figure 4.3. As can be seen from this figure, safety from crime at station during journey for the mini bus is unsatisfied and even strongly unsatisfied following the bus, Bajaj and damas. The satisfaction level is satisfied and even strongly satisfied with Bajaj following the Bajaj, damas and bus following the mini bus mode of the transportation.

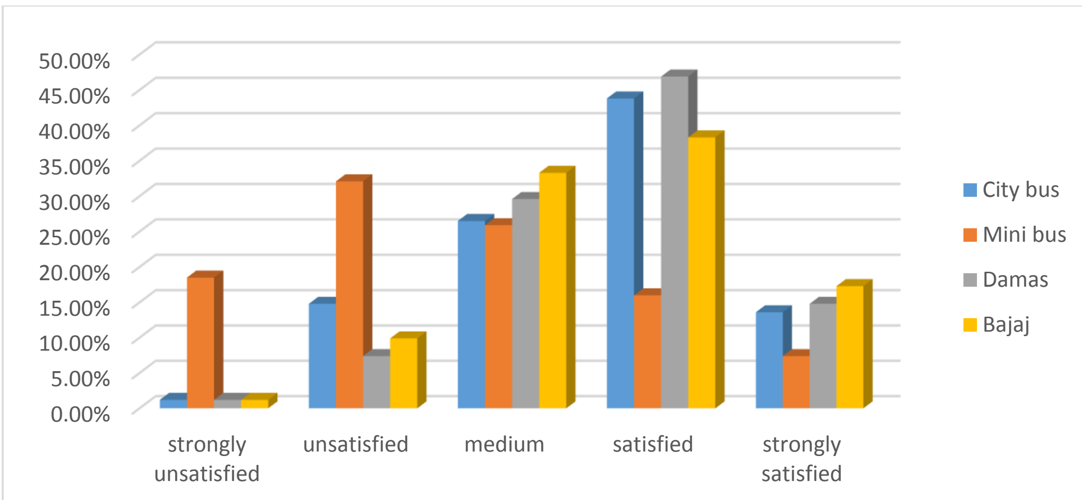

Figure 4.3. Relation between the mode of transport and safety from crime at station

4.3.1.4. Relation between the mode of transport and carrying as per specified capacity

The distribution of the transport modes that are usually used by the respondents over carrying as per specified capacity during journey of the trip makers is in Figure 4.4. As can be seen from this figure, carrying as per specified capacity during journey for the mini and bus is unsatisfied and even strongly unsatisfied following the damas and Bajaj. The satisfaction level is satisfied and even strongly satisfied with Bajaj and damas following the mini bus and bus mode of the transportation.

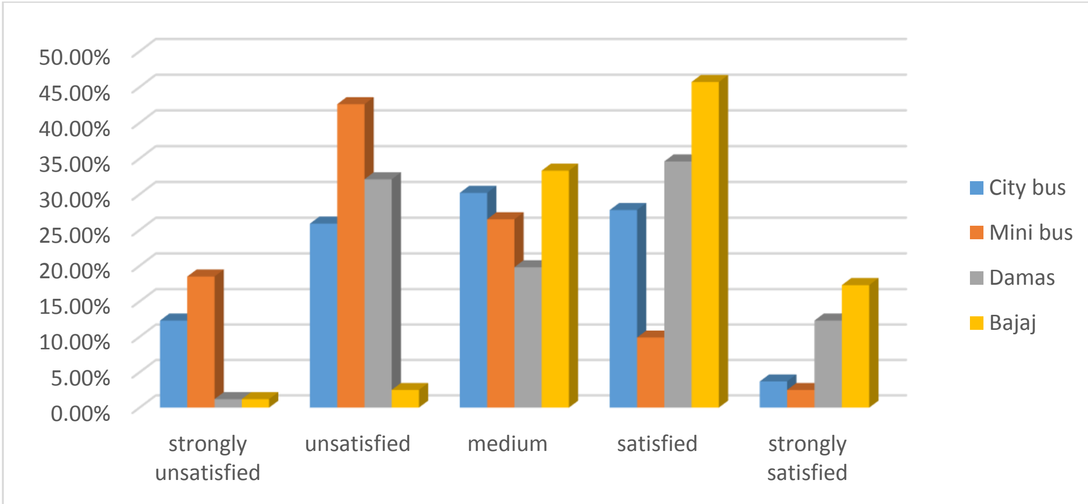

Figure 4.4. Relation between mode of transport and carrying as per specified capacity

4.3.2. Stated preference survey data presentation

The stated preference survey basically tries to estimate the diverted trip makers to a stated mode in the questionnaire with its probable modal characteristics. The stated preference survey have preference survey 1 and preference survey 2 trip alternatives.

Preference survey 1: Travel time of the 30% more than shared taxi, travel cost 40% less than shared taxi and service frequency is every 10 minutes (i.e., 15-5 = 10 minutes) lower than shared taxi.

preference survey 2: Travel time of the 10% more than shared taxi, travel cost 20% less than shared taxi and service frequency is every 3 minutes (i.e,8-5 = 3 minutes) lower than shared taxi.

The stated mode in this study was bus mode of transportation, and from the bar chart in Figure 4.5 for preference survey 1, around 25.3% of the trip makers were willing to divert to the stated bus mode of the transportation system, while 74.7% are not needed to divert stated bus mode of the transportation. On the other hand, for the preference survey 2 around 53.3% of the trip makers were willing to divert to the stated bus mode of the transportation system while 46.7% are not needed to divert stated bus mode of the transportation.

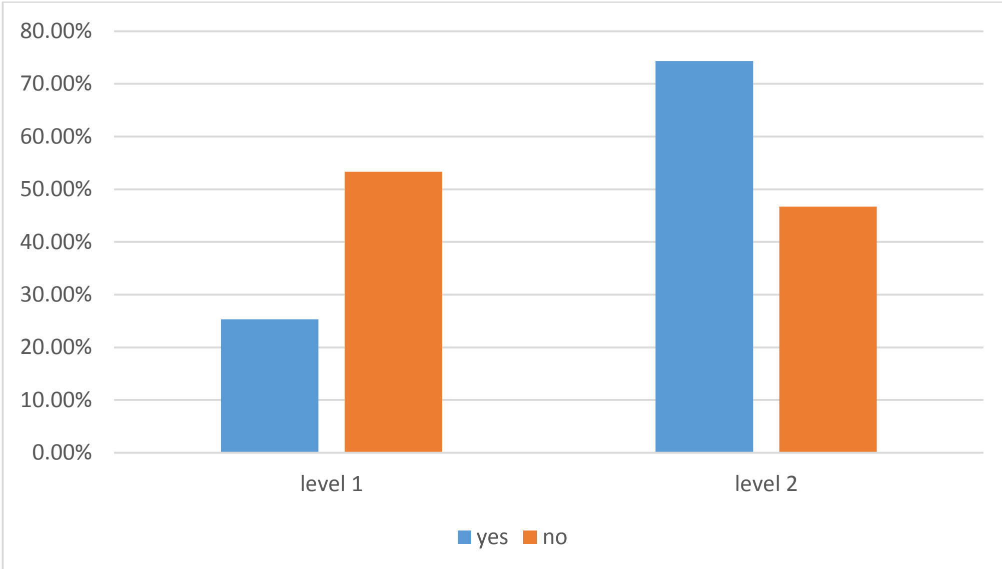

Figure 4.5. Distribution of the traveler's choice for their stated mode of transportation.

As can be seen in Figure 4.5 level 1, the large percent of travelers prefer to use shared taxi (Mini bus, Bajaj and Damas), so they put it as the first choice and while the large percent of travelers don't prefer to use bus, so they put it as the second choice for the preference survey 1. It also showed that the percent of travelers who put shared taxi as their first choice in preference survey 1 increases as the frequency time of the bus increases, although the reduction in cost decreases, but the percentage of travelers who put shared taxi as their first choice in preference survey 2 decreased as the frequency time of the bus decreases although the reduction in cost decreases.

This illustrated that the travelers are more sensitive to frequency which give indication about the travel waiting time. The largest percent of travelers who put the bus in the preference survey 2 as their first choice increased, as compared to preference survey 1 (which represent about 53.3% of the total sample) as the frequency for the bus is 8 minutes, which is relatively near to those of shared taxi although the reduction of cost is only 20 % less than the cost of travel by shared taxi.

4.3.3. Importance of factors that affect mode choice

As the Aibinu and Jagboro (2002) stated that Relative Importance Index (RII) and the Rank of the factors that affect the mode choice can be seen in the table below. The RII used to determine the relative importance of the various factors which affects mode choice behaviors. The frequency table for the each factors which affecting mode choice behavior is in Table 4.3.

Table 4.3. The frequency table for the each factors which affecting mode choice behavior

item	Very low	low	moderate	high	Very high	Total
Age	14	41	56	47	4	162
Gender	16	70	49	27	0	162
Average monthly Income	0	10	53	83	15	162
Travel cost	1	5	28	99	29	162
Out of the vehicle travel time	0	9	24	102	27	162
In vehicle travel time	0	10	43	84	25	162
Weather condition	2	36	62	56	6	162
Comfort	0	13	42	97	10	162
Availability of the own transportation mode	4	36	70	48	4	162
Interchangeability between transportation services	9	34	62	53	4	162

To determine the relative importance factor for Age is as follows:

RII of age = $\frac{4n1+3n2+2n2+1n4+0n5}{4N}$

RII of age = $\frac{4*4+3*47+2*56+1*41+0*14}{4N} = 0.48$

Table 4.4. Relative importance index and rank of the factors that affect mode choice.

Factor	RII	Rank
Travel cost	0.74	1
Out of the vehicle travel time	0.73	2
In vehicle travel time	0.69	3
Comfort	0.67	4
Average monthly income	0.66	5
Weather conditions	0.54	6
ITS	0.52	7
ATM	0.51	8
Age	0.48	9
Gender	0.38	10

The results in the table 4.4 show that travel cost, Out of the vehicle travel time, average monthly income, comfort, In vehicle travel time, weather conditions, ITS, ATM, age, and gender is the most important factors that affect the mode choice. Among them, the factors with a higher importance index such travel cost, out of the vehicle travel time and in-vehicle travel time have to be taken into account when analysis and developing a Multinomial Logit Model of mode choice behaviors of the passengers. These results compared with the results obtained from the model to stand on the consistency of the result obtained through questionnaire surveys for respondents about the factors that affect their mode choice, as well as from the results obtained from the case study which can be concluded through analysis of MLM.

4.4. Development of the multinomial logit mode choice model

There were 180 samples collected; from these, 18 samples were rejected due to missing values and other details. Therefore, 162 samples of the discrete choice data were analyzed using the SPSS 20 MNL program to formulate the model. The MNL program used to ascertain the essential attributes of the model.

The discrete choice data was analyzed using the SPSS 20 MNL program. The program ran with different models using various attributes to ascertain the essential attributes to the model. Of the attributes selected, two separate models (with the intercept only and with all the coefficients) were run using the same MNL analysis.

The MNL model results are displayed in Table 4.8 describes the relationship between the modal choice of dependent variable and the set of independent variables is significant. The MNL model is much better in fitting the sample data since it has a relatively high Nagelkerke pseudo-R2 value of 0.830 as shown in Table 4.7 indicating that approximately 83% of the variation in the dependent variable of modal choice can be explained by the estimated MNL regression model.

4.4.1. Model fitting information

A likelihood ratio test in Table 4.5 shows whether the model fits the data better than a null model. It is better to make the hypothesis that there is no significant difference between null and final model. Likelihood ratio test of the final model against the one in which all the parameter coefficients are 0 (Null). The chi-square statistic is the difference between the -2 log-likelihoods of the Null and Final models. In this model, the chi-square value of 269.375 has significance (0.000). If the significance value is less than 0.05, the null hypothesis is rejected. It means that the final model fits. So there is a significant relationship between the dependent variable and the set of independent variables.

Table 4.5. Model Fitting Information

Model	**Model Fitting Criteria**	**Likelihood Ratio Tests**		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	516.779			
Final	247.404	269.375	28	.000

In case of significant value, $p > 0.05$, it is not necessary to go further, stopping the analysis is better.

4.4.2. Goodness-of-fit Tests

The Multinomial Logistic Regression procedure reports, Pearson and Deviance goodness-of-fit statistics. The values of the Pearson, as well as deviance, are calculated. The Goodness of fit in Table 4.6 has a non-hypothesis. If the significance value < 0.05, the non-hypothesis are rejected while the significance value > 0.05 the non-hypothesis is accepted, and the model is adequately fit. The data clearly indicated that the believed attributes were indeed viable and provided the best fit to the data. The null model serves as a benchmark against which we compare the fit of the final choice model and because the null model is a complete model with other mode choices, a likelihood ratio test statistic is valid. So from both model fitting information and Goodness of fit, it could able to conclude that the model which are developing is good.

Table 4.6. Goodness-of-Fit

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	13903.561	679	.000
Deviance	223.119	679	.000

4.4.3. Pseudo R-Square

In linear regression it is R-square while in logistic regression it is called Pseudo R-square. The interpretation is the same with both regression. What this Pseudo R-square says is the two independent variables how they are showing the variation in the dependent variables is explained by Pseudo R-square. Its value fall between zero and one. Zero (0) indicates that there is no variation while 1 mean that there is perfect variation between dependent and independent variables (Mengistu, 2015).

It varies between different areas of application, and measures the variability in the dependent variable that is explained by a linear regression model, cannot be computed for multinomial logistic regression models. The pseudo r-squared statistics are designed to have similar properties to the true R-squared statistic and they are most useful when comparing competing models for the same data.

