

ADDIS ABABA UNIVERSITY
ADDIS ABABA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING



**Influence of Application-Assisted Taxi service on Passenger's
Mode Choice Behavior:
The Case of Addis Ababa City**

By:

Abiy Girma Teffera

A Thesis Submitted to the School of Graduate Studies in Partial
fulfilment of the requirements for the degree of Master of Science in
Road and Transport Engineering

Advisor:

Dr. Bikila Teklu

August, 2021

Addis Ababa

ADDIS ABABA UNIVERSITY
ADDIS ABABA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

Influence of Application-Assisted Taxi service on Passenger's Mode

Choice Behavior:

The Case of Addis Ababa City

By:

Abiy Girma Teffera

A Thesis Submitted to the School of Graduate Studies in Partial fulfilment
of the requirements for the degree of Master of Science in Road and
Transport Engineering

Approved by Board of Examiners

Dr. Bikila Teklu

Advisor

Signature

Date

Internal Examiner

Signature

Date

External Examiner

Signature

Date

Chairperson

Signature

Date

UNDERTAKING

I certify that the research work titled “Influence of Application-Assisted Taxi service on Passenger’s Mode Choice Behavior: The Case of Addis Ababa City” is my own work performed under the supervision of my research advisor Dr. Bikila Teklu and has not been presented elsewhere for assessment and for a degree in any other university. Where material has been used from other sources it has been properly acknowledged / referred.

Signature

Undertaker’s Full Name: Abiy Girma Teffera

Place of Undertaking: Addis Ababa

Acknowledgement

It is a great honor to give the appropriate credit for those who has helped me a lot throughout my study without whom the course and research work would not have been a reality.

First, I would like to thank almighty God for giving me the strength needed to accomplish my study. He has been a fortress for me during the hardest time of my life and everything I have done and achieved has been a blessing and a gift from him.

I want to thank and give the deepest gratitude to my Advisor, Dr Bikila Teklu who has been a great mentor during my course work and has provided me with the appropriate guidance and support in the thesis work. Your dedication to give all you have in classroom is something unforgettable.

I would also like to thank my Co-Advisor, Mr Mesay Shemsu who has helped me a great deal during the proposal preparation and throughout the thesis work.

My friends are those who should get the appropriate credit for their great help during the data collection period.

Lastly, I give a high credit to my precious family and especially to my wife, Elisabeth Beyene for helping me much in every aspect of my life throughout the study period.

Thank you all!

Abstract

Introduction of Application-assisted taxi service on urban transport in recent years is making a fundamental change on the service level of the transport system and is impacting its sustainability in different aspect. The purpose of this paper is to investigate modal shift impact of application-assisted taxi service on the different alternative transport modes by examining the factors which are accountable to this shift along with characterizing its users.

Revealed preference questionnaire developed for this purpose is disseminated to passengers selected from different locations in Addis Ababa and 384 valid questionnaires have been used for the analysis. Different factors that could explain the choice to shift from the different modes to application-assisted taxi have been selected based on a state of art literature review in addition to a preliminary interview to passengers of this service and were included in the questionnaire. Multinomial logit model have been used to quantify the effects of these different factors using Python Biogeme software package.

It is found that minibus taxi users account for the highest proportion to the modal shift followed by Traditional (lada) taxies, Private Vehicle, Large Bus and higer bus each with percentage value of 53.65, 23.7, 12.24, 5.99 & 4.43 respectively.

Further analysis intended to indicate the factors affecting the shift revealed that Socio-Economic factors (Income and Education level), factors related to adoption reasons (Lack of public transport, Travel time Saving, Seeking Comfort, Presence of Covid, Traffic congestion & difficulty to find Parking space) and Travel purpose reasons (trips to Work, Home, School & Recreational trip) do significantly explain the shift from the different modes to application-assisted taxies.

It is concluded that Utilization of application assisted taxies in the transport system has an effect on the passenger's mode choice behavior and different factors do account for the modal shift from the different modes of transport having different significance levels. Hence it is a requirement to improve the service levels of more sustainable public transport modes in terms of their quantity and quality in order to curb the potential substitutive effects that application-assisted taxies pose on them which could result in several negative externalities to the transport system. In addition to this: strict regulations to increase the vehicle occupancy rates of application-assisted taxi service on peak traffic hour should be devised and put in place.

Key Words: - Mode shift, Multinomial logit, Application-assisted taxi, Revealed preference.

Contents

Acknowledgement	i
Abstract	ii
List of Tables	v
List of Figure.....	vi
List of Abbreviations	vii
1.0 Introduction.....	1
1.1 Background.....	1
1.2 Statement of the problem	3
1.3 Research Question	4
1.4 Objective of the Study	4
1.5 Scope (Delimitation of the study)	5
1.6 Significance of the Study	5
1.7 Thesis Structure	6
2.0 Literature Review.....	8
2.1 Introduction.....	8
2.2 The Development of on Demand transport Service and related concerning issues	8
2.3 Application-Assisted Taxi Service in Addis Ababa.....	13
2.4 Factors that affect shift to Application-Assisted Taxi service.	17
2.5 Transport Mode Choice Behavior and Mode Choice Modelling.....	20
2.5.1 The planning concern.....	20
2.5.2 Mode choice Behavior and Utility Function.....	21
2.5.3 Mode choice modelling techniques	22
2.5.4 Likelihood Function.....	30
2.5.5 Method of model testing	30
2.6 Summary	30
3.0 Methodology	32
3.1 Introduction.....	32
3.2 Study area.....	32
3.3 Data collection Method.....	34
3.3.1 Questionnaire Development.....	34
3.3.2 Sample Size Determination.....	34
3.3.3 Sampling method and Data collection	35

3.4 Data Analysis	36
3.4.1 Mode Shift Modelling	36
3.4.2 Available Modes of Transport	37
3.4.3 Variable and Coding of Variable	37
3.4.4 Model selection	39
3.4.5 Detail on Mode Shift Model Development for app-assisted Taxi Service.....	39
3.4.6 Method of Analysis.....	40
3.5 Software used.....	41
4.0 Result and Discussion	42
4.1 Users of Application-assisted Taxi service	42
4.2 Travel needs and Trip characteristics.....	47
4.2.1 Travel needs	47
4.2.2 Day Time of Trip & how it is performed.....	48
4.2.3 Time saving.....	49
4.2.4 Passengers View on Cost	50
4.2.5 Use Frequency	51
4.3 Mode Substitution	52
4.4 Modelling application-assisted modal shift influencing factors	54
4.4.1 Model Estimation.....	56
4.4.2 Socio-Economic Factors	58
4.4.3 Adoption reasons.....	58
4.4.4 Travel purpose	60
4.5 Implications to the Transport system	61
5. Conclusion, Recommendation & Future Research Direction	62
5.1 Conclusion	62
5.2 Recommendation	63
5.3 Future Research Direction	64
6.0 References.....	65
7.0 Appendix.....	70
7.1 Questionnaire	70
7.2 Tables for Multi-Collinearity Checking.....	76

List of Tables

Table 2-1:- statistics for major App-assisted taxi service providers. Adopted from Business of Apps . https://www.businessofapps.com/data/uber-statistics	9
Table 3-1 Codes for variables	38
Table 4-1 Summary of Socio-Economic Characteristics of App-assisted Taxi service Users	42
Table 4-2 Trip proportion of app-taxi utilization.....	52
Table 4-3 Description of Variable	55
Table 4-4 Model Estimation result	57

List of Figure

Figure2- 1:Modern Taxies in Addis Ababa (Source Google Image).....	16
Figure 2-2: Conventional Lada taxi in Addis Ababa (source –Google Image)	16
Figure 2-3: Probability density function for Gumbel and normal distributions	23
Figure 2-4: Cumulative distribution function for Gumbel and normal distrbution	23
Figure.2-5 Adaptive Neural Network of the FIS. (Dell’Orco and Ottomanelli ,2012)	29
Figure 3-1: City Map of Addis Ababa	33
Figure 4-1 Gender Composition	43
Figure4-2 Age distribution.....	44
Figure 4-3 Employment Status	45
Figure 4-4 Income level	45
Figure 4-5 Educational Status.....	46
Figure 4-6 Car ownership	46
Figure 4-7 Pie chart of the Travel purpose distribution.....	47
Figure 4- 8 Time of day use distribution	48
Figure 4-9 Distribution of how trip is performed	49
Figure 4 -10 time saving from different modes	49
Figure 4-11 passengers View on cost	50
Figure 4-12 Trip frequency In proportions	51
Figure 4-13 Proportions of Alternative mode replaced	53

List of Abbreviations

ANN:	Artificial neural network
App:	Application
ATTS:	Application third taxi service
AU:	African union
BRT:	Bus rapid transit
CBD:	Central business district
ECA:	Economic commission for Africa
ERC:	Ethiopian rail way cooperation
FFBS:	Free floating Bike service
FIS:	Fussy inference system
GPS:	Global positioning system
IIA:	Independence of irrelevant alternative
LRT:	Light rail transit
MLE:	Maximum likelihood estimation
OLS:	Ordinary least square
MNL:	Multinomial logit
MNP:	Multinomial probit
NGO:	Non-governmental organization
NLM:	Nested logit model
PDF:	Probability density function
SOV:	Single occupancy vehicle
SPSS:	Statistical package for Social Science
TNC:	Transportation Network Company
VMT:	Vehicle mile travel

1.0 Introduction

1.1 Background

Taxi Transport service that uses Mobile application for ride booking has become a phenomena in the last few years and attracted a great deal of attention from different sector among which Transportation is the major one. This is a mode of transport where application is loaded on a smart phone which will be used as a means to ease communication between the service provider and the customer in real time. GPS technology is used to locate the places where the service provider appears and to go to the place where the customer who is waiting for the service resides. Passengers request for this service is made using an application or by calling to a call center after which a vehicle existing in the nearby location is assigned to pick the passenger and take him to the trip destination location. The travel service fare is fixed and calculated per kilometer traveled which differs significantly from the traditional taxi service where passengers are obliged to negotiate on prices before they got the service.

Among those kind of transport service providers, Uber is the major one around the world which has made the first innovation of this kind of transport service and is making a fundamental change in the way transport service is given in big metropolitan cities. According to Conway et al.(2018,p.1), “The advent of these “ridehailing” services, such as Uber and Lyft in the United States, has precipitated dramatic growth in travel via for-hire vehicles”.

The growing mobility needs of peoples in large metropolitan cities has opened the door for the provision of these kind of transport services. The accessibility and mobility problem in the transportation sector that exist in almost every large metropolitan cities could be examined from the high increase of the adoption of application-assisted taxies observed within a single decade time. Those needs are hardly met by the existing large metro system consisting the Train and bus rapid transit systems which cannot access all places where those demands need to be met especially on peak traffic hours This has led transport service giving entrepreneurs the opportunity to look for developing a transport service equipped with the recent technology for the provision of an on demand door to door transport service which exhibits travel mode characteristics that best suits the demand of passengers.

Uber has launched the first Mobile App.-Assisted transport service in 2009 (Mourdoukoutas, 2021). It was shortly after this that different company's join the sector in the American app-hailing business among which Lift and Sidecar are the major once. The European and Asian market has provided a high market to those transport services as could be seen from the fast expansion of those transport systems in these countries with in a short period of time of their operation (CURRY, 2021).

Giddy (2019) described it is South Africa, which is the first one among the African countries where this type of service was launched by Uber in 2013 G.C. Then after, different African countries has begun using these services which came abroad and started launching their own companies which give similar services. South Africa, Kenya, Egypt, Morocco, Nigeria, Tanzania and Uganda are among the first adopter of these services where Uber has expanded its service in the African market (Mourdoukoutas, 2021).

In Ethiopia, companies providing application-assisted taxi service started in 2016 when ZayRide transport service got established (Aga, n.d.). He also described that text messaging and call center service which was launched by Ride Company existed before the utilization of applications. Currently there are many companies which provide those service among which ZayRide, Ride, Taxiye, Feres, Seregela, Catch, Hello are the most prevalent once. It is seen that there is a high demand for this service especially in the morning and afternoon times where most of the commuting trip to work and home is performed.