The best model have the largest pseudo R-square statistic and the values indicated the model's strong explanatory power and relationship. The Cox and Snell R2 measure operates like R2, with higher values indicating greater model fit. So Nagelkerke's proposed a modification that had the range from 0 to 1. The factors included in the model for the employees are accounted in (Table 4.7) about 83.8% of the variation for the Nagelkerke's, 81.0% for Cox and Snell, 48.8% for the McFadden's value. The currently developed model was good in terms of goodness-of-fit, and almost all variable coefficients were stable. The literature suggests that "values of 0.2 to 0.4 for R 2 represent an excellent fit" (D. Mc Fadden, 1979). In this study however the R-square values for all developed models were always higher than 0.4. This enhances that the developed model able to predict the future mode of transportation service alternatives of the city.

Table 4.7. Pseudo R-Square

Pseudo R-Square	
Cox and Snell	.810
Nagelkerke	.838
McFadden	.488

4.4.4. Likelihood Ratio test

This test in Table 4.8 indicated the contribution of the variants to the overall relationship between the dependent and individual independent variable in differentiating between the groups specified by the dependent variable. The likelihood ratio test is a hypothesis test that the variable contributes to the reduction in error measured by the -2 log-likelihood statistic. If the significance of the test is small (less than 0.05), then the effect contributes to the model. In this case, the variables, out of vehicle time (OVTT), in-vehicle travel time (INVTT) and travel cost (TC) contributes significantly to explaining the mode choice since its significance values less than 0.05.

Table 4.8. Likelihood Ratio Tests

Effect	**Model Fitting Criteria**	**Likelihood Ratio Tests**		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	267.211	19.807	7	.006
COM	276.096	28.692	7	.000
OVTT	265.135	17.731	7	.013
TC	289.265	41.860	7	.000
INVTT	274.447	27.043	7	.000

4.4.5. Parameter estimates

The parameter estimates are interesting to do an analysis, and its minimum acceptable model is given in Table 4.9. The degrees of freedom (DF) of the chi-square distribution used to test the LR Chi-Square statistic and is defined by the number of predictors in the model. The term "Significance" is the probability getting an LR test statistic being as more extreme as, or more so, than the observed statistic under the null hypothesis; the null hypothesis is that all of the regression coefficients in the model are equal to zero. In other words, this is the probability of obtaining this chi-square statistic (269.375), or one more extreme, if there is, in fact, no effect of the predictor variables. The small *p*-value from the LR test, < 0.00001, would lead us to conclude that at least one of the regression confidence in the model is not equal to zero.

The most basic test of the estimation results is to examine the signs of the estimated parameters with theory, intuition and judgment regarding the expected impact of the corresponding variables. Any constraint can be adopted for each set of parameters; however, the simplest and most widely used is to set the preference related parameters for one alternative, called the base or reference alternative (Koppelman and Bhat, 2006). So, in this study minibus used as a reference category.

Table 4.9. Parameter estimates

mode of transport used for work trip[a]		B	Std. Error	Wald	df	Sig.	Exp(B)
private car	Intercept	-104.840	.000	.	1	.	
	OVTT	2.061	6163.717	.000	1	1.000	7.854
	TC	.181	323.872	.000	1	1.000	1.198
	INVTT	1.470	9689.659	.000	1	1.000	4.347
	COM	-.287	15136.166	.000	1	1.000	.751
bus	Intercept	-4.993	3.618	1.904	1	.168	
	OVTT	.097	.142	.459	1	.050	1.101
	TC	-.140	.017	5.431	1	.020	.961
	INVTT	.125	.206	9.181	1	.002	1.868
	COM	-2.233	.597	13.969	1	.000	.107
damas	Intercept	-3.268	3.737	4.896	1	.027	
	OVTT	.133	.146	.829	1	.042	1.142
	TC	.012	.012	1.048	1	.031	1.012
	INVTT	-.086	.186	2.376	1	.023	1.331
	COM	-1.523	.582	6.839	1	.009	.218
Bajaj	Intercept	-6.890	2.950	5.455	1	.020	
	OVTT	.413	.114	13.038	1	.000	1.511
	TC	.028	.009	9.760	1	.002	1.028
	INVTT	-.260	.154	2.872	1	.040	.771
	COM	-1.894	.494	14.664	1	.000	.151
motor cycle	Intercept	-8.983	3.629	6.126	1	.013	
	OVTT	-.009	.133	.004	1	.948	.991
	TC	.142	.010	5.699	1	.017	1.024
	INVTT	.310	.202	2.503	1	.014	1.377
	COM	.640	.578	1.226	1	.028	.527
bicycle	Intercept	10.743	23731.809	.000	1	1.000	

	OVTT	-1.547	464.560	.000	1	.997	.213
	TC	-.275	75.339	.000	1	.997	.759
	INVTT	1.376	1603.519	.000	1	.999	3.958
	COM	-1.753	29560.424	.000	1	1.000	.173
walking	Intercept	25.241	.000	.	1	.	
	OVTT	-.196	1659.201	.000	1	1.000	.822
	TC	-.088	428.541	.000	1	1.000	.916
	INVTT	-3.306	5931.786	.000	1	1.000	.037
	COM	-2.529	15970.564	.000	1	1.000	.080

Mini bus is taken as the reference category.

4.4.5.1. Interpretation of the model result

The interpretation of the model result from the above parameter estimates in (Table 4.9) are discussed as follows by holding mini bus as a reference category. When interpreting of the parameters sign, parameters with significant negative coefficients are interpreted to result in a decrease the likelihood of that response category with respect to the reference category. On the other hand, the parameters with positive coefficients were considered to result in increase the likelihood of that response category. Recall that OVTT stands for out of the vehicle travel time, INVTT was the in-vehicle travel time and TC is for travel costs.

i) Private car relative to Mini bus

A. Out of the vehicle travel time

The positive parameter sign of government employees in the above table indicated that they preferred of private cars was 1.754 times more than minibus while holding all other variables in the model constant. The Wald test statistic for the predictor government employee is 0.000 an associated p-value of 0.997, which was greater than 0.05; the regression coefficient for government employee has been found to be statistically insignificant and invalid.

B. In vehicle travel time

The positive parameter sign of government employees in the above table indicated that they preferred of private cars, was 1.685 times more than minibus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 0.000, an associated *p*-value of 1.000, which was greater than 0.05. Hence, it is statistically insignificant.

C. Travel cost

The positive parameter sign of government employees indicated that they preferred of private cars, was 0.160 times more than minibus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 0.000, an associated *p*-value of 0.998, which was greater than 0.05. Hence, it is statistically insignificant and invalid.

D. Comfort

The positive parameter sign of government employee indicating that the preferring of damas are 0.640 times more than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 1.226 an associated p-value of 0.028, which is less than 0.05, hence it is statistically significant and valid.

ii) Bus relative to Mini bus

A. OVTT of vehicle travel time

The positive parameter sign of government employees indicated that they preferred a bus, was 0.097 times more than minibus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time indicated 0.459 an associated *p*-value of 0.050, which was greater than or equal to 0.05; hence, it is statistically insignificant.

B. In vehicle travel time

The positive parameter sign of government employee indicated that they preferred of a bus, was 0.125 times more than minibus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 9.181 an associated *p*-value of 0.002, which was less than 0.05. Hence, it is statistically significant and valid.

C. Travel cost

The negative parameter sign of government employee indicated that the employees are 0.140 times less likely to prefer bus than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 5.431 an associated p-value of 0.02, which is less than 0.05, hence it is statistically significant and valid.

D. Comfort

The negative parameter sign of government employee indicated that the employees are 2.233 times less likely to prefer bus than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 13.969 an associated p-value of 0.000, which is less than 0.05, hence it is statistically significant and valid.

iii) Damas relative to mini bus

A. OVTT of vehicle travel time

The positive parameter sign of government employee indicating that the preferring of damas are 0.133 times more than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 0.829 an associated p-value of 0.042, which is less than 0.05, hence it is statistically significant and valid.

B. In vehicle travel time

The negative parameter sign of government employee indicated that the employees are 0.086 times less likely to prefer bus than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 2.376 an associated p-value of 0.023, which is less than 0.05, hence it is statistically significant and valid.

C. Travel cost

The positive parameter sign of government employee showed that they preferred a Damas, was 0.012 times more than minibus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 1.048 an associated p-value of 0.031, which was less than 0.05. Hence, it is statistically significant and valid.

D. Comfort

The negative parameter sign of government employee indicated that the employees are 1.523 times less likely to prefer bus than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 6.839 an associated p-value of 0.009, which is less than 0.05, hence it is statistically significant and valid.

iv) Bajaj relative mini bus

A. OVTT of vehicle travel time

The positive parameter sign of government employees showed that they preferred Bajaj with 0.413 times more than minibus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 13.038, an associated *p*-value of 0.000, which was less than 0.05. Hence, it is statistically significant and valid.

B. In vehicle travel time

The negative parameter sign of government employees indicated 0.26 times less likely to prefer Damas than minibus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time showed 2.872, an associated *p*-value of 0.040, which was less than 0.05. Hence, it is statistically significant and valid.

C. Travel cost

The positive parameter sign of government employees indicated that they preferred Bajaj with 0.028 times more than minibus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 9.76, an associated p-value of 0.002, which was less than 0.05. Hence, it is statistically significant and valid.

D. Comfort

The negative parameter sign of government employee indicated that the employees are 1.894 times less likely to prefer bus than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 14.664 an associated p-value of 0.000, which is less than 0.05, hence it is statistically significant and valid.

v) Motorcycle relative mini bus

A. OVTT of vehicle travel time

The negative parameter sign of government employees revealed that the employees were 0.009 times less likely to prefer motorcycle than minibus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 0.004, an associated p-value of 0.948, which was greater than 0.05. So, it is not statistically insignificant and invalid.

B. In vehicle travel time

The positive parameter sign of government employees indicated that they preferred motorcycle with 0.31 times more than minibus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 2.503 an associated *p*-value of 0.014, which was less than 0.05. Hence, it is statistically significant and valid.

C. Travel cost

The positive parameter sign of government employees showed that they preferred motorcycle. It was 0.142 times more than minibus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 5.699, an associated p-value of 0.017, which was less than 0.05. Hence, it is statistically significant and valid.

D. Comfort

The positive parameter sign of government employee indicated that the employees are 0.640 times more likely to prefer bus than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 1.226 an associated p-value of 0.028, which is less than 0.05, hence it is statistically insignificant and invalid.

But for the remaining mode of the transportation such as, bicycle and walking the statistical significance value indicated greater than 0.05. So, it is not necessary to interpret the results because their significance value was almost the same as the private car.

The empirical utility functions for different mode are:

City bus = – 4.993 + 0.097 **OVTT** + 0.125 **INVTT** – 0.14 **TC -**2.233 **Comfort**

Damas = – 3.268 + 0.133 **OVTT** – 0.086 **INVTT** + 0.012 **TC-**1.523 **Comfort**

Bajaj = –6.89 + 0.413 **OVTT** – 0.26 **INVTT** + 0.028 **TC-**1.894 **Comfort**

Motorcycle = – 8.983 + 0.31 **INVTT** + 0.142 **TC+** 0.64 **Comfort**

4.5. Prediction, Validation and verification of the developed model

4.5.1. Prediction level of the model for mode alternatives

This is the classification statistics used to determine which group membership were best predicted by model and to assess the fit of the model to the data (Koppelman and Bhat, 2006). The Table 4.10 indicated that overall percentage of the prediction level is 79.5%.

Table 4.10. The classification table of the mode alternatives and its correct prediction level

Observed	**Predicted**								
	private car	**bus**	**mini bus**	**damas**	**Bajaj**	**motor cycle**	**bicycle**	**walking**	**Percent Correct**
private car	2	0	0	0	0	0	0	0	100.0%
bus	0	17	3	0	0	1	0	0	81.0%
mini bus	0	0	38	0	5	3	0	0	82.6%
damas	0	2	8	1	1	0	0	0	8.3%
Bajaj	0	3	12	0	25	0	0	0	62.5%
motor cycle	0	3	1	0	1	29	0	0	85.3%
bicycle	0	0	0	0	0	0	2	0	100.0%
walking	0	0	0	0	0	0	0	5	100.0%
Overall Percentage	1.2%	15.4%	38.3%	0.6%	19.8%	20.4%	1.2%	3.1%	79.5%

As indicated in Table 4.10 Private car, bicycle and walking correctly predicted by the model 100%. The bus voters correctly predicted by the model 81% of the time (17/17+3+1=17/21= 0.81). Mini bus voters correctly predicted by the model 82.6%. Likewise damas, Bajaj, and Motorcycle correctly predicted by the model 8.3%, 62.5% and 85.3% respectively.

4.5.2. Prediction of the probability for the modal split mode choice alternatives

The utility function illustrate the manner in which different utility specifications and the estimated parameters associated with them are used to predict choice probabilities based on characteristics of the traveler (decision-maker) and attributes of the alternatives. But as Koppelman and Bhat (2006) stated that comfort not measureable and its effect is taken as constant

A MLM in Table 4.11 can be used to describe the mode choice of the study area between City bus, Damas, Bajaj and Motorcycle. A survey of the traveler in the study area regarding their travel experience yielded the following data. Among them daily travel cost (TC) is obtained by dividing monthly average travel cost of employees by 22 which is most probably the working time for the employees in a month.

Mode	INVTT (Minute)	OVTT (Minute)	TC (monthly) (ETB)	Average TC (daily) (ETB)
Bus	15-20	10-15	100-140	7.3
Damas	8-12	10-15	130-170	9.09
Bajaj	6-12	10-15	180-220	10
Motorcycle	8-15	0	300-500	18.18

The prediction probability of the current modal split with aid of the multinomial logit model described in Table 4.11. The probability of current mode share of the motor cycle in Table 4.11 is higher for employees which is about 39.58% in a Hawassa city. This implies that most of the employees tends to use their own means of the transportation mode in order to maximize their utility by minimizing their travel time and waiting time for the public transportation. Then the probability of current mode share of the city bus is about 28.83% in a Hawassa city. This is the crucial for the policy makers and transport planners because they are always in challenging by providing public transportation modes. The probability of current mode share of the damas is about 25.4% second to city bus. Finally, the probability of the current mode share of the Bajaj is less which is about 6.2%. This implies that the employees not prefer Bajaj mode of the transportation due to higher travel cost of the Bajaj.

Table 4.11. Prediction the probabilities of the current modal split with MLM

Mode alternative	Utility		Exponent	Probability
	Expression	**Value**		
City bus	– 4.993+0.097*15+0.125*20 – 0.140*7.3	– 2.071	0.126	28.83%
Damas	– 3.268+0.133*15– 0.086*12+0.012*9.1	– 2.196	0.111	25.4%
Bajaj	– 6.89+0.413*15 – 0.26*12+0.028*10	– 3.615	0.027	6.2%
Motorcycle	– 8.983+0.31*15 + 0.142*18.18	– 1.753	0.173	39.58%
			0.437	

The probability of choosing city bus is higher for this traveler following damas, motorcycle and Bajaj respectively.

4.5.3. Verification and validation of the model

The validation of the most satisfactory mode is done above by testing the reasonableness of the sign of the parameters and by the computation of the level of prediction.

As Koppelman and Bhat (2006) stated that the multinomial logit model has three important properties. So, the developed model is verified and validated by distinguishing either the model fit those 3 properties of the multinomial logit model or not.

The verification and validation is performed as follows by examining it with the fundamental properties of the multinomial logit model.

4.5.3.1. The Sigmoid or S-shape Probabilities of Multinomial Logit model

The S shape of the MNL illustrated the probability of choosing alternatives. Then from the above probability in Table 4.11 and Table 4.12 of the modal split the plotted graph by holding the probability of a mode alternative as a y-axis and utility function as an x-axis shows the sigmoid properties of the MLM in (Figure 4.6).

The s-shape limits the probability of the current modal split range between 0.062 when the utility of the Bajaj is very low, relative to other alternatives, and 0.39 when the utility of motorcycle is very high, relative to other alternatives. As the Figure 4.6 implies the as utility increases the value of the probability keeps increasing until some extent the slope along curve maximum.

The gradual slope at extreme values of the motorcycle utility in Figure 4.6 is much steeper when its utility reaches a value such that its choice probability is close to zero. This implies that if the representative utility of one alternative is very low or very high, compared with the others, a small increase in the utility of this alternative will not substantially affect its probability of the being chosen. The point at which an increase in the representative utility of an alternative has the greatest effect on its probability of being chosen (i.e. the slope of the maximum point along the curve) is when its representative utility is equivalent to the combined utility of the other alternatives. When this is true, a small increase in the utility of one alternative induce a large increase in the probability of the alternative being chosen. As indicated in Figure 4.6 the probability of future mode share of the motor cycle increasing as the utility approaches zero but it is for some determined future period until it gets its maximum then it gets decreasing for the positive utility value. After it gets its maximum, may the employees shift to other private mode of transportation such as private car since the utility and satisfaction of the people always not restricted.

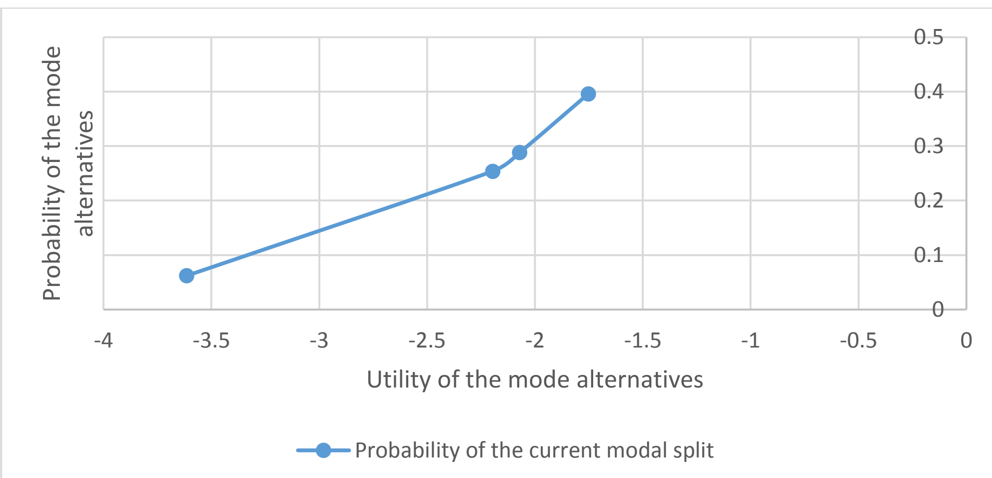

Figure 4.6. The Sigmoid or S-shape Probabilities of Multinomial Logit model

4.5.3.2. The Equivalent Differences Property

As Koppelman and Bhat (2006) stated that the equivalent differences property stated that choice probability equations are unchanged if the same incremental value, say 1, is added to the utility of each alternative in the equation.

The calculations supporting this comparison are shown in Table 4.13 and Table 4.14 which implies the probability of Each Alternative on the initial set of modal utilities before adding one and probability of Each Alternative after modal utility increased by one.

Table 4.12. Probability of each alternative on the initial set of modal utilities before adding one.

Mode alternative	**Utility**		**Exponent**	**Probability**
	Expression	**Value**		
City bus	– 2.071	– 1.071	0.343	28.84%
Damas	– 2.196	– 1.196	0.302	25.4%
Bajaj	– 3.615	– 2.615	0.073	6.2%
Motorcycle	– 1.753	– 0.753	0.471	39.59%
			1.189	

As expected, the choice probabilities are identical to those obtained before the addition of the constant to each mode.

4.5.3.3. Independence of Irrelevant Alternatives Property

Since, the IIA property states that for any individual, the ratio of the probabilities of choosing two alternatives is independent of the presence or attributes of any other alternative.

The ratios of each pair of probabilities are calculated from the data obtained in Table 4.11 and the verification with this IIA property has determined in Table 4.15.

As expected in the ratios of probabilities for each pair of alternatives and ratio of their exponent of the utility is the same and depend only on the attributes of those alternatives and not on the attributes of the third alternatives and would remain the same regardless of whether that third alternative is available or not.

Since the independence of irrelevant alternatives property allows the addition or removal of an alternative from the choice set without affecting the structure or parameters of the model. The flexibility of applying the model to cases with different choice sets has a number of advantages. Its property simplifies the estimation of the parameters in the multinomial logit model and advantageous when applying a model to the prediction of choice probabilities for a new alternative. Hence, the developed model verified with the most important properties of the MLM and it was valid and significant.

Table 4.13. The ratios of each pair of probabilities

For Bus and Damas	**For Bus and Bajaj**
$\frac{p(bus)}{p(damas)} = \frac{exp\ (Vbus)}{exp\ (Vdamas)}$ $\frac{0.2883}{0.2540} = \frac{0.126}{0.111}$ 1.13 = 1.13	$\frac{p(bus)}{p(bajaj)} = \frac{exp\ (Vbus)}{exp\ (Vbajaj)}$ $\frac{0.2883}{0.0620} = \frac{0.126}{0.027}$ 4.65 = 4.66
For Bus and Motorcycle	**For Damas and Bajaj**
$\frac{p(bus)}{p(motorcycle)} = \frac{exp\ (Vbus)}{exp\ (Vm/cycle)}$ $\frac{0.2883}{0.3959} = \frac{0.126}{0.173}$ 0.73 = 0.73	$\frac{p(damas)}{p(bajaj)} = \frac{exp\ (damas)}{exp\ (Vbajaj)}$ $\frac{0.254}{0.062} = \frac{0.111}{0.027}$ 4.10 = 4.11
For Damas and m/cycle	**for Bajaj and Motorcycle**
$\frac{p(damas)}{p(m/cycle)} = \frac{exp\ (Vbdamas)}{exp\ (Vm/cycle)}$ $\frac{0.2540}{0.3959} = \frac{0.111}{0.173}$ 0.64= 0.64	$\frac{p(bajaj)}{p(motorcycle)} = \frac{exp\ (Vbajaj)}{exp\ (Vm/cycle)}$ $\frac{0.0620}{0.3959} = \frac{0.0126}{0.173}$ 0.157=0.156

4.6. Analysis on the college students mode choice

4.6.1. General socio-demographic data presentation

The procedure used the same as the above and from 340 questionnaires distributed, of which 160 for the college student's school trips. These data were collected systematically selected school trip makers from different governmental organizations and university colleges**.**

The descriptive statistics in Table 4.14 represents on the profile of students which is the demographic profile of employee’s 160 data collected, of which 146 sample data was used for analysis because 14 sample data is missed due to different reasons. The socio-economic data included in this study was age, gender, education, level, monthly household income, family size, car ownership and marital status.

From the summarized data in Table 4.14, 57.5% of the samples composed of men, and 42.5% female. About 81.5% of the trip makers in the sample ranged from age 18-29, 18.5% ranged from age 30-45, and there were no respondents above age 45. The marital status of the trip makers, 24% were married, and 76% were single. The family size of the trip makers was 34.9% for one family member, 37% were in the 2-3 family member, and 28.1% of the family member greater than 3. The education level of the 8.2% was a diploma, 88.4% were degree, and 3.4% were master's degree. The average monthly income level of the trip makers was 69.9% less than 2000, 30.1% range from 2001-5000, there is no income level of the respondents range from 5001-1000 and more significant than 10001.

Table 4.14. Descriptive statistics on the demographic profile of students

Socio economic attributes	**Label**	**Category**	**Frequency**	**Percentage (%)**
Gender	1	Male	84	57.5
	2	Female	62	42.5
Age	1	18-29	119	81.5
	2	29-55	17	18.5
	3	> 45+	0	0
Marital status	1	Married	35	24
	2	Unmarried	111	76

Family size	1	1	51	34.9
	2	1-3	54	37
	3	>3	41	28.1
Educational level	1	Diploma	12	8.2
	2	Degree	129	88.4
	3	Master's degree	5	3.4
Income	1	< 2000	102	69.9
	2	2001-5000	44	30.1
	3	<5001-10000	0	0
	4	>10001	0	0

4.6.2. The mode chosen by the student

The modal share by the students is summarized in the Table 4.15 which illustrates the percentage of the modal split chosen by the student.

The students were chosen set of modal alternatives such as Walking, Bicycle, Motorcycle, Bajaj, Damas, Minibus, Bus, and Private car. In the study area, Minibus is the most predominantly used modes for work trips followed by Bajaj, Motorcycle, Bus, Damas, and Walking while less than 5 % are selecting for private car, damas, and bicycle for their trip purpose.

Table 4.15. Mode chosen by the student

Types of the mode	**male**	**female**	**Frequency**	**Percent (%)**
Walking	22	17	39	24.38
Bicycle	3	0	3	3.13
Motorcycle	5	3	8	8.75
Bajaj	22	18	40	25.62
Damas	3	2	5	3.75
Minbus	24	19	43	28.12
Bus	5	3	8	6.25
Total	84	62	146	100

4.7. Factor affecting mode choice behaviour of the students

4.7.1. Revealed preference survey data presentation for qualitative factors which affects mode choice behaviours

For the sake of better understanding of the relationship between the mode of the transport and qualitative factors affecting mode choice of the respondents result were performed between the modes of transport that are mostly used by the trip makers and those factors which affects mode choice behaviours.

4.7.1.1. Relation between the mode of transport and comfort of the seats during journey

The distribution of the transport modes that are usually used by the respondents over the comfort of the seats during the journey of the trip makers can be seen in Figure 4.7. As can be seen from this figure, the comfort of the seats during the journey for the minibus and Dumas was unsatisfied and even strongly unsatisfied following the Bajaj and bus. The satisfaction level is satisfied and even strongly satisfied with Bajaj and bus following damas and minibus mode of transportation.