There establishment has contributed a lot to the on demand transport service seeking sectors such as tourism and hotel services. A study done by Henama & Sifolo (2017) in south Africa showed that the service that is given by Uber has enhanced the tourism sectors and made an immense contribution for the night time market.

Apart from Ride hailing service, it is also common in some countries that ride sharing services exists. According to Dong et al. (2018) Ride sharing services promotes the sharing of one car by different passengers who are heading to same destination where the passengers share their journey. In America Uber and Lyft provide ride sharing service with their Uberpool and LyftLine differentiated services respectively.

Zhong et al., (2018) described “The rapid development of e-hailing services has already brought changes in the travel mode choices of urban residents”. This implies that their presence in the transport system will highly change the mode choice behavior of urban residents in the cities they are giving service.

Hence understanding changes in urban residents’ mode choice behaviors under in context of app-based transport is crucial for transport planners and transport operators giving those services which could yield a valuable information to devise appropriate regulation regarding those transport means. This will also be beneficial as it will yield an information to the performance levels of the current public transport service operations which will be an input to necessary policy implementations.

1.2 Statement of the problem

Mobility needs in capital cities around the world is in a hike at present. The busy time schedule of working peoples who are at middle and high income levels has urged them to get to work as fast as possible in order to undertake their activities. Addis Ababa: as the capital city of Ethiopia is the center place where tourists coming to the country reside for a substantial period during their stay. They badly need a reliable, safe and fast transport service during those days of their stay in the capital. As the capital is a place where organization’s like the AU and ECA is established, there are a number of meeting and conferences which are undertaken several times in a year which adds to the mobility and accessibility needs to the transport service in place. There are large numbers of international hotels which are serving their customers which depend on a reliable transport system for their services. In line with this need, Transport companies which use Mobile application for the fast delivery of their services are becoming prevalent during the last few years in order to fill those gap which could otherwise be not satisfied with the current public transport service. It is believed that peoples will shift to this transport service in order to fulfill their mobility needs.

The question as to who uses this transport mode and for what purpose in the context of Addis Ababa is not addressed yet. In addition the relative share of travel mode shift to application based transport service of different mode users (mode substitution effect) is not known. Moreover the factors which affect the modal shift to the application based transport is not studied yet which

could provide transport planners and operators with important information when devising management strategies, regulation and policies regarding this mode of transport.

Hence this study will try to find out who uses app-assisted taxi service, the travel purpose they are being used for, what their mode substitution effect is and the significant factors that affect this shift. The result will be an input to city transport Authority when dealing with issues related to those technology based transport services. The result will also be beneficial as it will indirectly show the performances of the existing public transport service which will be an input to the needed improvements in their service level.

1.3 Research Question

Based on the issues stated in the problem statement section, the following questions have been identified which need be answered and these are:-

- 1- Who are the users of application assisted taxi service?
- 2- What travel purposes are application- assisted taxi service being used for?
- 3- What is the mode substitution effect of application-assisted taxi service on different modes of travel?
- 4- What are the factors that do significantly affect the shift to application-assisted taxi service from different modes?

1.4 Objective of the Study

The questions being raised has led us to form the following research objective which has been classified as General and Specific.

General Objective:

The general objective of the research is **to find out the influence of application-assisted taxi service on mode choice behavior of Addis-Ababa residents.**

The following four Specific Objectives have been identified in order to meet the general objective and these are

I: -To specify the users of application-assisted taxi service. This is achieved by analyzing the socioeconomic characteristics of passengers that will be found from the collected data.

II:-To indicate the travel purpose that passengers host application-assisted taxies. Asking passengers what travel needs they satisfy by using those service addresses this objective.

III: - To find out modal substitution effect of application-assisted taxi services on different modes. Question regarding what travel mode passengers usually use for their trips had application-assisted taxies are not present will be used to answer this issue.

IV: - To show the significant factors that affect passengers decisions to shift from the different modes to application-assisted taxi service. In order to address this issue, relevant factors that affect the shift will be selected by making an in depth literature review and processed using the appropriate modelling technique.

1.5 Scope (Delimitation of the study)

The research focusses on finding out who the users of app.assisted taxi service are, The travel purpose they are being used for,the modal substitution effect of application-assisted taxi services on different modes in Addis-Ababa city and the significant factors that contribute to the shift to the utilization of application-assisted taxi service users in the context of Addis Ababa residents.It is conducted between December 2020 – June 2021.Writing for the first three chapters,data collection,data analysis and document conclusion has been framed in these period with 50, 60,30 and 3 day time periods respectively.The data collection is performed between march-April 2021.

A random sampling has been done from 16 data collection spots as it is practically impossible to take samples from all areas due to logistical considerations. The data collection spots have been selected based on their relative high potential to attract app-assisted taxi trips compared with other locations in the city. 384 valid responses have been selected to be included in the research as this is calculated to be the appropriate number using the cochran expression for situations where the actual population number is not known.

1.6 Significance of the Study

There are different studies being undertaken in different countries regarding Application-assisted taxi service having their own significances. This research which we have undertaken have great impact regarding urban transport mobility issues in Addis Ababa. It is clear fact that there is a

critical transport service problem in the capital which is characterized by large queues, high traffic congestion and poor transport infrastructure. As the city transport Authority is now making an effort to solve these problems in a sustainable manner, the effect of introduction of new services need be analyzed which otherwise should not at least introduce additional problems to the already struggling system.

The introduction of Application-Assisted taxi service will have its own positive and negative drawbacks which was shown in different literature's (Graehler et al., 2019; Young & Farber, 2019; Guo et al., 2019; Barnes et al., 2020). It is also shown that those effects are context specific (Acheampong et al., 2020; Moody & Zhao, 2020).Among the effect that those transport service have on urban transportation, their effect on the mode choice behavior have been cited in the scant literature that we have in this area.

Hence this research will try to show the effect those transport service have on the transport system:-especially to the modal shift in Addis Ababa by investigating the travel characteristics of individuals using this service. The research finding will come as a useful tool as a reference to device regulatory and policy issues needed to be implemented by the concerned Authority.

1.7 Thesis Structure

The thesis is structured as follows. The Introductory part which includes the study Background, problem statement, research question, the general and specific objective, study scope and its significance constitutes Chapter one. In chapter 2 relevant literatures have been reviewed in order to make us have an understanding of the available knowledge around the research topic and form a frame work needed for our study.

The Methodology part which is presented in chapter 3 of this study outlines the way the study has been conducted by illustrating the study area, data sample size determination procedure, the sampling method and the Analysis procedure utilized along with questionnaire development and data collection procedure.

In chapter 4 the result of the study along with the discussions have been presented. Appropriate Graphical and tabular presentations along with tables for the model developed is shown to present the result in order to make a better visualization on the output of the study. The last section of the

document which contains the conclusion, recommendation made and future research direction is presented in chapter 5 of the research paper and concludes our findings by attaching it with the objectives we set in the introductory part.

2.0 Literature Review

2.1 Introduction

According to Bashir et al.(2016,p.49),“Taxis are an important constituent of the public transport system in an economy, and their importance in providing comfortable and flexible services to customers cannot be ruled out”.

The century we are living in has revolutionized the way things are done due to the advancement of Technology. It could be seen that almost all sectors has become dependent on technology for the efficient delivery of their services. Application-assisted taxi service in big capital cities is among those sectors which has made progress in this respect.

The main reason for the introduction of this type of transport mode is the high demand for mobility needs in those large cities. Addis Ababa is one of those cities which recently has embraced an app-assisted taxi service introduced with car sharing schemes by mobility as a service providers which attempt to provide a modernized transport that is characterized by a reliable, fast, safe and affordable service.

This literature review is compiled to show how Application-assisted taxi transport has begun and its development with its main actors , related concerning issues, the main factors which contribute to the shift to application based transport service of different mode users and modelling technique to be employed.





2.2 The Development of on Demand transport Service and related concerning issues

Taxi service that utilizes application for ride booking has been known to be the result of recent innovations which is changing the travel behaviors of residents in urban cities across the world dating only a decade time. It was first started by Uber in year 2009 in California, North America. Since then Uber has progressively expanded in to different service segments, like the Uber X and Uber pool which provide different services for particular market segments.

At present this technology has been labeled to be the most disruptive in the transportation industry. Eisenmeier (2018) explained that after its establishment in 2009, Uber has made a steady progress and served 75 million riders in 600 cities in the world.

The following table shows some statistics for major App-assisted taxi service providers in the world (*Uber vs Lyft vs Grab vs Didi Chuxing*).

TABLE 2-1:- STATISTICS FOR MAJOR APP-ASSISTED TAXI SERVICE PROVIDERS. ADOPTED FROM BUSINESS OF APPS .[HTTPS://WWW.BUSINESSOFAPPS.COM/DATA/UBER-STATISTICS](https://www.businessofapps.com/data/uber-statistics)

				
Area of operation	600 cities in 65 countries worldwide	300 US cities, 2 Canadian	Southeast Asia	400 Chinese cities, Brazil, Japan, Mexico, Australia, Hong Kong, Taiwan
Launched	March 2009	June 2012	June 2012	June 2012
Headquarters	San Francisco, US	San Francisco, US	Singapore	Beijing, China
Users	75 million	23 million	36 million	550 million
Drivers	3.9 million	1.4 million	2.6 million (all time)	21 million
Rides per day	14 million	1 million	4 million	30 million
Total trips	10 billion	1 billion	2.5 billion	7.4 billion in 2017
Revenue	\$65 billion (gross), \$14.1 billion (net)	\$3.6 billion (2019)	\$2.8 billion (2019 estimate)	\$10.9 billion (2017 estimate)
Valuation/market cap	\$72 billion (investment round, August 2018) \$82.2 billion (IPO, May 2019) \$56.5 billion (July 2020)	\$15.1 billion (investment round, June 2018) \$26.6 billion (IPO, March 2019) \$8.6 billion (July 2020)	\$14 billion	\$56 billion

As can be seen from the table above, Uber have been valued to be over \$ 56.5 Billion and is serving over 14 million trips per day on average. Since the establishment of Uber, many companies has come to the scene and involved in this kind of transportation service. Lyft and SideCar has emerged in the American app-assisted service shortly after uber. Whlie Uber reported a net revenue of \$14.1 Billion in 2019, its closest rival Lyft has reported 3.6 billion dollars in the same year indicating Uber’s high market share over lyft.

Didi Chuxing which was founded in 2012 is the widely utilized app-assisted transport service provider which operates in most China cities. The company is valued \$ 56 Billion and it serves in different type of service segments like Hitching and express pool services. Grab is the major app-assisted transport service provider in Southeast Asia.

Application-assisted transport services are also becoming prevalent in most of the African capital cities in the recent time. In Gana, in addition to Uber, Bolt is a well-known Estonia based app-assisted on demand taxi service provider platform (Acheampong et al., 2020). Other countries in Africa that Uber operates include South Africa, Kenya, Egypt, Morocco, Nigeria, Tanzania and Uganda (Mourdoukoutas, 2021).

Many local technology based Taxi service providers are now operating in African major cities which are competing fiercely with themselves and those that came abroad. “The ease of use, short waiting time, provision of door-to-door service, and often reduced travel cost compared to the traditional modes have fueled the rapid growth of ERS.”(Shen et al., 2020).

Contreras and Paz (2018, p.2) explained that “With the observed growing popularity, in conjunction with the continuous exponential evolution of ride-hailing services across the nation, it is vital for transportation agencies and policy makers alike to fully understand, from all angles, the observed effects and implications to the transport system as a result of newly added operators” In order to have a brief understanding on these issues, some of the positive and negative effects associated with the utilization of on demand transport service as investigated by different researchers are described below.

One of the main issues that is the concern of most researchers on app-assisted taxi service is the impact it poses to the public transport. Among the impacts it has on public transport the substitutive / complementary effect is seen to be the crucial one. It is the concern of transport planners to promote transport operation in a sustainable manner in urban areas where there are different modes operating. In this regard the most feasible modes are Rail Transit, Bus Rapid Transit and other transport modes which operate on the concept of serving large number of passengers at a time. Hence understanding the substitutive vs. complementary effects of app. Assisted taxi service on feasible transport modes is a mandatory as it is believed it will attract some trips from them.