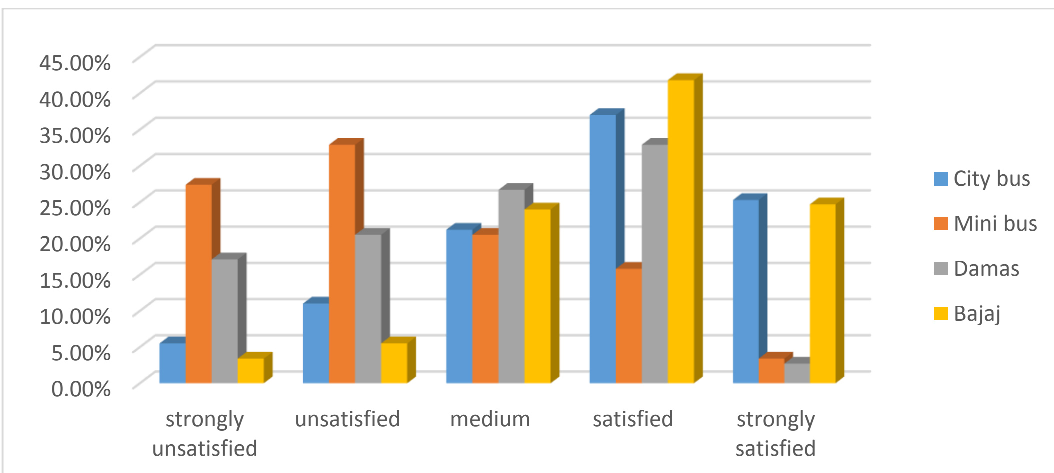

Figure 4.7. Relation between the mode of transport and comfort of the seats

4.7.1.2. Relation between the mode of transport and quick, accessible and frequent services

The distribution of the transport modes that are usually used by the respondents over the quick, accessible and frequent services during the journey of the trip makers in Figure 4.8, quick, accessible and frequent services during journey for the Damas and the bus is unsatisfied and even strongly unsatisfied following the Bajaj and minibus. The satisfaction level is satisfied and even strongly satisfied with Bajaj following the bus, damas, and minibus mode of transportation

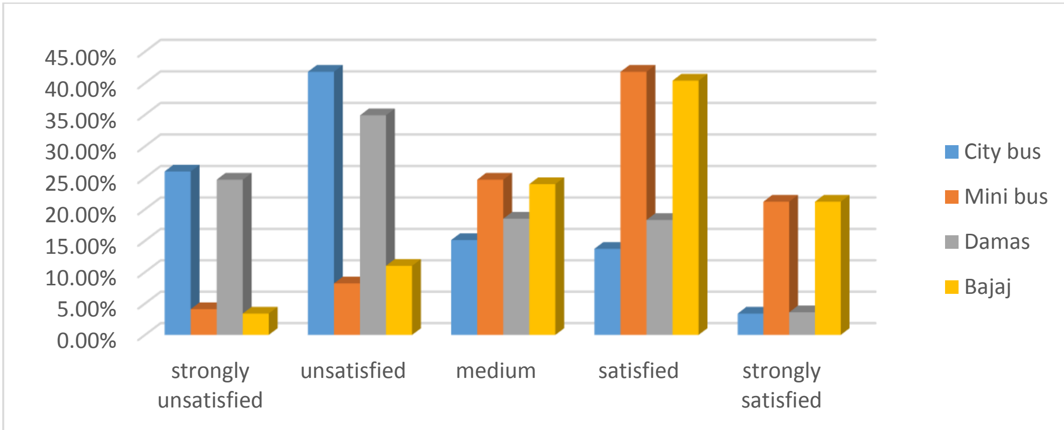

Figure 4.8. Relation between the mode of transport and quick, accessible and frequent services

4.7.1.3. Relation between the mode of transport and safety from crime at station

The distribution of the transport modes that are usually used by the respondents over safety from crime at the station during the journey of the trip makers in Figure 4.9. As it can be seen from Figure 4.9, safety from crime at the station during the journey for the bus is unsatisfied and even strongly unsatisfied following the minibus, Bajaj and damas. The satisfaction level is very good and even strongly satisfied with Bajaj, damas, and minibus following the bus mode of transportation.

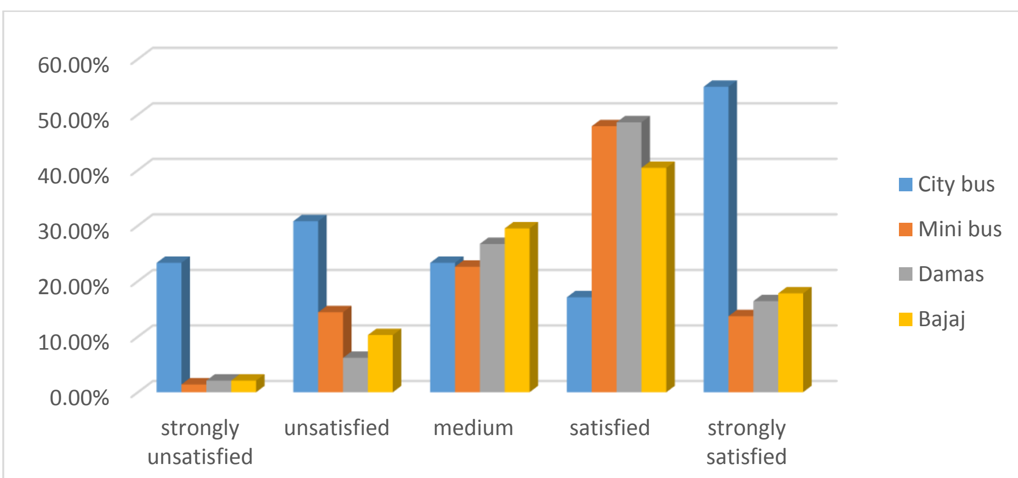

Figure 4.9. Relation between the mode of transport and safety from crime at station

4.7.1.4. Relation between the mode of transport and carrying as per specified capacity

The distribution of the transport modes that are usually used by the respondents over carrying as per specified capacity during the journey of the trip makers can be seen in Figure 4.10. As can be seen from this figure, carrying as per specified capacity during the journey for the mini and bus is unsatisfied and even strongly unsatisfied following the damas and Bajaj. The satisfaction level is satisfied and even strongly satisfied with Bajaj and damas following the minibus and bus mode of transportation.

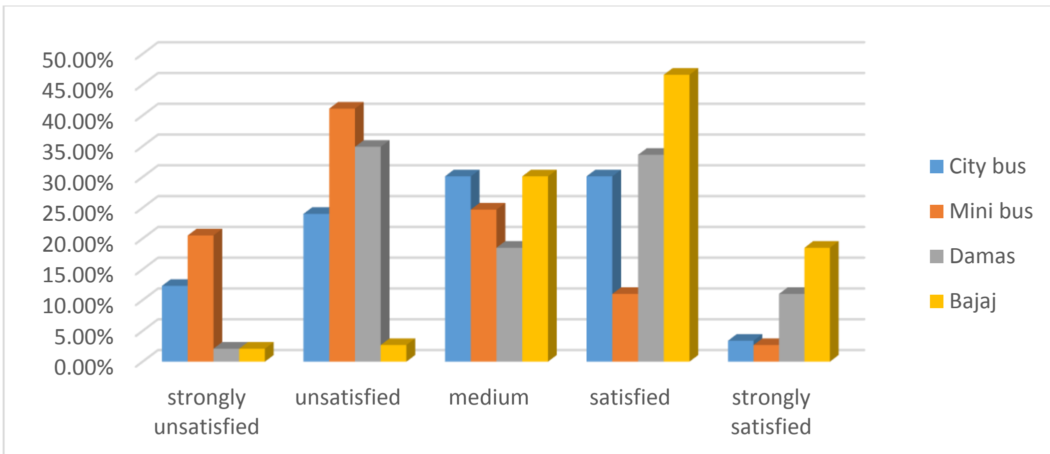

Figure 4.10. Relation between the mode of transport and carrying as per specified capacity

4.7.2. Stated preference survey data presentation

The stated preference survey basically tried to estimate the diverted trip makers to a stated mode in the questionnaire with its probable modal characteristics. The stated preference survey represented level 1 and level 2 trip alternatives.

Level 1: Travel time of the 30% more than shared taxi, travel cost 40% less than shared taxi and service frequency is every 10 minutes (15-5 = 10 minutes) lower than shared taxi.

Level 2: Travel time of the 10% more than shared taxi, travel cost 20% less than shared taxi and service frequency is every 3 minutes (8-5 = 3 minutes) lower than shared taxi.

The stated mode in this study was bus mode of transportation and based on the bar chart shown in (Figure 4.11), for level 1 around 36.3% of the trip makers were willing to divert to the stated bus mode of the transportation system, while the remaining 63.7% are not needed to shift to the stated bus mode of transportation. For level 2 around 54.8% of the trip makers were willing to divert to the stated bus mode of the transportation system, while the remaining 45.2% did not need to shift to the stated bus mode of transportation. Here, it considered the word "Yes" which implies the number of students who are willing to shift to the stated bus mode of transportation, while the word "No" stands to those who are not willing to shift that represented the distribution of traveler's choice for the hypothetical questions mentioned earlier.

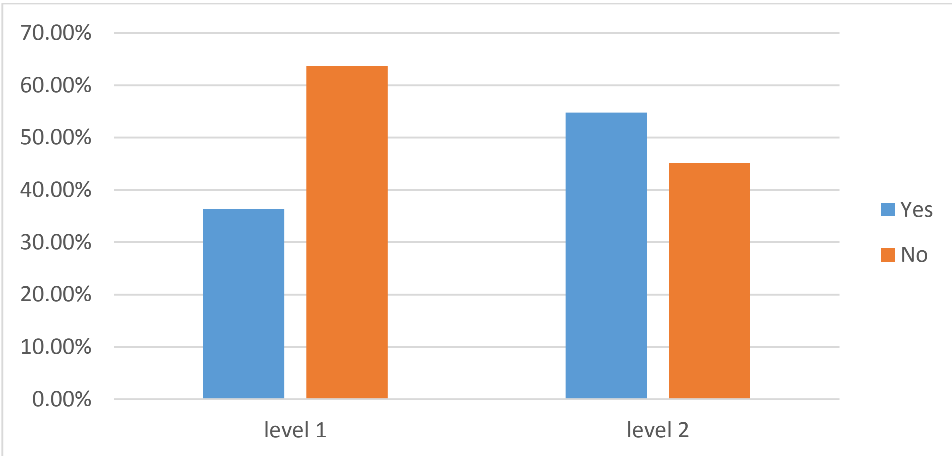

Figure 4.11. Distribution of traveler’s choice for stated mode of the transportation

As it can be seen from the bar chart above, the large percentage of travelers preferred to use shared taxi (Mini bus, Bajaj and Damas), so they put it as the first choice for level 1. While, the large percentage of travelers don't prefer to use bus, and they considered as the second choice. It also showed that the percentage of travelers who put shared taxi as their first choice in level 1 increased as the frequency of bus also increased, although the reduction in cost decreased. On the other hand, the percentage of travelers who put shared taxi as their first choice in level 2 decreased as the frequency time of the bus decreased and the reduction in cost decreased. This showed that the travelers are more sensitive to a frequency which provide an indication about the travel time. The large percentage of travelers who put bus in the level 2 as their first choice increased, as compared to level 1 (which represented about 54.8% of total sample) as the frequency for bus was 8 minutes which is relatively near to those of shared taxi although the reduction of cost is only 20 % less than the cost of travel by shared taxi.

4.7.3. Importance of factors that affect mode choice

The Relative Importance Index (RII) and the ranking of the factors that affect the mode choice can be seen in the Table 4.16.

Table 4.16. Frequency of the each respondents to the factor affecting mode choice

item	Very low	low	moderate	high	Very high	Total
Age	13	59	53	14	7	146
Gender	15	66	42	21	2	146
Income	1	5	31	79	30	146
Travel cost	2	6	30	83	25	146
Out of the vehicle travel time	0	2	31	99	14	146
In vehicle travel time	1	7	33	85	20	146
Weather condition	4	27	57	52	6	146
Comfort	0	12	30	89	15	146
Availability of the own transportation mode	4	57	54	29	2	146
Interchangeability between transportation services	3	43	54	43	3	146

Relative importance index and ranking of the factors that affect mode choice calculated in Table 4.19. For example, the RII value for age calculated as follow and for the remaining identified factors the same procedure is followed as indicated their value in Table 4.19.

RII of age = $\frac{4n1+3n2+2n2+1n4+0n5}{4N}$

RII of age = $\frac{4*7+3*14+2*53+1*59+0*13}{4*146} = 0.36$

Table 4.17.Relative importance index and ranking of the factors that affect mode choice.

Identified Factors	RII	Rank
Average monthly income	0.66	1
Out of the vehicle travel time	0.64	2
Travel cost	0.64	3
In vehicle travel time	0.63	4
Comfort	0.61	5
Weather conditions	0.49	6
ITS	0.45	7
ATM	0.40	8
Age	0.38	9
Gender	0.36	10

The results in Table 4.17 indicated that average monthly income, out of the vehicle travel time, travel cost, comfort and in-vehicle travel time are the most important factors that affect the mode choice based on its ranking from the highest to lowest. Hence, among these factors in-vehicle travel time, out of the vehicle travel time and travel cost considered into account when the analysis of the MLM is applied.

4.8. Development of the Multinomial Logit Mode Choice Model

There was 160 samples were collected, from this 14 samples are rejected due to missing values and any other reasons. Therefore 146 samples of the discrete choice data was analyzed using the SPSS 20 MNL program in order to formulate the model. The MNL program used to ascertain the essential attributes to the model.

The program ran with different models using various attributes to ascertain the essential parameters of the model. From the attributes selected, two separate models (with the intercept only and with all the coefficients) were run using the same MNL analysis.

The MNL model results, were displayed in Table 4.22 describes the relationship between the modal choice variable, and the set of independent variables was significant. The MNL model was much better in fitting the sample data since it has a relatively high pseudo-R^2 value of 0.924 Table 4.20, indicating that approximately 92.4% of the variation in the dependent variable (modal choice) can be explained by the estimated MNL regression model.

4.8.1. Model fitting information

A likelihood ratio test in Table 4.18 indicates whether the model fits the data better than a null model. It is better to establish hypothesis that there is no significant difference between null and final model. Likelihood ratio test of the final model against the one in which all the parameter coefficients are 0 (Null). The chi-square statistic is the difference between the -2 log likelihoods of the Null and Final models. In this model, chi-square value of 315.855 has significance (0.000). If significance value is less than 0.05, the null hypothesis is rejected it mean that the final model is fit. So, there is a significant relationship between the dependent variable and the set of independent variables.

Table 4.18.Model Fitting Information

Model	**Model Fitting Criteria**	**Likelihood Ratio Tests**		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	452.890			
Final	135.457	317.432	24	.000

If the significance value>0.05, it is not necessary to go further, stopping the analysis is better.

4.8.2. Goodness-of-fit Test

The Multinomial Logistic Regression procedure reports Pearson and Deviance goodness-of-fit statistics they measure how the model adequately fits the data. The values of the Pearson, as well as deviance, are calculated. The data clearly in Table 4.19 indicated that attributes were indeed viable and provided the best fit to the data. The null model served as a benchmark against which it was compared the fit of the final choice model and because the null model was a complete model with other mode choices, a likelihood ratio test statistic is valid.

Table 4.19. Goodness-of-Fit

	Chi-Square	**df**	**Sig.**
Pearson	300.118	624	.000
Deviance	128.127	624	.000

As Table 4.19 indicated that the attributes provided were best fit to the model since significance is less than 0.05.

4.8.3. Pseudo R- Square

In linear regression, it is R-square while in logistic regression it is called Pseudo R-square. The interpretation was the same for both regressions. What this Pseudo R-square says, is the two independent variables how they were showing the variation in the dependent variables, is explained by Pseudo R-square. Its value falls between zero and one. Zero (0) indicated that there was no variation, while one means that there was a perfect variation between dependent and independent variables.

It varies between different areas of application and measures the variability in the dependent variable that is explained by a linear regression model, cannot be computed for multinomial logistic regression models. The pseudo r-squared statistics are designed to have similar properties to the true r-squared statistic and they are most useful when comparing competing models for the same data.

The best model have the largest R-Square statistic. The Cox and Snell R2 measure operates like R2, with higher values indicating greater model fit. This measure is limited in that it cannot reach the maximum value of 1. The factors included in the model for the students in Table 4.20 accounted about 92.4% of the variation for the Nagelkerke's, 88.5% for Cox and Snell, 68.4% for the McFadden's value. The currently developed model was good in terms of goodness-of-fit, and almost all variable coefficients were stable. The literature suggests that values of 0.2 to 0.4 for R 2 represent an excellent fit (Fadden, 1979). In this study however the R-square values for all developed models were always higher than 0.68.

Table 4.20.Pseudo R-Square

Cox and Snell	.886
Nagelkerke	.925
McFadden	.688

Thus it can be concluded that the MLM fits the sample data well.

4.8.4. Likelihood Ratio test

This test in Table 4.21 indicates the contribution of the variable to the overall relationship between the dependent and individual independent variable in differentiating between the groups specified by the dependent variable. The likelihood ratio test is a hypothesis test that the variable contributes to the reduction in error measured by the -2 log likelihood statistic. If the significance of the test is small (less than 0.05) then the effect contributes to the model. In this case, the variables, in vehicle travel time (INVTT), out of the vehicle travel time (OVTT) and travel cost (TC) contributes to explaining the mode choice since they have a significance value < 0.05.

Table 4.21.Likelihood ratio tests

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	138.189	2.732	6	.842
INVTT	158.329	22.872	6	.001
OVTT	147.621	12.164	6	.058
INC	137.034	1.577	6	.954
TC	213.555	78.098	6	.000

Thus it can be concluded that MLM fits the sample data well since significance value <0.05.

4.8.5. Parameter estimates

The parameter estimates of the minimum acceptable model are given in (Table 4.22). The degrees of freedom (DF) of the chi-square distribution used to test the LR Chi-Square statistic and is defined by the number of predictors in the model. The term “Significance” is the probability getting a LR test statistic being as extreme as, or more so, than the observed statistic under the null hypothesis; the null hypothesis is that all of the regression coefficients in the model are equal to zero. In other words, this is the probability of obtaining this chi-square statistic 315.855, or one more extreme, if there is in fact no effect of the predictor variables. This p-value is compared to a specified alpha level, our willingness to accept a type I error, which is typically set at 0.05 or 0.01. The small p-value from the LR test, < 0.00001, would lead us to conclude that at least one of the regression confidents in the model is not equal to zero. The most basic test of the estimation results is to examine the signs of the estimated parameters with theory, intuition and judgment regarding the expected impact of the corresponding variables.

Table 4.22. Parameter estimates

mode of transport used for work trip		B	Std. Error	Wald	df	Sig.	Exp(B)
bus	Intercept	-.573	7.273	.006	1	.937	
	INVTT	.162	.255	4.979	1	.026	1.767
	OVTT	.135	.284	3.029	1	.042	1.640
	INCOME	-.320	.817	.154	1	.049	.726
	TC	-.224	.056	5.066	1	.024	.881
damas	Intercept	-7.725	6.159	1.573	1	.210	
	INVTT	-.258	.363	1.592	1	.027	.633
	OVTT	.575	.204	.005	1	.041	.985
	INCOME	-.247	.683	.131	1	.017	.781
	TC	.079	.030	7.174	1	.007	1.082
Bajaj	Intercept	-2.490	3.800	.429	1	.512	
	INVTT	-.314	.220	7.818	1	.005	.541
	OVTT	.233	.127	3.375	1	.036	.792
	INCOME	.317	.392	.653	1	.019	1.373
	TC	.085	.022	14.493	1	.000	1.089
motor cycle	Intercept	2.078	6.557	.220	1	.639	
	INVTT	-.515	.589	5.777	1	.016	.243
	OVTT	-.435	.213	6.297	1	.112	.586
	INCOME	.468	1.339	.122	1	.027	.626
	TC	.095	.023	16.453	1	.000	1.100
bicycle	Intercept	12.403	.000	.	1	.	
	INVTT	1.498	3047.056	.000	1	1.000	4.471
	OVTT	-4.426	3806.078	.000	1	.999	.012
	INCOME	3.203	29912.242	.000	1	1.000	24.604
	TC	-.150	388.585	.000	1	1.000	.861
walking	Intercept	23.733	30716.378	.000	1	.999	
	INVTT	-.037	3490.851	.000	1	1.000	.963
	OVTT	.239	3071.502	.000	1	1.000	1.270
	INCOME	2.354	16599.218	.000	1	1.000	10.532
	TC	-.510	490.315	.000	1	.999	.600

4.8.5.1. Interpretation of the model results

In the methodology analysis section, it was indicated that the ratio of the coefficient to its standard error, squared, equals the Wald statistic. With regard to the interpretation of the parameters sign, parameters with significant negative coefficients are interpreted to result in a decrease the likelihood of that response category with respect to the reference category. On the other hand, the parameters with positive coefficients were considered to result in increase the likelihood of that response category.

i) City Bus relative to Mini bus

A. Out of vehicle travel time

The positive parameter sign of student indicated that they preferred a city bus which was 0.135 times more than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 3.029, with an associated p-value of 0.042, which was less than 0.05. Hence, it is statistically significant and valid.

B. In vehicle travel time

The positive parameter sign of students indicated that they preferred a city bus which means 0.162 times more than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 4.979, with an associated p-value of 0.026, which was less than 0.05. Hence it is statistically significant and valid.

C. Travel cost

The negative parameter sign of student indicated that they were 0.224 times less likely to prefer city bus than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 5.066, with an associated p-value of 0.024, which was less than 0.05. Hence it is statistically significant and valid.

D. Income

The negative parameter sign of government employee indicated that the employees are 0.320 times less likely to prefer bus than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 0.154 an associated p-value of 0.049, which is less than 0.05, hence it is statistically significant and valid.

ii) Damas relative to mini bus

A. Out of vehicle travel time

The decisive parameter sign of student indicated that they preferred damas, which means 0.575 times less likely to prefer damas than minibus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 0.005, with an associated p-value of 0.041, which was less than 0.05. Hence, it is statistically significant and valid.

B. In vehicle travel time

The negative parameter sign of students indicated that they were 0.258 times less likely to prefer Bajaj than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 1.592, with an associated p-value of 0.027, which was less than 0.05. Hence, it is statistically significant and valid.

C. Travel cost

The positive parameter sign of students indicated that they preferred a damas, which means 0.079 times more than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 7.174, with an associated p-value of 0.007, which was less 0.05. Hence, it is statistically significant and valid.

D. Income

The negative parameter sign of government employee indicated that the employees are 0.247 times less likely to prefer bus than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 0.131 an associated p-value of 0.017, which is less than 0.05, hence it is statistically significant and valid.

iii) Bajaj relative mini bus

A) Out of vehicle travel time

The positive parameter sign of students indicated that they preferred a Bajaj, which means 0.233 times more than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 3.375 with an associated p-value of 0.036, which is less than 0.05, hence it is statistically significant and valid.

B. In vehicle travel time

The negative parameter sign of students indicated that they were 0.314 times less likely to prefer Bajaj than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 7.818, with an associated p-value of 0.005, which was less than 0.05. Hence, it is statistically significant and valid.

C. Travel cost

The positive parameter sign of students indicated that they preferred a Bajaj, which means 0.085 times more than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 14.493 with an associated p-value of 0.000, which is less than 0.05, hence it is statistically significant and valid.

D. Income

The positive parameter sign of government employee indicated that the employees are 0.317 times more likely to prefer bus than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 0.653 an associated p-value of 0.019, which is less than 0.05, hence it is statistically significant and valid. .317

iv) Motorcycle relative mini bus

A. OVTT of vehicle travel time

The negative parameter sign of student indicating that they were 0.435 times less likely to prefer motorcycle than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 6.292 an associated p-value of 0.112, which is greater than 0.05, hence it is statistically insignificant and invalid.

B. In vehicle travel time

The negative parameter sign of students indicated that they were 0.515 times less likely to prefer motorcycle than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 5.777, an associated p-value of 0.016, which was less than 0.05. Hence it is statistically significant and valid.

C. Travel cost

The positive parameter sign of student indicated that the preferring of motorcycle are 0.095 times more than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time was 16.453, an associated p-value of 0.000, which was less than 0.05. Hence it is statistically significant and valid.

D. Income

The positive parameter sign of government employee indicated that the employees are 0.468 times more likely to prefer bus than mini bus while holding all other variables in the model constant. The Wald test statistic for the predictor out of vehicle time is 0.122 an associated p-value of 0.027, which is less than 0.05, hence it is statistically significant and valid.

The empirical utility functions for different mode are:

City bus = – 5.503 + 0.135 **OVTT** + 0.162 **INVTT** – 0.224 **TC** – 0.135 **INCOME**

Damas = – 7.725 + 0.575 **OVTT** – 0.258 **INVTT** + 0.079 **TC** – 0.247 **INCOME**

Bajaj = – 2.49 + 0.233 **OVTT** – 0.314 **INVTT** + 0.085 **+** 0.317 **INCOME**

Motorcycle **=** 2.078 – 0.515 **INVTT +** 0.095 **TC +**0.468 **INCOME**

4.9. Prediction, validation and verification of the developed model

4.9.1. Prediction level of the model for mode alternatives

The classification statistics in Table 4.23 used to determine which group membership were best predicted by model.

Bicycle and walking correctly predicted by the model 100% of the time. The bus voters correctly predicted by the model 75% of the time (6/8= 0.875). Mini bus voters correctly predicted by the model 83.7%. Likewise damas, Bajaj, and Motorcycle correctly predicted by the model 20.2%, 77.5% and 75% respectively. The overall percentage of the prediction level is 82.9%.

Table 4.23. The classification table of the mode choice and its correct prediction level.

Observed	**Predicted**							
	bus	**mini bus**	**damas**	**Bajaj**	**motor cycle**	**bicycle**	**walking**	**Percent Correct**
bus	6	2	0	0	0	0	0	75.0%
mini bus	0	36	0	7	0	0	0	83.7%
damas	0	2	0	3	0	0	0	20.2%
Bajaj	0	8	0	31	1	0	0	77.5%
motor cycle	0	1	0	1	6	0	0	75.0%
bicycle	0	0	0	0	0	3	0	100.0%
walking	0	0	0	0	0	0	39	100.0%
Overall Percentage	4.1%	33.6%	0.0%	28.8%	4.8%	2.1%	26.7%	82.9%

4.9.2. Prediction of the probability for the modal split mode choice alternatives

The utility function illustrate the manner in which different utility specifications and the estimated parameters associated with them are used to predict choice probabilities based on characteristics of the traveler (decision-maker) and attributes of the alternatives. Since the effect of the average monthly income and travel cost have the same effect, only travel cost taken to calculate it in utility function.

A MLM can be used to describe the mode choice of the study area between City bus, Damas, Bajaj and Motorcycle. A survey of the traveler in the study area regarding their travel experience yielded the following data.

Mode	**INVTT (Minute)**	**OVTT (Minute)**	**TC (monthly) (ETB)**	**TC (daily) (ETB)**
Bus	15-20	10-15	80-120	5.5
Damas	8-12	10-15	120-150	6.8
Bajaj	6-12	10-15	140-180	8.2
Motorcycle	8-15	0	250-400	18.18

The prediction probability of the current modal split with aid of the multinomial logit model described in Table 4.24. The probability of current mode share of the city bus in Table 4.24 is higher for students which is about 35.92% in a Hawassa city. This implies that most of the students tend to use city bus in order to maximize their utility by minimizing their travel cost. Then the probability of current mode share of the damas is about 29.74% in a Hawassa city. This is the crucial for the policy makers and transport planners because they are always in challenging by providing public transportation modes. The probability of current mode share of the Bajaj is about 19.79% second to city bus. Finally, the probability of the current mode share of the Bajaj is less which is about 14.53%. This implies that the students not prefer Bajaj mode of the transportation due to higher travel cost of the Bajaj.

Table 4.24. Prediction the probabilities of the current modal split with MLM

Mode alternative	**Utility**		**Exponent**	**Probability**
	Expression	**Value**		
City bus	– 5.503+0.135*15+0.162*20 – 0.224*5.5	– 1.471	0.2299	35.92%
Damas	– 7.725+0.575*15– 0.258*12+0.079*6.8	– 1.658	0.1903	29.74%
Bajaj	– 2.49+0.233*15 – 0.314*12+0.085*8.2	– 2.066	0.1267	19.79%
Motorcycle	3.078 – 0.515*15 + 0.095*18.18	– 2.374	0.0930	14.53%
			0.6399	

4.9.3. Verification and validation of the model

The validation of the most satisfactory mode is done above by testing the reasonableness of the sign of the parameters and level of prediction. The verification is performed as follows by examining it with the fundamental properties of the MLM.