Tang et al.(2020) have found that the shift from traditional Taxi to application based taxi services amounts to 35 % the total shift which explains the competitive relations that exist between those modes. On the Other hand the share of shift that comes from public transport (Busses and Metro) to app based taxies is found to be 37% which showed the needed improvement in the public transport system in order for their service to go in balance.

Tirachini & Gomez-Lobo (2020) explained that recent data from different researches showed a complementary effect of ride hailing is less than its substitution effect for public transport.

In addition : Henao and Marshall (2019) made a note that mode substitution rates from sustainable modes of transport to be significantly higher for ride hailing passengers that did not own a car as their research indicated that 34.1 % of the passengers would have used a transit, walked or bicycled.

Moreover de Souza Silva et al.(2018, para.4),added “it is possible that the entry of ride-hailing companies would increase the deterioration of sustainable urban mobility from the point of view of capturing the demand for public transportation and transferring it to individual ones, which generates several negative externalities”.

On the other hand Moody & Zhao (2020,p.1) showed that the substitutive effect of TNC on different modes are not same for all contexts as their research indicated that “while TNC trips in the U.S. primarily induce additional trips or replace trips by public and non-motorized transport, in Singapore they primarily replace personal/private vehicle trips”

Traffic congestion is another major problem in big metropolitan cities witch comes as a result of the transport operation. Every effort to make the transport operations efficient by making a good transport system should not result to increase the traffic congestion in urban streets. Hence it is mandatory to look at the effects on traffic congestion of the provision of new modes which are disrupting the transport system and will continue to do so in the future. Different studies are being made in different countries to quantify the effects that app-assisted taxi service has on traffic congestion. The result of those studies are indicating conflicting results as some of them say that their provision will increase traffic congestion while others provide results that show its reduction.

According to Erhardt et al.(2019, p.1), “TNCs are the biggest contributor to growing traffic congestion in San Francisco. Between 2010 and 2016, weekday vehicle hours of delay increased by 62% compared to 22% in a counterfactual 2016 scenario without TNCs”. Tirachini (2020)

further showed an increment in congestion is recorded in different cities due to app-hailing taxi utilization.

Li et al. (2016) utilized a difference in difference technique in order to explore the impact that Uber transport service have on traffic congestion in different US urban cities and found contrary result that traffic congestion have reduced after Uber entry implying that the utilization of TNCs in urban areas reduce traffic congestion. This indicates that there is a need to make investigation on the traffic congestion effects of the utilization of application-assisted taxi service in other contexts.

The possession of Vehicles as a means to ease transport operation in urban areas is becoming one of the main challenges to a sustainable transport. This is because having a vehicle on a personal basis (SOV) have many negative externalities as opposed to its positive effect on Mobility. Among the main problems: the congestion on streets especially at peak traffic hours is seen to be the major one. Air pollution which comes as the result of the gas emissions is the other one. As a result transport planning operations are looking for ways to reduce Vehicle ownership in an attempt to maintain the sustainability of the transport system.

The introduction of Application-assisted Taxi service is shown to have relations with vehicle ownership in different literatures. Some studies show that using an app-assisted services reduces car ownership. According to Henao and Marshall (2019,p.20),“Ride-hailing passengers tended to have lower car ownership rates than average. Those that did not own a car tended to use ride-hailing services more frequently but for shorter trips.” Tang et al. (2020) have also made a research on major china cities and found that the presence of app-assisted taxi service in future scenario of more severe traffic condition could make passengers to reconsider and abandon their car purchasing interests. They have found that more than 50 % of passengers that use app-assisted taxi service will change their interest to purchase car while 6.6% of passengers confirmed not to purchase new car.

Clewlow, Regina R. Mishra (2017) On the Other hand made a research in major cities of US and reported contrary result that ride hailing users do not possess a significant amount of fewer vehicles than the rest of the population and expressed the needed investigation of factors related to socioeconomic, attitude and environmental characteristics that could influence those decisions over the long term.

One of the many questions that are raised due to the introduction of app-assisted taxi service is their influence on the Vehicle Miles Travel (VMT). Transport policy makers are in deep concern to find ways in which the VMT be reduced to mitigate problems related with Congestion, Environmental pollution and reduction of traffic accident as the VMT has a direct relationship with those negative externalities associated with the provision of a transport service.

In relation with this different studies produce different results. Henao and Marshall (2019) used a quasi-natural experiment analysis technique on a survey of 416-ride hailing trips in the Denver, Colorado and got results that show an increase of the VMT by 83.5 % on the system taking in to account the deadheading's, travel induced and substitution of more sustainable modes.

Tirachini and Gomez-Lobo (2020) on the other hand undertaken a survey on Uber use by residents in Santiago, Chile and used a monte-carlo simulation technique in order to assess the effect of app – assisted taxi service on VMT. The result of their study indicates that VMT depends on Vehicle occupancy rate and unless this occupancy is increased for trips made by app-assisted taxi services, the effect it will have is an increase on VMT.

2.3 Application-Assisted Taxi Service in Addis Ababa.

It has been indicated that the high mobility needs of residents in urban areas is the driver to the existence of App-assisted taxi service and its wide adoption. At this point, it is good to look at the prevailing transport service in the city briefly in order to have an idea about the extent to which the mobility needs are being served by different service segments.

In this regard, the public transport consisting of bus and minibuses took the major proportion which serve about 46 % of trips according to the last modal split assessment done in 2006 (Clélie Nallet, 2018). As of walking and private transport, the same assessment showed that they account for 45 and 9 percent of the trips undertaken.

The bus transport which was started in year 1943 by the well-known Anbesa city bus embarrasses 700 busses under it which carry 600,000 passengers per day (Clélie Nallet, 2018). She also reported the waiting time for the busses to be 40 minute with an average travel speed of 15 km/hr that operates 45 minutes for the average travel time taken by a passenger. The same report showed Private busses services begun operation in 2009 and busses that are aimed at transporting public servant's to their work place and back to home meet the scene in year 2012 which also serves the

city dwellers on the remaining time of the day and has been accompanied by the introduction of the sheger bus in year 2016 that has increased the operation of the bus transport.

Clélie Nallet (2018) further showed the minibus taxi which was introduced 50 years ago undertakes 840,000 journeys a day with its 10,500 taxis in the capital. She explained the high expansion rate of the city owing to the economic transformation initiated by the city development plan in 2003 has resulted in the high increase to the mobility needs in the capital and resulted in the conception of LRT project to come to existence. Accordingly the project was implemented and the two lines which are the East-West and North-South having a total length of 34 km have come to operation in year 2015. There are 39 station which are used to take and drop passengers and the capacity of one tram is reported to be 317 passengers on average with the daily uptake estimated at 11000-15000 passengers according to the ERC.

Despite all those efforts, the transport service rendered has hardly met the high demand prevalent exemplified by the large queues and long waiting times especially on peak hour time which has made the door open to accommodate other transport service to satisfy these demands and hence resulted in the existence of on demand transport service.

The introduction of app-assisted taxi service in Addis Ababa first begun when Zayride started its operation in year 2016 (Aga, n.d.). He also described “Ride” transport service has then announced its launching of the application- assisted taxi service in the city which has first started ride booking service using text messaging and call center service before the application based service begun .

At present, there are many application-assisted taxi services in Addis Ababa among which Ride , Zay Ride,ETTA, Zelucy ,pick pick, Taxiye, Feres, Hello, Segerela, Catche are the once that are actively operating and it is expected that many other types will emerge as competition among this transport service sector is becoming noticeable. “Ride” transport is the major app-assisted taxi transport service provider at present.

Private car owners are provided the opportunity to get registered after having made trade registration which requires there plate be changed from number 2 code to that of number 3 which establishes the base to sign a contract with the respective companies that provide those services. One exception to the service provision is seen on Seregela taxi service where only women’s are employed as drivers of the company vehicles for a salary.

Some service providers have differentiated their services to different market segments. In this regard the establishment of Hello taxi service as a taxi service provider that gives service only for tourists could be mentioned.

There have been a fierce dispute between these service providers and the city transport Authority owing to regulatory issues in the public transport sector. While the Transport Authority demands those taxis services need be registered under the regulation for plate number 1 Taxies in order to be considered as a public taxies, the TNC however claim that they could do it with the plate number 3 that can establish the legal ground for them to work under the ministry of trade regulations as a rental vehicle for transporting peoples and goods. This issue has been sent to the court and remained under scrutiny for long time.

Although it is prevalent that those transport services are serving a good share of trips in a day, data on the number of trips they carry and the revenues they got is not disclosed at present due in part to their unwillingness to disclose those information for the company's privacy protection. It could easily be hypothesized from the high increase in this transport service and the on demand taxi hailing type of service being provided by them that they will definitely affect the travel mode choice behavior of residents in the city.

In order to get those transport service, one has to first download the application from app. store on the smart phone or use the call center. After a request is made to a specific ride service using one of the two mentioned ways, the taxi will arrive to the requested location and picks the passenger to the destination location requested. The payment is made according to the travelled distance which is measured in kilometer basis. The fare for the kilometer travel has been fixed by the respective transport operator. This has made their operation to be simpler as passengers know the cost they will incur in advance and make a choice irrespective of the involvement of getting in to negotiation with drivers which is the usual case with the traditional Taxies.

It is worth mentioning that Blue lada taxies are the traditional taxi service provider in the city for long period of time before this kind of service begun. some lada taxi service providers argue that the modern app.based taxi service which are equipped with the necessary technology is taking their work and they are frustrated about the future of their work while others say it is good to engage with new technology for a better service provision and are making an effort to switch to

the modern once. Following are some pictures of the modern and the conventional (Traditional) taxis in the city.



FIGURE2- 1:MODERN TAXIES IN ADDIS ABABA (SOURCE GOOGLE IMAGE)



FIGURE 2-2: CONVENTIONAL LADA TAXI IN ADDIS ABABA (SOURCE –GOOGLE IMAGE)

2.4 Factors that affect shift to Application-Assisted Taxi service.

Identification of the relevant factors that have an impact on the passenger behavior to make a shift to app-assisted taxi service in order to undertake their activities is the main task which affects the results of the study. The model fitness that we develop highly depends on the explanatory level of the variables included in its formulation. Hence a curious review need be done in order to select the most important variables that could make us answer the research question we are interested to solve.

Most of the studies that are undertaken in this area focuses on the determinant's to the adoption of ride hailing services which directly doesn't show which of the variables are responsible for the modal shift from any specific travel mode that operates prior to the arrival of on demand app-assisted taxi service. However, these studies tell what passengers value most while selecting those travel modes which also means that those are the causes for replacing the trips that were undertaken by other modes before the app-assisted taxi service begun operating which could serve as an indicator of the modal shift. Hence in this review we will also look at the variables that passenger's value most while adopting app-assisted taxi service in addition to the specific once which influence the modal shift described in the scant literature found on the topic under consideration.

According to Rayle et.al.(2014,p.18), "ride sourcing meets a latent demand for urban travel, appealing to generally younger, well-educated users looking for short wait times and fast point-to point service, while avoiding the inconveniences of driving like parking and having to drink and drive"

Tang et al. (2019) showed factors that affect the choice to shift to application based transport service of residents is highly related to **house hold income** and **House hold types**. In addition they have found that **taxi** and **short distance private car travelers** and **those people who live in places where there is no a much developed metro system** are the one who are most likely to shift to the application based taxi services indicating that variables related to **trip distance**, **the frequent mode used** and **residential place characteristic's** to have an effect on the modal shift.

Etminani-Ghasrodashti & Hamidi (2019) on the other hand has found that those individuals that doesn't own a car and who choose semipublic transit are the once which adopt ride hailing frequently indicating variable related to the most frequent mode used to have an effect on the

modal shift. In addition, they found that passengers' attitudinal variables such as **trip security, time efficiency and cost effectiveness** have a significant effect on the propensity of app-assisted taxi service and hence on the modal shift. They also reported that socioeconomic variables and the distance from the passenger's home to the nearest public transport station have an effect on the app-assisted taxi service utilization. Accordingly, **women's, passengers with high income, those with high education level and living at distant location from public transport station** are reported to be the significant ones who used this service, while those with **large household size** are related negatively with the utilization of app-assisted taxi service.