4.9.3.1 The Sigmoid or S shape of Multinomial Logit Probabilities

The S shape of the MNL illustrated the probability of choosing alternatives. Then, from the probability in Table 4.24 and Table 4.25 of the modal split, graph is plotted by holding the probability of a mode alternative as a y-axis and utility function as an x-axis. The sigmoid properties of the MLM in Figure 4.12.

The s-shape limits the probability of the current modal split range between 0.1453 when the utility of the motorcycle is very low, relative to other alternatives, and 0.3592 when the utility of city bus is very high, relative to other alternatives. As in the Figure 4.6 indicated that as utility increases the value of the probability keeps increasing until some extent the maximum slope along curve.

The gradual slope at extreme values of the city bus utility is much steeper when its utility reaches a value such that its choice probability is close to zero. This implies that if the representative utility of one alternative is very low or very high, compared with the others, a small increase in the utility of this alternative will not substantially affect its probability of the being chosen. The point at which an increase in the representative utility of an alternative has the greatest effect on its probability of being chosen (i.e. the slope of the maximum point along the curve) is when its representative utility is equivalent to the combined utility of the other alternatives. When this is true, a small increase in the utility of one alternative induce a large increase in the probability of the alternative being chosen.

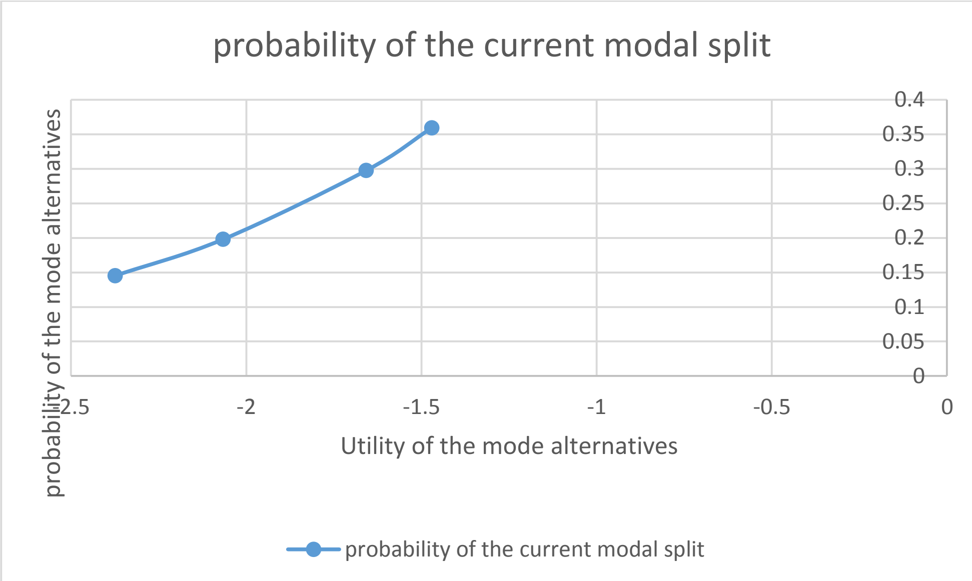

Figure 4.12.The S- shape of Multinomial Logit Probabilities of the existing modal split.

4.9.3.2. The Equivalent Differences Property

As discussed earlier the equivalent differences property stated that choice probability equations are unchanged if the same incremental value, say 1, is added to the current utility of each alternative in the Table 4.25, then new utility value is shown in Table 4.26.

Table 4.25. Probability of Each Alternative at initial set of modal utilities.

Mode alternative	**Utility**		**Exponent**	**Probability**
	Expression	**Value**		
City bus	– 1.471	– 1.471	0.6244	35.90%
Damas	– 1.658	– 1.658	0.5178	29.76%
Bajaj	– 2.066	– 2.066	0.3443	19.79%
Motorcycle	– 2.374	– 2.374	0.2531	14.54%
			1.7396	

Table 4.26. Shows the same computation after each of the modal utilities is increased by one.

Mode alternative	Utility		Exponent	Probability
	Expression	Value		
City bus	– 1.471	– 0.471	0.2299	35.91%
Damas	– 1.658	– 0.658	0.1903	29.75%
Bajaj	– 2.066	– 1.066	0.1267	19.79%
Motorcycle	– 2.374	– 1.374	0.0930	14.53%
			1.7396	

As expected, the choice probabilities are identical to those obtained before the addition of the constant to each mode.

4.9.3.3. Independence of Irrelevant Alternatives Property

Since, the IIA property states that for any individual, the ratio of the probabilities of choosing two alternatives is independent of the presence or attributes of any other alternative.

As expected in Table 4.27 the ratios of probabilities for each pair of alternatives and ratio of their respective exponent utility is the same and depend only on the attributes of those alternatives and not on the attributes of the third alternatives and would remain the same regardless of whether that third alternative is available or not.

Since the independence of irrelevant alternatives property allows the addition or removal of an alternative from the choice set without affecting the structure or parameters of the model. The flexibility of applying the model to cases with different choice sets has a number of advantages. Its property simplifies the estimation of the parameters in the multinomial logit model and advantageous when applying a model to the prediction of choice probabilities for a new alternative. Hence, the developed model verified with the most important properties of the MLM and it was valid and significant.

Table 4.27. Ratios of each pair of probabilities

For Bus and Damas	For Bus and Bajaj
$\frac{p(bus)}{p(damas)} = \frac{exp\ (Vbus)}{exp\ (Vdamas)}$ $\frac{0.3590}{0.2976} = \frac{0.6244}{0.5178}$ 1.21 = 1.21	$\frac{p(bus)}{p(bajaj)} = \frac{exp\ (Vbus)}{exp\ (Vbajaj)}$ $\frac{0.3590}{0.1979} = \frac{0.6244}{0.3443}$ 1.81 = 1.81
For Bus and Motorcycle	**For Damas and Bajaj**
$\frac{p(bus)}{p(motorcycle)} = \frac{exp\ (Vbus)}{exp\ (Vm/cycle)}$ $\frac{0.3590}{0.1454} = \frac{0.6244}{0.2531}$ 2.46 = 2.46	$\frac{p(damas)}{p(bajaj)} = \frac{exp\ (damas)}{exp\ (Vbajaj)}$ $\frac{0.2976}{0.1979} = \frac{0.5178}{0.3443}$ 1.50 = 1.50
For Damas and m/cycle	**for Bajaj and Motorcycle**
$\frac{p(damas)}{p(m/cycle)} = \frac{exp\ (Vbdamas)}{exp\ (Vm/cycle)}$ $\frac{0.2976}{0.1454} = \frac{0.5178}{0.2531}$ 2.05= 2.05	$\frac{p(bajaj)}{p(motorcycle)} = \frac{exp\ (Vbajaj)}{exp\ (m/cycle)}$ $\frac{0.1974}{0.1454} = \frac{0.3443}{0.2531}$ 1.36=1.36

Case study

The case study was done on the characteristics of the transport facility and qualitative factors influencing passenger mode choice behavior at the major bus/tax station of the Hawassa city such as Aroge Menaheria taxi station, Addisu Menaheria taxi station, TTC membo station, Meskel adebabay and mobile taxi station was determined by site investigation and observation by using stop watch and format filling sheet in addition to the trip makers response. This is because to enhance the questionnaires provided.

i) Characteristics of the transport facility: Passengers waiting time for tax/bus, in vehicle waiting time until the taxi or bus start to move and the frequency of the tax or bus at major station of the Hawassa city.

ii) The quality of the transportation service regarding frequent, accessible and quick service and carry as per the specified capacity.

Waiting time is the time passengers have to wait at bus stops for buses/taxis. Even though, their expectations may vary, most passengers are delighted with minimum waiting time. The shorter the waiting time is the greater the level of convenience (Iles, 2005). Longer waiting time indicates poor quality of service. As World Bank, cited in (Armstrong, 1993) to achieve a reasonable level of service, the average waiting time should be in the range of 5- 10 minutes and the maximum waiting time should be in the range of 10-20 minutes. Therefore, the waiting time for the Aroge Menaheria, Addisu Menaheria and Atote bus station fall between 5-10 minutes which is good in quality of the services while meskel adebabay and Alamura taxi station the maximum waiting time fall in the range of 10-20 minutes which is reasonable poor in quality of the services.

i) Characteristics of the transport facility

Table 4.28.Summarized characteristics of the transport facility

No	**Bus/taxi station from Initial to destination**	**Mean waiting time**	**Mean Service Frequency**	**Time duration morning at the morning**
1	Menaheria to Piazza and gebeya	8 minutes	Every 3-5 minutes	For 60 minutes
2	Meskel adebabay to Hawassa Referal Hospital via TTC warka	11 minutes	Every 4-6 minutes	For 60 minutes
3	From Addisu Menaheria to Aroge Menaheria via shell	8 minutes	Every 3-5 minutes	For 60 minutes
4	From the Alamura high school to Menaheria via Atote	11 minutes	Every 5-8 minutes	For 60minutes
5	From the Mobile to the Piazza	7 minutes	3-6 minutes	For 60 minutes

Waiting time is a component of out of vehicle time the waiting time for car drive and private car passenger is zero, for the case of city bus according to the Enterprise the average waiting time is currently 20 minutes. The shared taxi, the waiting time is better for the damas following Bajaj and mini bus. The taxi/ bus station of the Aroge Menaheria to Piazza, Addisu Menaheria to Aroge Menaheria via shell station and Mobile to Piazza have average waiting time since their service range from 5-10 minutes while the bus/taxi station of the Meskel adebabay station and Alamura high school taxi station have maximum waiting time since their service ranges from 10-12 minutes. This means that the taxi station of Aroge and Addisu Menaheria have enough number of the taxis than Meskel adebabay and Alamura high school bus station.

ii) **The quality of the transportation service**

The mini bus mode of the transportation has frequent, accessible and quick services than city bus, damas and Bajaj as the site observation data has indicated. But the carrying as per specified capacity of the mini bus is not comfortable following city bus, damas and Bajaj as the observation and data recording at the each station of the city.

Figure 4.13. Taxis or buses waiting at the different major station of the Hawassa city

5. CONCLUSSIONS AND RECOMMENDATIONS

5.1. Conclusions

5.1.1. Conclusion on the employees mode choice

The most important significant factors that affect the mode choice of the employees were travel cost, out of the vehicle travel time, in vehicle travel time, comfort and average monthly income with their relative importance index 0.74, 0.73, 0.69, 0.67 and 0.66 respectively. Therefore, it can be concluded that travel cost, out of the vehicle travel time, average monthly income, comfort, and in vehicle travel time were the deterministic variables for the model development and contributing factors that influence the model shift from share taxi (Mini bus, Damas and Bajaj) to city bus in Hawassa city. Further, Increasing in time and cost per distance cause the employees to choice two-wheelers (motorcycle) than public transport. So, identification of such factors and its variations will help transport planners to formulate effective transport policies to improve the transport within the city.

The current probability transportation modal split of the developed model for the employees were 39.58% for motorcycle, 28.83 % for city bus, 25.4% for damas and 6.2% for Bajaj. Therefore, employee’s mode choice highly rely on motor cycle and city bus than damas and Bajaj.

The developed model can predict future mode share of the employees perfectly. Since the overall percentage of the prediction level is 79.5%, the validation of the most satisfactory mode is done by testing the reasonableness of the sign of the parameters were statistically valid and significant. Moreover, the developed model is verified and validated by the three properties of the multinomial logit model those were Sigmoid or S-shape Probabilities of Multinomial Logit model, The Equivalent Differences Property and Independence of Irrelevant Alternatives Property. Therefore, the developed model for the employees was significant and can be applied to the Hawassa city.

5.1.2. Conclusion on the student mode choice

The most important significant factors that affect the mode choice of the students were average monthly income, out of the vehicle travel time, travel cost, in vehicle travel time and comfort with their relative importance index 0.66, 0.64, 0.64, 0.63 and 0.61 respectively. Therefore, it can be concluded that travel cost, average monthly income, out of the vehicle travel time, in vehicle travel time and comfort were the deterministic variables for the model development and contributing factors that influence the model shift from share taxi (Mini bus, Damas and Bajaj) to city bus in Hawassa city.

The current probability transportation modal split of the developed model for the student's mode share is 35.92 % for city bus, 29.74% for damas, 19.79% Bajaj and 14.53% motorcycle. Therefore, student's mode choice behaviour highly rely on city bus and damas following Bajaj and motorcycle.

The developed model can be applicable to Hawassa city and can predict future mode share of students because the overall percentage of the prediction level is 82.9%, the validation of the most satisfactory mode is done by testing the reasonableness of the sign of the parameters which was statistically valid and significant. Moreover, the developed model is verified and validated by the three properties of the multinomial logit model those were Sigmoid or S-shape Probabilities of Multinomial Logit model, The Equivalent Differences Property and Independence of Irrelevant Alternatives Property. Therefore, the developed model for the students were significant and can be applied to the Hawassa city.

Finally, it can be concluded both for employees and students that the number of the available transportation mode in a city and their mode choice behavior were mismatched. Currently, there is about 2750 Bajaj in Hawassa city, but the employees and students mode choice behavior towards Bajaj mode of transportation is very low while there is about 17 city bus but their mode choice behavior towards city bus is very high. Therefore, currently available mode of the transportation unable to maximize utility of the employees and student.

5.2. Recommendations

- It is recommended for Hawassa city road and transportation burreo to provide public transportation services mainly by providing access to city bus in order to manage the deterministic variables (travel cost, travel time and monthly income) which affects mode choice behaviour of the employees and students. It is obvious that in the future, population and consequently the trips will increase in a Hawassa city, this may bring congestion to city and increase travel time more. As the estimation of the developed model, bus mode of the transportation is primary choice for the future since it has lower cost than other mode of the transportation and it reduces the congestion level of the city by giving services for many travelers once a time. Therefore, it is recommended that transport planner and policy makers should have to seriously concentrate on guiding trips to public transportation especially for the city bus.
- It is recommended that for the policy makers and transport planners in a Hawassa city to use the developed logit model for mode choice behavior of the employees and students. Since the models were verified and validated, it capable in giving beneficial information to the policy-makers and transport planners.
- It is recommended that Bajaj mode of the transportation should be less in a city since the developed model indicated that the probable current and future market share of the Bajaj is less than other mode of the transportation. Instead it is suggested that city bus should be more in Hawassa city following damas. Therefore, Decision-makers can utilize the outcomes to enhance mode choice of the transport service by increasing city bus and damas mode of the transportation than Bajaj.

5.2.1. Recommendation for the future researchers

- This study was focused only on the mode choice from four pillar of the transportation planning, so the future researchers can focus on the other transportation planning process, such as, traffic generation, distribution and assignment of the city.
- It is recommended to develop the model related qualitative factors which affect mode choice behaviour such as comfort, safety, availability, convenience and reliability of transport modes in the study area using structural equation modeling (SEM) method.

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APPENDEX A

HAWASSA UNIVERSITY INSTITUTE OF TECHNOLOGY (IOT)

FACULITY OF CIVIL ENGINEERING AND BUILT ENVIRONMENT

MSc IN ROAD AND TRANSPORT ENGINEERING

"ANALYSIS OF TRANSPORTATION MODE CHOICE BEHAVIOUR USING MULTINOMIAL LOGIT MODEL FOR WORK AND SCHOOL TRIPS: A CASE STUDY IN HAWASSA CITY''

Questionnaire Survey

Dear respondents:

This questionnaire aims to study the situation of transport system and the factors that affect the governmental employee's and college students' choice for transportation modes in Hawassa city by developing a mode choice model for work trips or school trips in the Hawassa city. Therefore, you are kindly requested to read the questions carefully and give accurate and real data which exists on the ground.

The response that you reply will not be used for any other purpose other than this research work, so be free and give your honest and genuine response. During filling this questionnaires keep in mind that:

1) The individual should be either the governmental employees or the college students and should not have transportation services from his organization.
2) The individual mostly leaves home between 12:00-3:00 AM local time.
3) The trip of the respondent should be from the route they used only

Thank you in advance for your Cooperation!

Instruction: Circle the letter of your choice or fill the blank spaces for the following questions.

Part I: socio-economic information

1. What is your gender?

A) Male B) Female

2. What is your age? ------Years.

A) 18-29 B) 30-45 C) >45

3. What is your marital status?

A) Single B) Married

4. Education level?

A) Diploma B) Degree C) Masters

5. What is your family size? ---------------------- Persons.

A) 1 B) 2-3 C) >3

6. What is average family monthly income?

A) Less than 2000 ETB B) 2001-5000 ETB C) 5001-10000 ETB

D) More than 10,000 ETB

Part II: factors affecting mode choice

A) To what extent do you think that the following Factors are affecting in choosing the transport mode for work and school trips?

Attribute	**Very low 1**	**Low 2**	**Medium 3**	**High 4**	**Very high 5**
Age					
Gender					
Average monthly income					
Cost of travel					
Out of the vehicle travel time					
In vehicle travel time					
Weather conditions					
Comfort					
Availability of own transportation mode					
Interchangeability between mode of the transport					

B) Responses of Passengers on Service Satisfaction list among the listed modes of services. Say 1=strongly unsatisfied with, 2=unsatisfied with, 3= moderate, 4=Satisfied with, 5=strongly satisfied.

no	Item	City bus	Minbus	Damas	Bajaj
1	Comfort of seats during journey				
2	Frequent, accessible and quick service				
3	Safety from crime at Stations				
4	carry as per the specified capacity				

Part III: Trip Characteristics

1. What is the mode of transport you usually use to go to your work/school trips?

A) Private car B) Bus C) Min bus D) Damas E) Bajaj F) Motorcycle G) bicycle H) Walking

2. Do you have more than one mode of transportation service for your Home based work/school trip? (Interchangeability between services)

A) Yes A) No

3. Please list your route from the initial bus station up to your work place/ school?

....

4) Please give your estimation for travel time and cost for the modes you can use in your trip? (Fill only for the modes you can use)

A) Walking mode

Travel time ……………………..minutes.

B) Bicycle mode

Travel time ……………………..minutes.

Maintenance cost ……………… ETB/month

C) Motorcycle mode

Travel time……………………………minutes

Average monthly fuel consumption …………… ETB/month

Maintenance cost………………...ETB/month

D) Private car mode

Travel time …………………….....minutes.

Average monthly fuel consumption …………… ETB/month

Maintenance cost ………………………..…ETB/month

E) Bajaj mode

Time from home to station …….........minutes.

Time waiting a Bajaj ……………...…. minutes.

In-vehicle travel time …………………………....minutes.

Time from station to work ……………………….minutes.

Travel cost (fare)...ETB/month

F) Damas mode

Time from home to station …….........minutes.

Time waiting a Damas……………...…. minutes.

In-vehicle travel time …………………………....minutes.

Out vehicle travel time (Time from station to work) ……………………….minutes.

Travel cost..ETB/month

G) Mini bus mode

Time taken from home to bus station ……..................minutes.

Time waiting a mini bus ....…..........minutes.

In-vehicle travel time ………........…………..………minutes.

Time from station to work ……...……………………minutes.

Travel cost (fare)...ETB/month

H) Bus Mode

Time from home to station ……........minutes.

Time waiting a bus ……………...… minutes.

In-vehicle travel time …………………………....minutes.

Out vehicle travel time (Time from station to work) …………………………minutes.

Travel cost..ETB/month

Part V: stated preference survey

Assume that a new bus service will be introduce to transport system in Hawassa city. Are you willing to shift to Bus with the following attributes for work or school trips?

NB: Shared taxi (minbus, damas and Bajaj)

<u>Preference survey 1</u>

Attribute/mode	Bus	Shared taxi
Travel time	30% more than shared tax	-
Travel cost	40% less than shared tax	-
Service frequency	Every 15 minutes	5 minutes

The table shows that if the travel time of the bus 30% more than shared taxi, travel cost 40% less than shared taxi and service frequency is every 10 minutes (15-5= 10 minutes) lower than shared taxi? So, do you prefer bus?

A) Yes **B) No**

<u>Preference survey 2</u>

Attribute/mode	Bus	Shared taxi
Travel time	10% more than shared tax	-
Travel cost	20% less than shared tax	-
Service frequency	Every 8 minutes	5 minutes

The table shows that if the travel time of the bus 10% more than shared taxi, travel cost 20% less than shared taxi and service frequency is every 3 minutes (8-5= 3 minutes) lower than shared taxi? So, do you prefer bus?

A) Yes **B) No**

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"ANALYSIS OF MULTINOMIAL LOGIT MODEL FOR WORK AND SCHOOL TRIPS MODE CHOICE BEHAVIOR: A CASE STUDY IN HAWASSA CITY'' በሚል ርዕስ ለሚደረገው የመመረቂያ ፅሁፍ ጥናት አጋዥ እንድሆን ተብሎ የተዘጋጀ መጠይቅ፣ ሰኔ 2011 ዓ.ም፡፡

- ይህ መጠይቅ ሀዋሳ ውስጥ ያለውን የትራንስፖርት ሁኔታ ወደ ሂሳባዊ ሞዴል በማዘጋጀት ጥናት ለማድረግና ወደፍት የሀዋሳ የትራንስፖርት ሁኔታ ምን መሆን እንዳለቤት የሚያሳይና የተሳለጠ የተገልጋዮች እርካታ እንድኖር የምያስችል ነው፡፡
- ይህ መረጃ ለሳይንሳዊ ጥናት ብቻ እንደሚያገለግል በማሰብ እባክዎ የሚከተለውን መጠይቅ እውነታዉን ብቻ በኃላፍነት በመሙላት ይተባበሩን፡፡ ይህን መጠይቅ ለመሙላት የተመረጡት ምላሽ ሰጪዎች የሚከተሉትን መስፈርቶች ሊያሟሉ ይገባል፡፡

1) ግለሰቡ ስራ ያለው/ያላት ወይንም የኮለጅ ተማሪ የሆነ/ የሆነች እና ከሚሰራበት ድርጅት የመጓጓዣ አገልግሎት የሌለው መሆን አለበት

2) ግለሰቡ በአብዛኛው ከጠዋቱ 12 ሰአት እስከ 3 ሰአት ጀምሮ ከቤት ወደ ስራ ወይንም ት/ቤት የሚወጣ መሆን አለበት

3) ጉዞው እርስዎ አልፊዉ የሚሄዱቤትን/ የምመጡበትን ቦታ ብቻ ይመለከታል

ክፍል1. ማህበራዊ እና ኢኮኖሚያዊ መረጃ

1. ጾታ [ ] ሴት [ ] ወንድ
2. ዕድሜ........ ዓመት [ ] 18-29 [ ] 30-45 [ ] > 45
3. የጋብቻ ሁኔታ [ ] ያገባ [ ] ያላገባ
4. የትምህርት ደረጃ [ ] ዲፕሎማ [ ] ዲግሪ [ ] ማስተርስ
5. በቤተሰብዎ ውስጥ ስንት ሰዎች ይኖራሉ? [ ] 1 [ ] 2-3 [ ] >3
6. ጠቅላላ የቤተሰብዎ ወርሃዊ ገቢ

[ ] 2,000 ብር በታች [ ] ከ 2,001 እስከ 5000 ብር
[ ] ከ 5,001 እስከ 10,000 ብር [ ] ከ 10,001 በላይ

ክፍል 2፡ በጉዞ ምርጫ ላይ ተጽኖ የምያሳድሩ ነገሮች

ሀ) ከታች ከተዘረዘሩት ነገሮች በትምህርት ቤትና በሥራ ጉዞ ምርጫ ላይ ምን ያህል ተጽኖ እንደምያሳድሩ ይግለጹ

ዝርዝሮች	**በጣም ዝቅተኛ ተጽኖ**	**ዝቅተኛ ተጽኖ**	**መካከለኛ ተጽኖ**	**ከፍተኛ ተጽኖ**	**በጣም መካከለኛ ተጽኖ**
ዕድሜ					
ጾታ					
ገብ					
የጉዞ ዋጋ					
ለትራንስፖርት መጠበቅያ ሰዓት					
የትራንስፖርት ዉስጥ የጉዞ ሰዓት					
የአየር ሁኔታ					
የጉዞ ላይ ምቾት					
የግል መኪና መኖር					
በጉዞ ላይ የትራንስፖርት መቀያየር					

ለ) እባኮትን ለምከተሉት ከተዘረዘሩት የጉዞ አይነት በጣም የምመች ፣ የምመች የማይመችና በጣም የማይመች በማለት በኃላፍነት ይሙሉ::

ተ.ቁ	**ዝርዝር**	**በባስ**	**ምንባስ**	**በታክስ**	**ባጃጅ**
1	በጉዞ ላይ ተቀምጠዉ ስሄዱ ያለዎት ምቾት				
2	ፈጣንና ቀልጣፋ የጉዞ አገልግሎት ከማግኘት አንጻር				
3	ከደህንነትዎ አንጻር (ከሌብነትና ዘረፋ)				
4	ከልክ በላይ ከመጫን አንጻር				

ክፍል 3፡ የጉዞ ባህሪያ

1) ለእርስዎ ወደ ትምህርት ወይንም ወደ ለስራ ለመጓዝ ያሉ አማራጮች የትኞቹ ናቸው?

[ ] የግል መኪና [ ] ባስ/ ታክስ [ ] ሚን ባስ [ ] ባጃጅ [ ] ሞተር ሳይክል [ ] ሳይክል [ ] የእግር ጉዞ

2) በጉዞዋችሁ ላይ ከ1 በላይ የመጓጓዣ ዓይነት ይጠቀማሉ?