Zhang et al. (2016) has done a study in Beijing that compared the preference between tailored taxi and traditional taxis using a binary logit model and has found that the variables age, income level, Education level, convenience, Trip Purpose and safety insurance have significant impact on the choice between the two modes. **Commuting trip** is also reported to be the significant one in their research, which was described to have a positive relationship with the propensity of app-assisted taxi service, as opposed to other research findings that reported social related trips like travelling to the **restaurants and recreational trips** to be the prevalent ones that are undertaken by app-assisted taxi service (Guo et al., 2019). Hence, this calls for more research on the effect of trip purpose on application-assisted taxi utilization.

According to Shamshiripour et al. (2020), the presence of **Covid 19** has made a change in travel behavior of passengers and showed that travels that were once undertaken by Airplane mode are substituted by personal vehicles and described the risk of sharing of space as the main reason to abandon using the airplane travel mode. Analysis of the effects of Covid 19 on mode shift in urban transport has not been done yet, probably due to its prevalence being not too long. It is fair to assume that there will be a modal shift from transport services that accommodate many passengers to app-assisted taxi service due to the prevalence of Covid 19, since the risk of exposure on the latter mode is low as compared to the public transport one.

Among the researches done in Africa regarding the identification of the utilization factors of app-assisted taxi service, Acheampong et al. (2020) have shown in the Ghanaian context that **Travel distance, Trip purpose and Trip location** had a significant effect.

Moreover, Dias et al. (2017) has found that **Employment status, car ownership rates and Development Density** are the ones that have the highest effect on the utility of those technology-based transport services. They also showed **Lack of Parking space and avoiding drinking while**

driving are the top reason's for replacing driving a car by an app-assisted taxi service. In addition they found that those people who live in **city centers** use ride hailing more often than those who live in the suburbs indicating factor related to **living area** to be an indicator to their utilization levels. It is seen in the same report that the reasons people replace app-assisted taxi service for transit are:- **the lack of available stops, traveling at times when transit services are not available, and perceived unreliability of transit services**

Giddy (2019) has done a study in south Africa and found that the utilization of Uber as a substitute to other taxi service is mainly due to the **safety features** it has like the background check, transaction's that are cashless, tracking of the trips and the affordability it provides. They also stated replacing driving personal car with Uber is associated with **avoiding driving while drunk**. Another study done which has tried to investigate the factors to the adoption of ATTS and FFBS has revealed that Travel purpose variables such as **entertainment** and **business** and that related to **trip distance** are significant to the adoption of ATTS (Du et al., 2019).

The impact of socioeconomic status has been put forward on a research done in Bogota by Oviedo et al. (2020) witch indicated that those transferred trips from the public transport to TNC are characterized with passengers who are at **middle Income levels**. It was shown on the same report that trip distance that lies in the range between 6-12 km took the highest proportion among those replaced trips from public transport confirming the effect of the trip distance attribute on mode shift.

Tarabay and Abou-Zeid (2020) on the other hand on their study to the determinant's to the switching choice to app. Assisted taxi service (i.e Uber)for the Social/recreational trip in lebanon has found that waiting time for ride sourcing pick up, in door to door travel time, travel fare and distance are significant once. In addition they verified that conventional taxi service took the highest proportion in relation to the shifting choice and short distance travels are the most replaced. They also found Constrained driving condition when collaborated with a reduced app -assisted fares have a significant effect on car users to make a switching choice to the ride sourcing transport service.

The built environment and Residential density variables have been tested to have significant relationship with the propensity of app-assisted taxi service on a research done in major American cities (Conway et al., 2018) . It was also shown on the same report that the number of vehicles

owned by a house hold has a negative relationship indicating those households having more vehicles make less utilization of app-hailing service.

In accordance with the reviewed literature and making contextual transport considerations, the following variables are selected as major indicators for the modal shift and need be considered in our case.

1. Age
2. Gender
3. Educational status
4. Income level
5. Utilization reasons....
6. Travel purpose

2.5 Transport Mode Choice Behavior and Mode Choice Modelling

2.5.1 The planning concern

One of the main questions that researchers opt to answer in the transportation sector is how the choice of transport modes is affected and what the determinants to this choice are. The interest to device those questions raised on the notion that mode choice behavior in urban areas have great effect on the transport system and its Sustainability.

Transport planners and policy makers tempt to advocate the Utilization of Public transport modes by city residents in order to solve problems related to Traffic congestion, Environmental Pollution and Traffic accidents which in most situations have been reported to be the result of poor Transport system operations. Hence a need arises to know modal choice behavior of city residents in order to influence decision behaviors for utilizing more sustainable transport mode.

In order to do so, transport planners make use of different modelling techniques for charactering the significant factors that affect those choices and make decisions that will take care of the most significant factors influence on the choice of sustainable public transport modes.

The most widely used mode choice model that is being used along a spectrum of research question in this area is the Discrete Mode choice Model. Aloulou (2018) indicated that a prediction can be made of the probability of choosing a specific mode from a set of alternatives using discrete choice models.

Different variables are selected based on an extensive review of the state of art literature which are to be used while modeling mode choice behavior using discrete choice model.

2.5.2 Mode choice Behavior and Utility Function

Specific travel Mode choice by an individual traveler is governed by the **Utility** that he /she get by deciding to choose this mode from a set of Alternative travel modes in the market place. This Utility is seen to result from the characteristics of the traveler and the mode chosen. As described in the previous section, the socio- economic and travel mode characteristics are the main elements that leads to the choice of one mode over another.

Utility functions are defined in order to quantify the benefits that particular travel mode yields to the traveler who chooses that mode. This is essential to the modal Analysis as it will yield the basics up on which comparative assessment of the utilization of different modes by a particular traveler is made. The individual will make a decision that maximizes this Utility.

Two different concepts are applied while defining a utility function one of which is the deterministic while the other is the probabilistic. The deterministic utility maximization relies on a notion that the decision to choose a particular mode from a set of travel modes by a particular traveler is certain in a sense that he /she will choose the alternative that is ranked the highest among the available modes. Koppleman and Chandra(2006) On the other hand described being unable to fully know the decision process of a traveler owing to non-realistic possibility of getting the required information has resulted in the evolution of probabilistic choice theory.

Difference in the value estimated by the Analyst and the traveler on the utility value describes the probability predictions of the analyst.

Al-Salih & Esztergár-Kiss (2021) represented this difference using the following expression.

$$U_{it} = V_{it} + \epsilon_{it}$$

Where U_{it} is the actual utility to the decision maker of utilizing mode i . V_{it} explains the utility as calculated by the analyst which is observable to him.

The error term ϵ_{it} shows the random error which comes as a result of the utility that the analyst is unable to observe. This error term is represented as a random variable in order to show the total error which comes as a sum of the error from many sources.

The deterministic portion of the above expression i.e V_{it} composes the following components.

$$V_{it} = (S_t) + V(X_i) + V(S_t, X_i)$$

Where, V_{it} is the deterministic portion of utility of mode i for trip maker t ,

(S_t) explains the utility related to the trip maker characteristic

(X_i) explains the utility related to the travel mode characteristics

(S_t, i) explains the utility related to the interactions between the characteristics of trip maker t and mode i .

2.5.3 Mode choice modelling techniques

Transportation problems that are being addressed by researchers in this field are usually complex in nature and require a modelling approach that best suit the specific problem. Different modelling approaches have been devised and put forward by professionals in order to solve different type of problems encountered. Hence a need arises to select the best modelling approach by making a comparison of the available once that can be used to solve the problem at hand.

With respect to mode choice modelling, the state of art available approaches are put forward here under with their merits and demerits as a base to make a comparison between them and select the best one to be used in our situation.

1:- Multinomial Logit Modelling

“ Multinomial logistic regression is used to predict categorical placement in or the probability of category membership on a dependent variable based on multiple independent variables” (Kwak & Clayton-Matthews, 2002). The independent variables can be binary, continuous, nominal or ordinal in nature.

The error terms for the unobserved utility are assumed to have a Gumbel distribution.

Koppleman and Chandra (2006) described the advantages to Gumbel distribution of the error terms in multinomial logit model has made it to be the most widely used discrete choice model.

Those advantages are:-

- i. gumbel distribution has computational advantages in a context where maximization is important.
- ii. It closely approximates the normal distribution as can be seen in Figures 3 and 4
- iii. It produces closed form probabilistic choice model; for which the probability can be calculated without the use of numerical integration or simulation method.

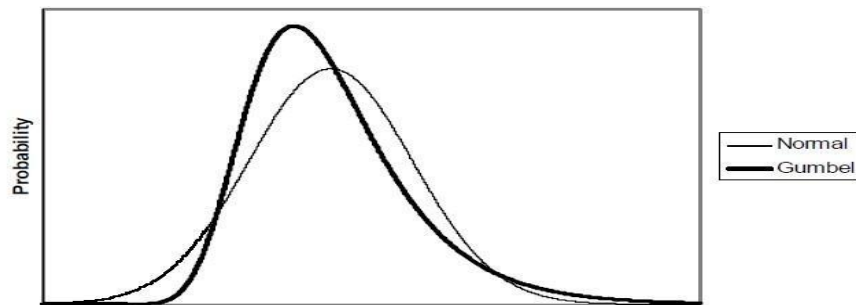


FIGURE 2-3: PROBABILITY DENSITY FUNCTION FOR GUMBEL AND NORMAL DISTRIBUTIONS

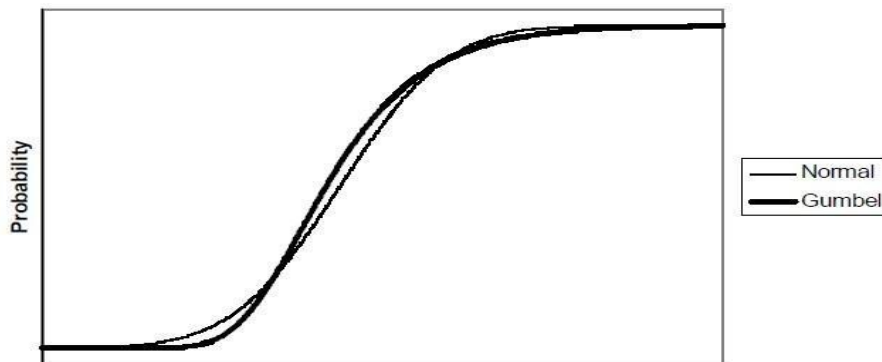


FIGURE 2-4: CUMULATIVE DISTRIBUTION FUNCTION FOR GUMBEL AND NORMAL DISTRIBUTION

The logit expression derived from the probability density functions which is used to express the probability of choosing a particular mode over a set of available alternatives takes the following form

$$P_{ij} = \frac{e^{U_{ij}}}{\sum_j e^{U_{ij}}}$$

Where P_{ij} is the probability of the decision-maker i choosing alternative j

U_{ij} is the systematic component of the utility of alternative j .

The utility function as has been defined in the previous section is composed of the variables related to the mode and the traveler. The coefficients to each of the variables is determined by running the model after a representative data is gathered and processed in the model specified. The error term in MNL model are independently and identically distributed with the Type -1 extreme value distribution.

Kwak and Clayton-Matthews (2002) described MNL model takes on an assumption that choosing a mode in one category will not have an effect on the choice of a mode in other category. In this assumption which usually stated as Independence of irrelevant alternatives (IIA), when any two alternatives have a non- zero probability to be chosen, the presence or absence of any additional alternative does not have an effect on ratio of one probability over the other. This has been cited as the advantage of multinomial logit model which makes the model computation to be simpler. Based on this assumption any new alternative can be treated easily. However, there are many situations under which this assumptions could not hold to be true which the main disadvantage of the MN model is.

The red/ blue Bus paradox is one of them and is best described by the following example.

Suppose we have three equally distributed transportation categories:

Blue bus (P=33%), Red bus (P=33%), Car (P=33%)

If we paint the red Buses Blue, We then have two choices.

Hence with the Assumption of IIA, (i.e in order for the probability ratio of car over blue Bus not to change)

We should have: Blue bus (P=50%), Car (P=50%).

But, the more likely actual distribution would be

Blue bus (P=66%), Car (P=33%).