ሀ) አዎ ለ) አይደለም

3) እባኮትን በጉዞዎ ከቤትዎ ተነስተዉ እስከመዳረሻዎ ስሄዱ ያሉትን ቦታዎችና የተጠቀሙትን የመጎጎዣ ዓይነት ይግለጹ ……………………………………………………………………………………………………

4) እባኮትን በጉዞዋችሁ ላይ የምወስድባችሁን የመጓጓዣ ሰዓትና ክፍያ ይግለጹ (ለጉዞ በምታዘዎትሩት መጓጓዣ ብቻ ላይ ይሙሉ)

ሀ) የእግር ጉዞ

የጉዞ ሰዓት ……………………….ደቅቃ ነው።

ለ) የሳይክል ጉዞ

የጉዞ ሰኣተ ……………………….ደቅቃ ነው።

በወር ለጥገና የምታወጣዉ/ የምታወጭዉ የገንዘብ ልክ ……………… ብር ነው።

ሐ) የሞተርሳይክል ጉዞ

የጉዞ ሰኣተ) ……………………….ደቅቃ ነው።

በወር ለጥገና የምወጣዉ/ የምታወጭዉ የገንዘብ ልክ …………… ብር ነው።

ወርሃዊ የቤንዝል ፍጆታ……………………….ብር ነው።

መ) በግል መኪና ጉዞ

የጉዞ ሰኣተ ……………………….ደቅቃ ነው።

ወርያዊ የቤንዝል ፍጆታ……………………….ብር ነው።

በወር ለጥገና የምታወጣዉ/ የምታወጭዉ የገንዘብ ልክ……… ብር ነው።

ሠ) የባጃጅ ጉዞ

ከቤት ወደ ባስ መቆምያ ስሄዱ የምፈጂቦት ግዜ …………… ደቅቃ ነው።

ባጃጅ በመጠባበቅ የምፈጅቦት ግዜ ……………………… ደቅቃ ነው።

ጉዞ ላይ የምፈጅቦት ግዜ …………………………………… ደቅቃ ነው።

ከባስ መቆምያ ወደ ሥራ ቦታ ስሄዱ የምፈጅቦት ግዜ ……………………… ነው።

ወርያዊ የጉዞ ክፍያ………………ብር ነው።

ረ) ዳማስ

ከቤት ወደ ምንባስ መቆምያ ስሄዱ የምፈጂቦት ግዜ.......................... ነው፡፡

ምንባስ በመጠባበቅ የምፈጅቦት ግዜ ....ነው፡፡

ጉዞ ላይ የምፈጅቦት ግዜ ....ነው፡፡

ከምንባስ መቆምያ ወደ ሥራ ቦታ ስሄዱ የምፈጅቦት ግዜ ....ነው፡፡

ወርያዊ የጉዞ ክፍያ..................ብር ነው፡፡

ሰ) የሚን ባስ ጉዞ

ከቤት ወደ ምንባስ መቆምያ ስሄዱ የምፈጂቦት ግዜ ....ነው፡፡

ምንባስ በመጠባበቅ የምፈጅቦት ግዜ ....ነው፡፡

ጉዞ ላይ የምፈጅቦት ግዜ ....ነው፡፡

ከምንባስ መቆምያ ወደ ሥራ ቦታ ስሄዱ የምፈጅቦት ግዜ ....ነው፡፡

ወርያዊ የጉዞ ክፍያ..................ብር ነው፡፡

ሸ) የባስ ጉዞ

ከቤት ወደ ባስ መቆምያ ስሄዱ የምፈጂቦት ግዜ ....ነው፡፡

ባስ በመጠባበቅ የምፈጅቦት ግዜ ....ነው፡፡

ጉዞ ላይ የምፈጅቦት ግዜ ....ነው፡፡

ከባስ መቆምያ ወደ ሥራ ቦታ ስሄዱ የምፈጅቦት ግዜ ....ነው ፡፡

በ 1 ሊትር ነዳጅ የሚጉዋዙት ርቀት መጠን በኪሎሜትር……………………..ነው፡፡

ወርያዊ የጉዞ ክፍያ..................ብር፡፡

ክፍል 4. ስተትድ ፒሪፈረንስ ሰርቨይ

በሀዋሳ ከተማ አዲስ የአውቶቡስ አማራጭ በተለየ አቀራረብ በቅርቡ አገልግሎት መስጠት ይጀመራል ብለዉ ብያስቡና፤ ለመጓዝ የሚከተሉትን ባህርያት ብኖሩት እርስዎ የትኛዉን ይመርጣሉ?

<u>አማራጭ ደረጃ 1</u>

ባህርያት	ባስ	ታክስ
የጉዞ ርዝመት በደቅቃ	30% ከታክስ ይበልጣል	-
የጉዞ ክፍያ	40% ከታክስ ያንሳል	-
በየ ስንት ደቅቃ ተሽከርካር ይመጣል	በየ 15 ደቅቃ	በየ 5 ደቅቃ

ሀ) አዎ ለ) አይደለም

<u>አማራጭ ደረጃ 2</u>

ባህርያት	ባስ	ታክስ
የጉዞ ርዝመት በደቂቃ	10% ከታክስ ይበልጣል	-
የጉዞ ክፍያ	20% ከታክስ ያንሳል	-
በየ ስንት ደቅቃ ተሽከርካር ይመጣል	በየ 8 ደቅቃ	በየ 5 ደቅቃ

ሀ) አዎ ለ) አይደለም

APPENDEX B

No route	Origin	Destination	Length in km	Tariff for Bajaj in km	Price in birr for Bajaj	Tariff for Damas and Mini bus in km	Price in birr for Damas and mini bus
1	TTC warka	Aroge Menaheria	2.2	1.25	2.75	0.75	1.65
2	TTC warka	Referal hospital	2	1.25	2.5	0.75	1.5
3	TTC warka	Addisu gebeya	3.66	1.25	4.575	0.75	2.745
4	TTC warka	Pizza Total	5.51	1.25	6.8875	0.75	3.855
5	Addisu gebeya	Alamura h/school	1.2	1.25	1.50	0.75	1.125
6	Addisu gebeya	Nigiste Fura	1.7	1.25	2.125	0.75	1.275
7	Addisu gebeya	Membo	2.2	1.25	2.75	0.75	1.65
8	Referal	Aroge gebeya	5.5	1.25	6.875	0.75	4.125
9	Referal	Piazza municipality	5.2	1.25	6.50	0.75	3.9
10	Atote	Aroge Menaheria	2	1.25	2.50	0.8	1.60
11	Atote	Alamura	2.2	1.25	2.75	0.8	1.76
12	Atote	Trufat	1	1.25	1.25	0.8	0.80
13	Atote	Aroge gebeya	3.5	1.25	4.375	0.8	2.8
14	Atote	Alamura h/school	2.2	1.25	2.75	0.8	0.76
15	Atote	Debub condominium	1.5	1.25	1.875	0.8	1.2
16	Debub condominium	Saint Gabriel	3.2	1.25	4	0.75	2.4
17	Debub condominium	Aroge Menaheria	3.5	1.25	4.375	0.75	2.625
18	Debub condominium	Menaheria wanza	2.2	1.25	2.75	0.75	1.65
19	Debub condominium	Addisu gebeya	2	1.25	2.50	0.75	1.5
20	Aroge Menaheria	Hawassa university	2.2	1.25	2.75	0.75	1.65
21	Aroge Menaheria	Piazza	3.2	1.25	4	0.75	2.40
23	Aroge Menaheria	Areb sefer	1.2	1.25	1.5	0.75	0.9
22	Aroge Menaheria	Pepsi factory	1.8	1.25	2.25	0.75	1.35
24	Piazza	Mobile	1.5	1.25	1.875	0.75	1.125
25	Piazza	Arab sefer	1	1.25	1.25	0.75	0.75
26	Hawassa university	Mobile	1.6	1.25	2	0.75	1.2
27	Mobile	South star hotel	3.1	1.25	3.875	0.75	2.325
28	Mobile	Aroge gebeya	1.4	1.25	1.75	0.75	1.05
29	Mobile	Areb Sefer	1	1.25	1.25	0.75	0.75

APPENDEX C

Format sheet for site survey

Date: 2/11/2011 E.c

Local time: 1:45-2:45 am

Initial station: Aroge Menaheria tax station

Destination: Piazza and Aroge gebeya

no	Vehicle type	Targa number	arriving time to the station (1)	Leaving time from the station (2)	Waiting time at the station (3=2-1)	Frequent, accessible and quick services	Carry as per specified capacity
1	Mini bus	15404	1:45	1:49	4	high	Not comfortable
2	Mini bus	18438	1:45	1:56	11	high	Not comfortable
3	Mini bus	18387	1:45	1:59	14	high	Not comfortable
4	Mini bus	04453	1:45	2:01	16	high	Not comfortable
5	Mini bus	18733	1:45	2:04	19	high	Moderate
6	Mini bus	16867	1:52	2:08	16	high	Not comfortable
7	Mini bus	06476	1:58	2:13	15	high	Not comfortable
8	Damas	16886	2:01	2:14	13	low	Moderate
9	Mini bus	03829	2:03	2:18	15	high	Not comfortable
10	Mini bus	13140	2:08	2:22	14	high	Not comfortable
11	Mini bus	45092	2:13	2:25	12	moderate	Moderate
12	Damas	13338	2:14	2:20	6	low	Moderate
13	Mini bus	15791	2:17	2:29	12	moderate	Not comfortable
14	Mini bus	07429	2:19	2:32	13	moderate	Moderate
15	Mini bus	11023	2:23	2:35	12	high	Comfortable
16	Damas	15227	2:25	2:39	14	low	Comfortable
17	Damas	14662	2:27	42	16	moderate	comfortable

Date: 4/11/2011 E.c

Local time: 1:30-2:30 am

Initial station: Addisu Menaheria taxi station

Destination: TTC warka Via Alamura high school

	Vehicle type	Targa number	arriving time to the station (1)	Leaving time from the station (2)	Waiting time at the station (3=2-1)	Frequent, accessible and quick services	Carry as per specified capacity
1	Bajaj	22532	1:30	1:34	4	High	Comfortable
2	Mini bus	15038	1:30	1:36	6	High	Not Comfortable
3	Mini bus	15049	1:32	1:39	7	High	Not Comfortable
4	Mini bus	09935	1:34	1:43	9	High	Not Comfortable
5	Bajaj	16135	1:36	1:44	8	High	Comfortable
6	Damas	22521	1:38	1:46	8	Moderate	Comfortable
7	Bajaj	19427	1:40	1:46	6	High	Comfortable
8	Bajaj	08934	1:43	1:48	5	High	Comfortable
9	Damas	16891	1:46	1:53	7	Low	Comfortable
10	Bajaj	10862	1:50	1:38	8	High	Comfortable
11	Mini bus	11910	1:54	2:04	10	Moderate	Moderate
12	Bajaj	07933	1:59	2:07	8	High	Comfortable
13	Bajaj	12254	2:04	2:10	6	High	Comfortable
14	Bajaj	21778	2:07	2:12	5	High	Comfortable
15	Mini bus	15551	2:10	2:18	8	Moderate	Moderate
16	Mini bus	22045	2:12	2:23	11	Moderate	Not Comfortable
17	Bajaj	16625	2:12	2:18	6	High	Comfortable
18	Bajaj	20788	2:14	2:20	8	High	Comfortable
19	Mini bus	13325	2:16	2:29	13	Moderate	Moderate

Date: 5/11/2011 E.c

Local time: 1:45-2:45 am

Initial station: Meskel Adebabay taxi station

Destination: TTC warka and Referal Hospital

no	Vehicle type	Targa number	arriving time to the station (1)	Leaving time from the station (2)	Waiting time at the station (3=2-1)	Frequent, accessible and quick services	Carry as per specified capacity
1	Bajaj	05224	1:45	1:47	2	High	Comfortable
2	Mini bus	18591	1:47	1:54	7	High	Not Comfortable
3	Bajaj	02774	1:47	1:51	4	High	Comfortable
4	Mini bus	12966	1:49	2:02	12	High	Not Comfortable
5	Bajaj	02539	1:53	2:01	8	High	Comfortable
6	Mini bus	16815	1:55	2:05	10	High	Not Comfortable
7	City bus		1:56	2:12	15	Low	Moderate
8	Bajaj	01852	1:57	2:02	5	moderate	comfortable
9	Damas	08384	2:01	2:10	9	Moderate	Moderate
10	Bajaj	01105	2:04	2:09	5	Moderate	Comfortable
11	Bajaj	13140	2:08	2:14	6	High	Comfortable
12	Mini bus	17495	2:13	2:25	12	Moderate	Moderate
13	Damas	13338	2:14	2:20	6	Low	Moderate
14	Bajaj	15793	2:17	2:22	12	Moderate	Comfortable
15	Mini bus	15367	2:19	2:31	11	High	Moderate
16	Bajaj	04452	2:21	2;24	3	High	Moderate
17	Mini bus	13878	2:24	2:36	12	High	Not Comfortable
18	Bajaj	07216	2:24	2:29	5	High	Comfortable
19	Mini bus	11024	2:28	2:38	10	High	Moderate
20	Bajaj	02123	2:29	2:33	4	Moderate	Comfortable
21	Mini bus	15611	2:31	2:43	12	High	Moderate

Date: 7/11/2011 E.c

Local time: 1:30-2:30 am

Initial station: Mobile taxi station

Destination: Piazza via Arab sefer

no	Vehicle type	Targa number	arriving time to the station (1)	Leaving time from the station (2)	Waiting time at the station in minutes (3=2-1)	Frequent, accessible and quick services	Carry as per specified capacity
1	Mini bus	11402	1:30	1:37	7	High	Not Comfortable
2	Mini bus	14483	1:30	1:38	8	High	Moderate
3	Bajaj	13878	1:30	1:34	4	High	Comfortable
4	Mini bus	03454	1:35	1:42	7	High	Not Comfortable
5	Mini bus	13731	1:37	1:45	8	High	Moderate
6	Bajaj	17864	1:32	1:37	5	High	Comfortable
7	Bajaj	05466	1:33	1:38	5	High	Comfortable
8	Damas	16822	1:41	1:48	7	Low	Moderate
9	Mini bus	02839	1:45	1:54	9	High	Not Comfortable
10	Bajaj	14130	1:45	1:49	4	High	Comfortable
11	Mini bus	24090	1:48	1:57	9	High	Moderate
12	Damas	18332	1:49	1:57	8	Low	Moderate
13	Mini bus	11795	1:53	1:58	5	Moderate	Not Comfortable
14	Bajaj	02669	1:54	2:02	8	High	Comfortable
15	Bus	xxxxx	1:57	2:13	16	Low	Moderate
16	Bajaj	04900	1:58	2:04	6	High	Comfortable
17	Bajaj	03976	1:59	2:04	5	High	Comfortable
18	Mini bus	11097	1:59	2:10	11	Moderate	Moderate
19	Damas	15536	2:02	2:11	9	Low	Moderate
20	Mini bus	13936	2:04	2:17	13	High	Not Comfortable
21	Bajaj	15051	2:04	2:10	6	High	Moderate
22	Bajaj	22590	2:05	2:10	5	High	Comfortable
23	Mini bus	07216	2:05	2:17	12	High	Not Comfortable
24	Mini bus	04038	2:07	2:21	14	High	Moderate
25	Damas	07832	2:08	2:15	7	Low	Moderate
26	Bajaj	04038	2:09	2:14	5	Moderate	Comfortable
27	Mini bus	05186	2:11	26	15	High	Not Comfortable
28	Mini bus	12054	2:13	2:27	14	High	Moderate