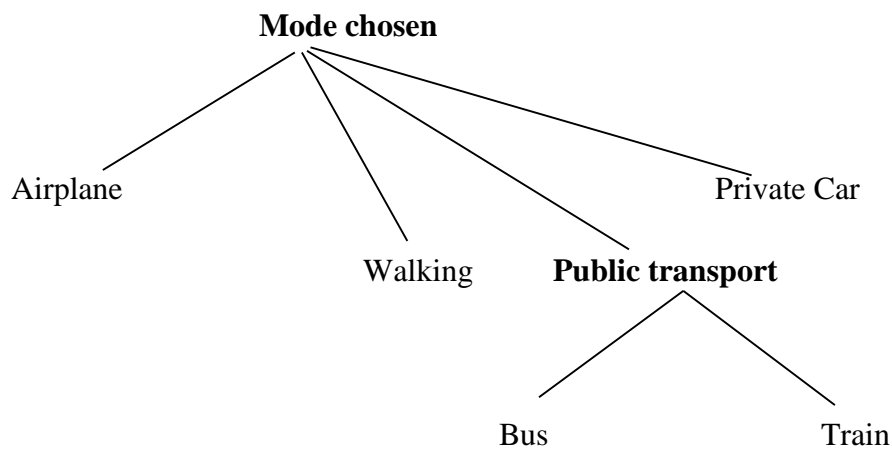
Hence the presence of correlated alternative like the Red/Blue busses could make MNL model to fail (Gallego & Li, 2017).

2:- Nested logit Models

According to Hensher & Greene (2002, p.1) “The appeal of the nested logit model is its ability to accommodate differential degrees of interdependence ,i.e., similarity) between subsets of alternatives in a choice set” .In this technique a structure consisting of different nests is formulated in order to group those choices which resemble similar properties under one nest.

Nested logit model technique could best be explained by those cases where there appears a need to model choice situation containing modes which exhibit similar characteristics like Train and Bus modes.

In order to cater the possible correlation that exists between these modes, we will include them under a nest that treats both mode as a public transport. A modelling structure containing two levels will be developed as shown below. Then two different choice models will be developed incorporating the modes in the first structure (Airplane, walking, public transport, private car) and that are contained in the public transport (Bus and train)



The algorithm implemented in the model gives different scaling factor for the choices under the **mode chosen** and the **public transport**. This will solve the limitations of IIA which can occur in MNL models and these alternatives can be treated independently using the nested modelling technique explained.

3:- Binary logit models

This is a logistic regression modelling method of a dependent dummy variable whose outcome assumes two values as a function of different independent variables which can be continuous, categorical, ordinal or binary in nature. This modeling method has great application in transportation studies where there is one discrete dependent variable which is dummy in nature and other independent variables which can take any of the form described before. An example of a choice model that could be modelled using this technique is those choice situations where we have only two modes to choose from.

The Binary logistic regression estimates the probability that a characteristic is present (e.g. estimate probability of "success") given the values of explanatory variables, in this case a single categorical variable; $\pi = Pr(Y = 1|X = x)$.

- Let Y be a binary response variable

$Y_i = 1$ if the trait is present in observation i

$Y_i = 0$ if the trait is NOT present in observation i

- $X = (X_1, X_2, \dots, X_k)$ be a set of explanatory variables which can be discrete, continuous, or a combination. X_i is the observed value of the explanatory variables for observation i .

The binary logit takes the following probability expression

$$\pi_i = Pr(Y_i=1|X_i=x_i) = \frac{\exp(\beta_0 + \beta_1 X_i)}{1 + \exp(\beta_0 + \beta_1 X_i)}$$

$$\text{logit}(\pi_i) = \beta_0 + \beta_1 X_{i1} + \dots + \beta_k X_{ik}$$

Assumptions: Harrell (2015) described that the assumptions in the logistic model is only on the form of the equation as they are probability models

Following are the assumptions which are considered in constructing binary logit model

- The data Y_1, Y_2, \dots, Y_n are independently distributed, i.e., cases are independent.
- Distribution of Y_i is *Bin* (n_i, π_i), i.e., binary logistic regression model assumes binomial distribution of the response. The dependent variable does NOT need to be normally distributed, but it typically assumes a distribution from an exponential family (e.g. binomial, Poisson, multinomial, normal,)
- Does NOT assume a linear relationship between the dependent variable and the independent variables, but it does assume linear relationship between the logit of the response and the explanatory variables; $\text{logit}(\pi) = \beta_0 + \beta X$.
- Independent (explanatory) variables can be even the power terms or some other nonlinear transformations of the original independent variables.
- Errors need to be independent but NOT normally distributed.

- The homogeneity of variance does NOT need to be satisfied. In actual situations, it is not even possible in many cases with this model structure.
- It uses maximum likelihood estimation (MLE) rather than ordinary least squares (OLS) to estimate the parameters, and thus relies on large-sample approximations.

Parameter Estimation: Parameter estimation is done by maximizing the likelihood function in the model.

4:- Multinomial Probit model

Multinomial probit modelling is another technique that can be used to model mode choice situations in which the dependent variables consists of choices which are usually above two in number as a function of independent variables which are continuous, nominal ,Binary and ordinal in nature. The difference between MNL and MNP models has come as a result of the assumption taken on the error terms that account for the unobserved utilities of the different Choices in the utility function. The functional form in the utility function for both Models takes similar structure.

In the MNL model the error terms are not correlated across different choices and the assumption of IIA is a mandatory while in MNP modelling technique the error terms are allowed to be correlated and the assumption of IIA is not required. This property of MNP is cited as its advantage over MNL which could make it useful to model choice situations where the IIA assumption is not satisfied. The error terms are distributed by a multivariate normal distribution each error having a mean value of 0 and being correlated.

Kropko (2008) showed the inclusion of the correlated error term which came as a result of the formulation of MNP modelling technique has resulted in a joint probability density function that required the implementation of rigorous algorisms and high capacity computers in order to estimate the model specified. He further described that as the number of choices increases, the complexity of probability choices will be very high and recommended its use in situations when the choice set are few in number which could be cited as the model disadvantages.

It is explained in different scholars that the choice between MNL and MNP is a matter of choice of one of the two especially when the choice set are few in number and it doesn't as such produce results that differ that could lead to different interpretation of the significant variables.

5:- Conditional Logit models

The MNL and MNP modelling techniques that have been described before do good in situations where the value of explanatory variables that are used in the model specification does not change across choices. However there appears situations under which the value of the variables change across alternatives. The conditional Logit model have been devised to cater for those situations. The expression for the utility function in this model type takes the following form.

$$U_{ij} = \gamma z_{ij} + \varepsilon_{ij}$$

Where, z_{ij} is the explanatory variable that varies across choices,

γ is the coefficient for the explanatory variable .

Note that γ is fixed across choices. It is assumed in this model structure that those variables which have different value for each choice have the same effect across the different choices (Kropko, 2008). Example of variable of this kind are cost and travel time of a transport mode where the increase of the value of this variables decreases the choice of all type of modes indicating the similar effect those variables have on the choice of different modes.

6:- Hybrid Logit Models.

The variation in the value of the explanatory variable across the different choices has brought about the conditional modelling technique described before. However the assumption that those variables which take different values have similar effect across choices is not valid in cases where the independent variable has different effects across choices as in MNL (Kropko, 2008). Hence a need arises for a modelling technique that could account for both variations that would be used for both type of variables on situations where this condition appears. Hybrid logit models are there to account for these situations. The utility function in this case takes the following form

$$U_{ij} = \beta_j x_i + \gamma z_{ij} + \varepsilon_{ij}$$

It is evident to see that this expression considers both situations at once.

7:- Simulation techniques

Dell'Orco and Ottomanelli (2012) has described that transportation and traffic problems which are characterized by an ambiguous, subject and being uncertain to get information regarding the variables used in the modelling task demanded a more accurate way to refine the modelling task.

In this regard simulation techniques have been proposed as a means to model passenger's behavior by expressing user's decision process with approximate or linguistic values which are similar to human reasoning while they undertake the specific choice. Decision rules for selecting a specific mode among the available once are established to simulate travelers choice using IF.....THEN statements. The utility calculation to the user in this case is not similar to the classical random utility models expressed before. Instead methods like Fuzzy Inference system (FIS) are used for mode preference which simulates the reasoning that users undertake to compare between transport modes.

ANN (Artificial Neural Network) tools which can learn and simulate the real behavior are currently used along with the FIS to specify a Neuro Fuzzy model. Iterations are performed incorporating different variables in order to simulate and get the more appropriate model that fits the situation to be described. The model requires high capacity computers and a higher processing time which is described as its disadvantages. The following figure shows the tree established to simulate passengers choice behavior in accordance with the FIS.

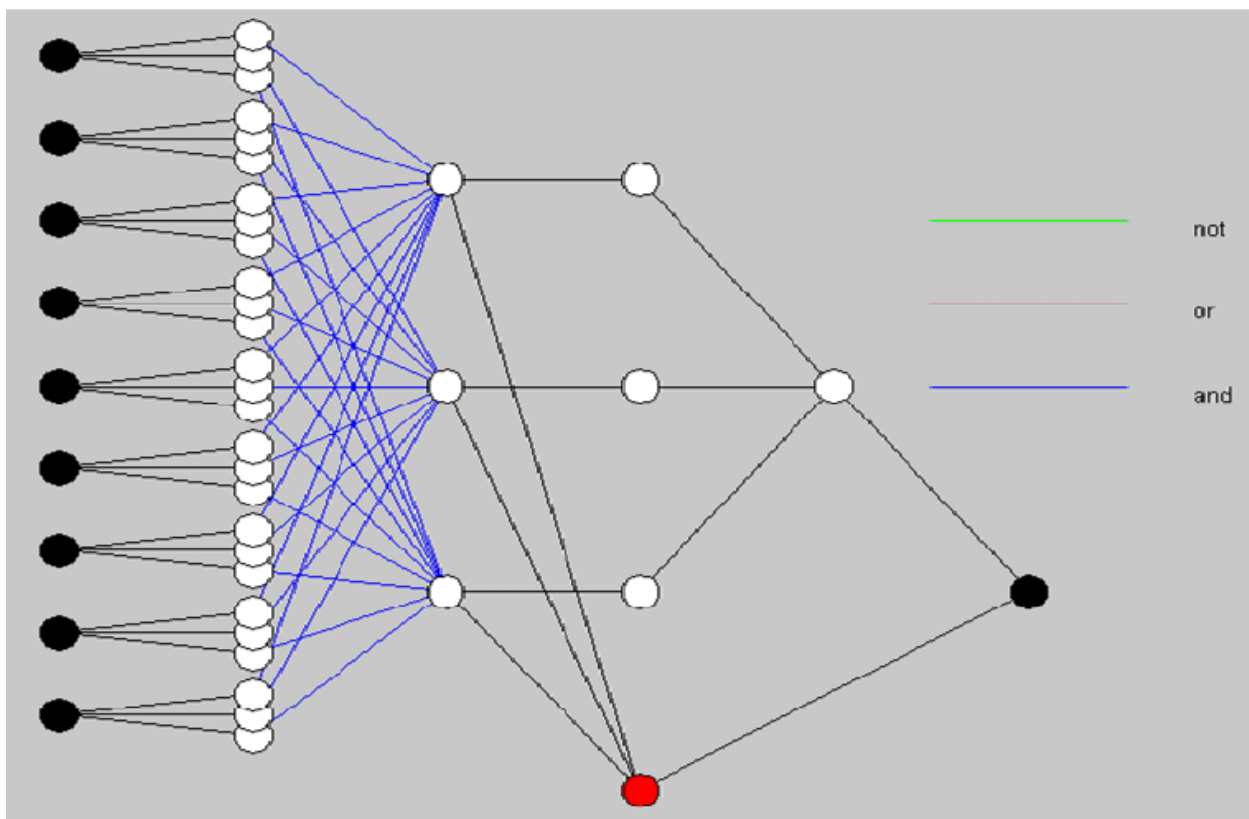


FIGURE.2-5 ADAPTIVE NEURAL NETWORK OF THE FIS. (DELL'ORCO AND OTTOMANELLI,2012)

2.5.4 Likelihood Function

Likelihood function is a joint probability density function formulated for the sample taken consisting of T individuals. It is used for estimating parameter in the different logit models.

This probability density function takes the following form

$$L(\beta) = \prod_{t \in T} \prod_{j \in J} (P_{jt}(\beta))^{\delta_{jt}}$$

Where: - P_{jt} is the probability that individual t chooses alternative j.

δ_{jt} = is a choice indicator

=1 if mode j is chosen by individual t and 0 otherwise

The maximum value to each parameter can be found by taking the derivative of the likelihood function and setting it to the value of zero.

However differentiating this function as it is poses some mathematical difficulties. But the value of the first derivative of this equation is similar to the derivative of its log function which is simple to compute. So we use this advantage of the log likelihood function in order to find the parameter estimate. Hence the different logit models described use the concept of maximizing the log likelihood function in parameter estimation.

2.5.5 Method of model testing

The model test utilized in the modelling task is the Rho-square Value which describes how well the variables included in the model fit the data collected. This value shows how descriptive the models is with respect to a null model where all the coefficients of the variables take a value of 0. A Rho-square Value having a value of 0 indicates a poor model while a value of 1 is associated with a model which describes the situation perfectly.

2.6 Summary

It was able to see from the literature review that application-assisted taxi is making a fundamental change in the way Taxi service is being implemented in large urban cities of the world making itself as an added option to solve the mobility needs of residents. Nonetheless different researches indicated that there are some negative impacts that are associated with this transport means. Among those impacts, it is indicated that a modal substitution effect is being observed from more sustainable public transport service to app-assisted taxi service. This effect is also shown to be context specific and different variables do account for the modal shift. The introduction of this

type of taxi service in Addis Ababa is hypothesized to have similar effects. However, issues regarding this has not been researched yet in Addis Ababa context. Hence this research will try to find out the effects of Application-Assisted Taxi service on transport service in Addis Ababa (i.e. modal shift) along with characterizing its users and the travel purpose they are being used for which will give a valuable information for policy makers while making decision's regarding this transport mode in particular and the public transport in general.

3.0 Methodology

3.1 Introduction

The methodological steps that is outlined for doing the research is presented in detail in this section. The study area where the research is undertaken is described first followed by the data collection and analysis method used to answer the research question raised before.

Primary data is collected for modelling the factors that affect the modal shift to application assisted taxi services of different mode users. The study utilizes quantitative approaches for the analysis. Multinomial logit modelling is used to characterize the factors that affect the travel mode shift to application assisted taxi service from the different alternative modes. Descriptive analysis is used to characterize who and why passengers adopt app-assisted taxi and to calculate the relative percentage share of shift (modal substitution effect) from the different modes.

3.2 Study area

Addis Ababa which is the capital city of Ethiopia is selected as the study area in this research. It is a metropolitan city which is the resident place for many international embassies, different NGOs, AU and ECA. As a result many conferences and international meetings are hosted at a regular interval which has forced the federal government to look for different ways of modernizing the transport service in order to provide a safe, reliable and affordable transport service. The city is home to the largest university in the country (Addis Ababa University) which hosts 13 campuses under it.

The well-known Airport in Africa which gives service to high number of passengers a day is placed in the outskirts of the city. Mercato, which is the largest market place in Africa is also found in Addis Ababa. There are also plenty of public and privately owned large Hospitals and many more medium health centers which serve most of the referred patients in the country and those in the city. Being a venue for most of the freight that is imported and exported to the country has made it to be the busiest business place where high transactions are performed in a day. The city is located at a geographical coordinate of Latitude: 9°01'29" N Longitude: 38°44'48" E Elevation above sea level: 2405 m. The land area inundated by the city is 527 sq.km which made it to be one of the largest capital cities in Africa. The geographical positioning places the city around the center

of the country having an elevation which best suits the city as a capital for the country and as a living place for its residents.

It is shown the current population of Addis Ababa in 2021 to be 5,006,000 which has increased from its number in 2020 by 4.42% (www.macrotrends.net, n.d.). This number is expected to increase at high rate in the future due to the growing economic and social activities. Clelie Nallet (2018) described that Addis Ababa's population is estimated to reach 10 million by 2037.

It is in relation to this high increase in population number that the transport demand has risen to the highest level in recent time. Hence a need arises for transport planners in order to consider possible measures to provide a sustainable transport infrastructure and service that can meet these high demand and assess the operational performance of the once which are operational in the city at present.

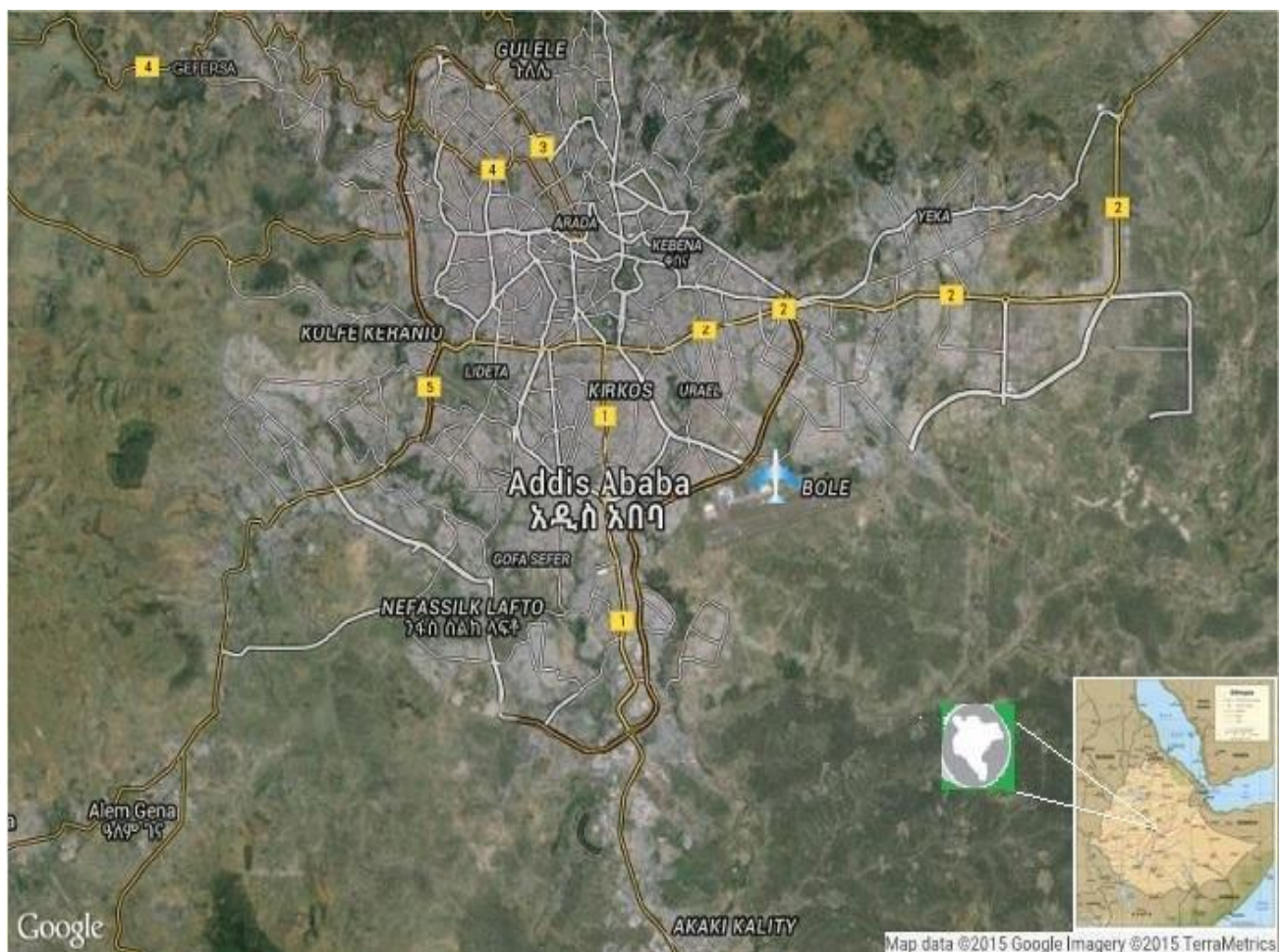


FIGURE 3-1: CITY MAP OF ADDIS ABABA

The city transport Authority is struggling to find ways to provide efficient transport service to the high demand by providing the needed infrastructure and public transport service along with the traffic management strategies.

Transport Policies and regulations are being implemented to support the operation of the transport service being provided.

The transport service as it stands at present consists of the traditional and modern transport modes. Among the transport services providing mobility service to the residents in the capital, the on demand application-assisted taxi service is becoming dominant serving a good share of trips in a day. As this transport service is hypothesized to have positive and negative influences in the transport system in the capital, it is mandatory and the essence of this thesis to test a segment of the issues that is worth considering and provide necessary policy direction and recommendations.

3.3 Data collection Method

3.3.1 Questionnaire Development

The questionnaire contains important variables that are selected based on a detail literature review and contextual investigation. A preliminary questionnaire prepared has been distributed to passengers to fill in the form by including an additional information that they think worth to be included in our context. The final questionnaire is then prepared and has been distributed to peoples while they are at their work places, school, cafes & restaurants and recreational areas.

The developed questionnaire contains 2 parts. The first part is devoted to the Socio-economic and residential place characteristics of respondents. The second part contains questions related to the trip characteristics. The questionnaire has been contained in the appendix part of this report.

3.3.2 Sample Size Determination

The sample size up on which we will make our survey will usually depend on the population size. As the actual number of people using application assisted taxi service is not known, it is appropriate to consider taking sample size by employing the expression which was developed by Cochran as this is the usual way in sample size determinations as far as situations of this type is concerned.

The expression that was developed by Cochran takes the form:

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

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

e is the desired level of precision (margin of error)

For 95 % level of confidence Z= 1.962

For Maximum variability p = 0.5

e = 5% level of precision or sampling error

Hence the minimum sample size is calculated to be 384

3.3.3 Sampling method and Data collection

There are different sampling methods that can be employed while making a sample selection. The sampling technique to be employed should ascertain the representativeness of the data that is going to represent the target population. Random (probabilistic type) sampling method is employed in this research in order to assure every item of the population has equal chance of being selected.

The place where the questionnaire data are collected is based on the attractiveness of trips. Trip attraction spots are selected in the city where much of the application -assisted taxi trips could potentially be destined to. This has been done by interviewing drivers where their trip destination are for most of the time. Accordingly, the following areas have been selected as a data collection spots based on the potential to attract most of application -assisted taxi trips in the city.

- 1) Bole around friendship
- 2) Stadium area
- 3) Piassa around the city municipality
- 4) Arat kilo university Area

- 5) Megegnagna Roundabout area
- 6) Mexico around Federal police building
- 7) Mercato area
- 8) Around 22 (golagul tower)
- 9) Kasanchis area
- 10) Bisrategebriel
- 11) Gergi around Emperial
- 12) Biherawi tiater
- 13) Kera
- 14) Tor hailoch
- 15) Saris around adey abeba
- 16) Lideta around federal court

The Questionnaire developed is distributed and Respondents were kindly asked at random if they have an experience of utilizing application -assisted taxi service in the past month and fill on questions stated on the form for most of the trips they have undertaken. Most of the studies that are undertaken in this area ask respondents about the trips characteristic's based on information from the last trip they undertake which the Author of this thesis believes to be inappropriate and cannot give reliable result. Instead: by asking passengers on the characteristics of most of the trips they undertake, we make the research result to be reliable and accurate. The questionnaire prepared are distributed randomly among the mentioned places while collecting the data using the data collectors deployed in these areas.

3.4 Data Analysis

3.4.1 Mode Shift Modelling

There are different modes of transport being in use for transporting people in Addis Ababa.

The main aim of modal shift characterization is to identify significant factors that influence the shift to application based taxi services. This will help a concerned body to make important considerations while making a decision that will influence the better utilization by the community of a specific mode of interest which will be beneficial.

The respondents were asked what travel mode they would have used if application assisted taxi service has not been present in the city and the factors that affect their choice to shift to application-assisted taxi service utilization. In order to make the characterization we need to first list the available modes of transport, list the variables that influence the modal shift, select the modelling technique and analysis method to be used.

3.4.2 Available Modes of Transport

Before starting characterizing the mode shift behaviors, it is mandatory to specify the modes that are available as an alternative to the application based Taxi service. The transport modes that are available at the study area as an alternative to app-assisted taxi service are:-

1. Bus transport
2. Rail Transport
3. Minibus Transport
4. Traditional Taxi Transport (Lada Taxi)
5. Private car
6. Walking
7. Midi - Bus (Higer bus)
8. Other

3.4.3 Variable and Coding of Variable

The variables that have influence on passengers choice to shift to app-assisted taxis have been selected based on an in depth literature review and contextual consideration. As it is important to tell the computer what the variables stand for, they have been coded as in the following table.

TABLE 3-1 CODES FOR VARIABLES

1. Gender: - 0 for male and 1 for female
2. Age group :- 1 for 18-29 , 2 for 30-45, 3for 46-60 , 4 for 60& above
3. Educational Status: - 1 for 8th grade and below, 2 for preparatory & high school, 3 for diploma , 4 for degree, 5 for graduate studies & above
4. Income level a month (Birr):- 1 for < 5000, 2 for 5001-15000, 3 for Above 15000
5. Reason for using app-assisted taxi service:- Lack of public transport (1 if yes ,0 otherwise) , Time saving (1 if yes ,0 otherwise), Being economical (1 if yes ,0 otherwise), Parking problem (1 if yes ,0 otherwise), Seeking comfort (1 if yes ,0 otherwise), Traffic congestion (1 if yes ,0 otherwise), Presence of covid 19 (1 if yes ,0 otherwise), Other reason (1 if yes ,0 otherwise)
6. Travel Purpose:- Work Trip (1 if yes, 0 otherwise), School Trip (1 if yes, 0 otherwise), Trip to home (1 if yes ,0 otherwise), Recreational Trip (1 if yes ,0 otherwise), Other trip purposes (1 if yes , 0 otherwise)
7. Alternative mode Replaced:- 1for large Bus, 2 for Minibus, 3for private car, 4 for Lada Taxi, 5 for light Rail, 6 for Walking, 7 for Higer bus, 8 for other modes

Multicollinearity check on the explanatory variables has been done with SPSS based on threshold values for Pearson correlation coefficient, Tolerance and Variance inflation factors. This is done in order to see the possible high correlation that could exist between variables which can result in the drop of some variables from the modeling task.

According to suggestions from statistics the values for Pearson correlation coefficient, Tolerance and Variance inflation factors should not be greater than 0.7, < .1 and > 10 respectively in order for multicollinearity not to exist. The values calculated for the variables included in the model lie in these range and hence multicollinearity doesn't exist. The table containing those values is included in the appendix part.

3.4.4 Model selection

The model selection considered the problem we have at hand and the best model that can describe it. Based on this, multinomial logit model is selected for the model construction as the variables that need be calibrated are mostly individual preference variables related to socioeconomic factors, reasons for using and travel purposes.

The value of these variables doesn't vary across the different modes as compared to variables like travel cost and time which do vary across modes demanding the utilization of conditional logit model. These variables have characteristics which also are distinct to each mode having effect that are independent among the different modes which can be modelled easily using the multinomial logit model described. The simplicity of the model is also taken in to consideration when selecting it as this is the most referenced advantages of MNL model among the available discrete multivariate choice models.

3.4.5 Detail on Mode Shift Model Development for app-assisted Taxi Service

The choice of shift to app – assisted Taxi service is modelled using a multinomial logit model. The modeling is done using questions devised to ask what alternative travel mode the user would have taken if there is no an app-assisted Taxi service in the city.

There are different variables which affect the mode choice shift to application based taxi service of individuals using those services. Different researches are being made in different countries in order to find out the significant variables that affect this shift. For this research: an in depth review have been made in order to find out those variables which we have included in our model specification. Those Variables which are selected by making a thorough literature review are analyzed using MNL in order to provide us an information as to what causes travelers to abandon their original mode and make them use app-assisted Taxi service. The computation is performed as follows:

Each app-assisted taxi service user i is faced with j alternative travel modes in the MNL model framework. App-assisted taxi service is selected by a traveler instead of the eight other travel alternative modes. We set the alternative travel mode: Large Bus as $j = 1$; Minibus Taxi as $j = 2$ private car as $j = 3$; Traditional taxi(Lada taxi) as $j = 4$; Light Rail as $j = 5$; walking as $j = 6$ Midi-bus (Higer Bus) as $j = 7$ other as $j = 8$

Based on this, the utility to a user of selecting a particular travel mode is given by

$$U_{ij} = b_j X_{ij} + e_{ij}$$

Where

X_{ij} is a vector of explanatory variables expected to influence users to change their travel mode to app-assisted Taxi services. The vector b_j represents the coefficients for the vector of explanatory variables X_{ij} for alternative j .

Utilizing the MNL model, the probability that a user would choose alternative travel mode j if there were no app-assisted taxi service, which also means that the probability that a user will switch to app-based ride hailing from alternative travel mode j , is computed by:

$$P_{ij} = \frac{e^{U_{ij}}}{\sum_j e^{U_{ij}}}$$

MNL model uses Maximization of the log likelihood function to estimate the parameters (b_j).

The model is used to estimate a set of parameters b such that the probability of the observed choices being realized is highest. This technique is described in the next section

3.4.6 Method of Analysis

The main aim of the modelling task is to find a set of coefficient values for the variables that can describe their effects. There are different methods of analysis that can lead us to the determination of those coefficients. Multinomial logistic regression uses maximum likelihood estimation technique in order to calculate and estimate those parameter values.

The analysis procedure employed starts with developing a joint probability density function (PDF) for the sample collected. The PDF function developed takes the following form.

$$L(\beta) = \prod_{\forall t \in T} \prod_{\forall j \in J} (P_{jt}(\beta))^{\delta_{jt}}$$

Where: - P_{jt} is the probability that individual t chooses alternative j . The equation describing this probability is given by the expression:-

$$P_{jt} = \frac{\exp(X'_{jt}\beta)}{\sum_{j'} \exp(X'_{j't}\beta)}$$

δ_{jt} is a choice indicator

= 1 if mode j is chosen by individual t and 0 otherwise.

The next step involves differentiating the likelihood function and setting its first derivative to the value of 0. This will provide us the maximum values for the parameters. However, differentiating the likelihood function as it is will pose some mathematical difficulties. On the other hand, we know that the value of a functions derivative is the same as the derivative of its log function which is simple to compute. Hence we make use of this advantage of the log likelihood function and set its first derivative to the value of 0 for the parameter estimation.

The log likelihood and its derivatives are given us:-

$$LL(\beta) = \text{Log}(L(\beta)) = \sum_{\forall t \in T} \sum_{\forall j \in J} \delta_{jt} \times \ln(P_{jt}(\beta))$$

$$\begin{aligned} \frac{\partial(LL)}{\partial \beta_k} &= \sum_{\forall t \in T} \sum_{\forall j \in J} \delta_{jt} \left(X'_{jt} - \sum_{j' \in J} P_{j't} X'_{j't} \right) \\ &= \sum_{\forall t \in T} \sum_{\forall j \in J} ((\delta_{jt} - P_{j't}) X'_{jt}), \forall k \end{aligned}$$

The derivative of the likelihood function is then set to a value of 0 and the parameters computed using Python Biogeme by iteration mechanism to find the values that best fits the data.

3.5 Software used

Python Biogeme software have been used for the mode shift modeling while application software are used for the document editing and data Analysis.

4.0 Result and Discussion

The objective of this section is to present the result in a way that it would be easily understood and make the discussion on the findings in order to answer the research questions we are interested. On the first and second part of this section: the result which answers question number one and two is presented using tables and appropriate graphs along with the discussions. The third part shows the graphical and tabular presentations to the descriptive analysis of the mode substitution effects which has made us answer question number 3. The last section presents the multinomial logit model developed which is used to characterize the factors that affect the mode substitution effect from the different alternative modes we have. Data screening on 465 questionnaires collected was made to get the 384 valid questionnaire that have been used for the analysis.

The result is presented as follows:

4.1 Users of Application-assisted Taxi service

The socio economic and demographic characteristics of application-assisted taxi users are presented with the following table and frequency graphs.

TABLE 4-1 SUMMARY OF SOCIO-ECONOMIC CHARACTERISTICS OF APP-ASSISTED TAXI SERVICE USERS

Socio Demographic Attribute	Label	Category	Frequency	Percentage
Gender	0	Male	182	47.40
	1	Female	202	52.60
Age group	1	18-29	145	37.76
	2	30-45	165	42.97
	3	46-60	67	17.45
	4	>60	7	1.82
Education level	1	8th grade or below	3	0.78
	2	Completed prep& High school	45	11.72
	3	Completed Diploma	87	22.66
	4	Completed Degree	183	47.66
	5	Completed Graduate Studies & above	66	17.19

Marital status	1	Single	179	46.61
	2	Married	184	47.92
	3	Divorced / Widowed	21	5.47
Employment Status	1	Employed-Full time	161	41.93
	2	Employed-part-time	53	13.80
	3	Self-employed	83	21.61
	4	Student	52	13.54
	5	Unemployed	24	6.25
	6	Retired	11	2.86
HH Income	1	Below 5000	54	14.06
	2	5000-15000	170	44.27
	3	Above 15000	160	41.67
HH size	1	1 member	85	22.14
	2	2-4 members	201	52.34
	3	Above 4 members	98	25.52
Car Ownership	0	No	290	75.52
	1	yes	94	24.48

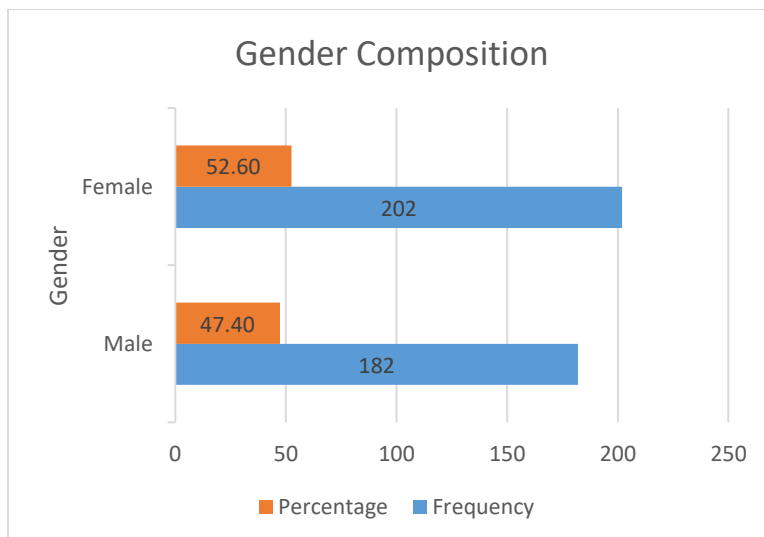


FIGURE 4-1 GENDER COMPOSITION

As can be seen from the figure above females took a bit high proportion of app - assisted taxi users accounting for 52.6 % while males constitute 47.4 % of the users. The reason for the higher adoption by females comes as a result of the shopping trip that is being performed using this transport mode which in most cases is undertaken by females. It is also seen that the comfort attribute which is provided by this transport modes is valued highly by females making them to select this transport modes better than males.

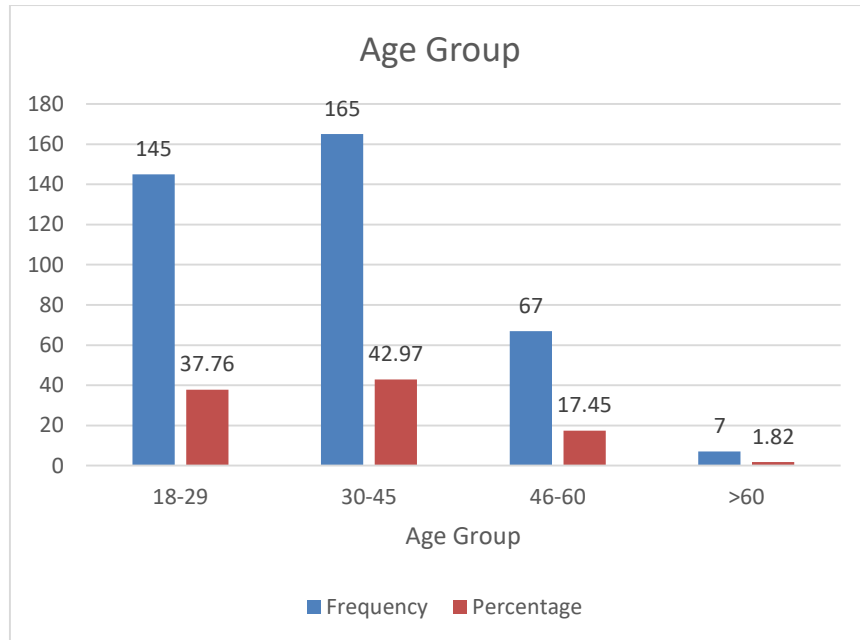


FIGURE4-2 AGE DISTRIBUTION

The age group that lies in the range of 30-45 has the highest proportion followed by 18-29, 46-60 and >60 age ranges having percentage frequencies of 42.97, 37.76, 14.45 and 1.82 respectively. This is in line with Rayle et.al. (2014) findings which showed younger persons are the once that use this service in order to undertake their activities mostly.

The justification to this is that younger persons are those who are usually attracted by new technologies willing to incorporate new innovations in order to ease their activities. They are the once that like to try things that are new and different making them to adopt app-assisted taxies to support the trips they perform.

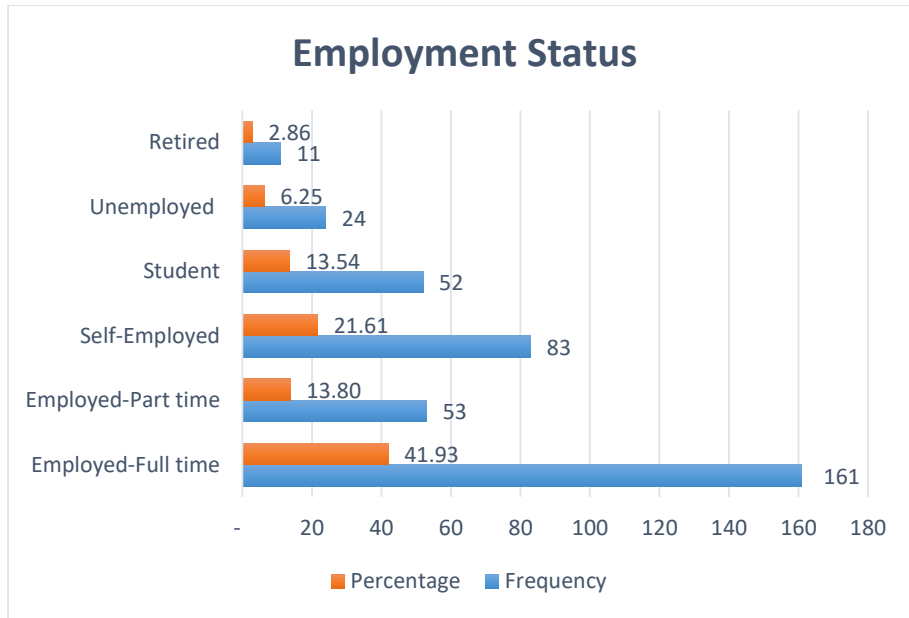


FIGURE 4-3 EMPLOYMENT STATUS

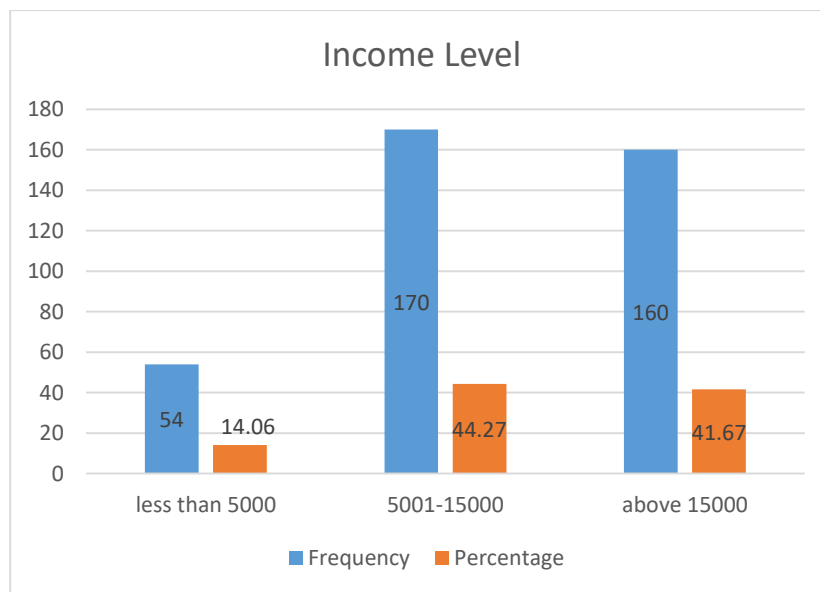


FIGURE 4-4 INCOME LEVEL

The graphs presented above shows the frequency and percentages of application-assisted taxi users Employment and Income Status. As it could easily be seen from the result, users of this transport service are those employed to the full extent and earning a medium to high income level. The relative high cost of this transport service makes itself to suit for the high income earning passengers.

As for the educational status, the figure below shows those who are highly educated once are the high ranking on the utilization of app assisted taxi service. The work responsibilities and tight schedule of individuals having high education level make them to use app-assisted taxis to reduce the travel time and get engaged in their duties on time. It is also noted that people who have high education level make use of new technologies for easing their operations which in the case of urban transport is being offered at present by app-assisted taxi service.

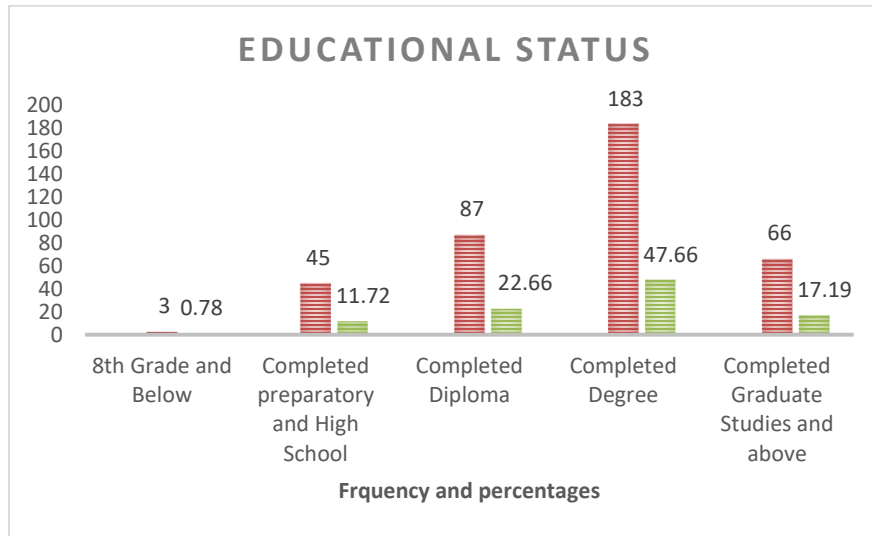


FIGURE 4-5 EDUCATIONAL STATUS

About a quarter of the passengers of app-assisted taxis have reported that they own a car and is displayed in the following figure indicating that this transport modes are actually used mostly by those who do not own a car.

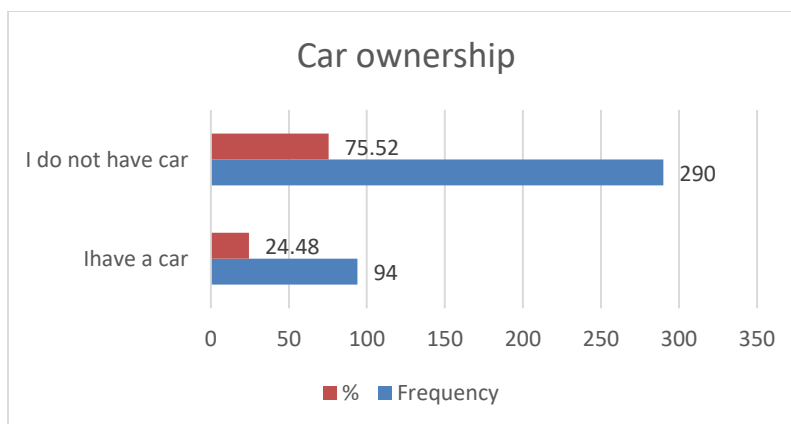


FIGURE 4-6 CAR OWNERSHIP

4.2 Travel needs and Trip characteristics

4.2.1 Travel needs

The extent of different travel needs that passengers host application-assisted taxi service for is explored by plotting the percentage frequency graph as under.

It could easily be seen that most of the trip purposes that application-assisted taxis are used in Addis Ababa is for work followed by home, school, shopping/marketing, recreational, health center and other trip purposes. This is in line with Zhang et al.(2016) finding that app-assisted taxis are mainly used for commuting trips to work and home and against Du et al.(2019) for which recreational trips are the dominant once confirming that travel needs by passengers are context specific. Looking at the situation on ground it could easily be seen that the high demand for transport service appears to exist at the time on which commuting trip to work and home is undertaken which is verified in the next section. This demand is not satisfied with the existing public transport and has led passengers to make use of app-assisted taxis for these travel purpose.

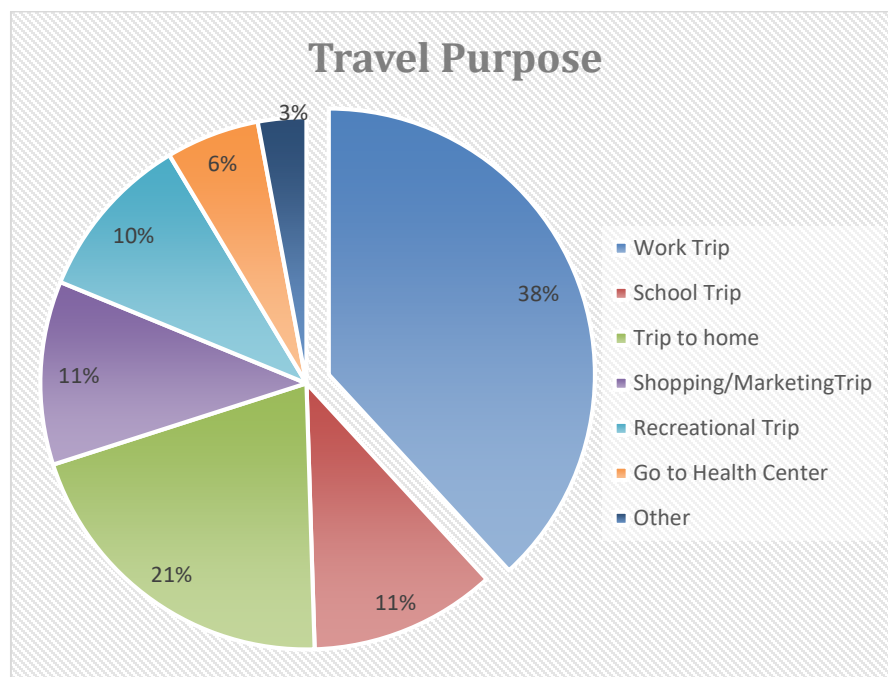


FIGURE 4-7 PIE CHART OF THE TRAVEL PURPOSE DISTRIBUTION

In order to further expand our understanding about application-assisted taxi services, we have included questions as to when passengers do prefer to use, how they perform the trip, the travel

time they spent using alternative modes vs. App-assisted taxies, frequency of usage and their perception on the cost of travel. The results are presented in the following graphs.

4.2.2 Day Time of Trip & how it is performed

The graphs presented below shows that application-assisted taxies are used in the morning time mostly which is consistent with the finding we got that this type of modes are mostly used for the work trip purpose. This is the time when high demand for transport service exists for commuting trip to work. The combination of afternoon and evening times also shows a higher percentage on which much of the home trips are undertaken. The midday travel is small as compared with the morning once. There appears to be a minimum number of trips being performed during the night periods.

Looking at the graph as to how the trip is performed, it was able to see that most of the trips that are undertaken using app-assisted taxies are alone trips encompassing 83.59 % while those performed with other passengers accounts only for 16.41 % of the trips. This phenomena should be looked at carefully as it could tell us that these transport means are acting as single occupancy vehicles (SOV) which can result in several negative externalities like traffic congestion and environmental pollutions.

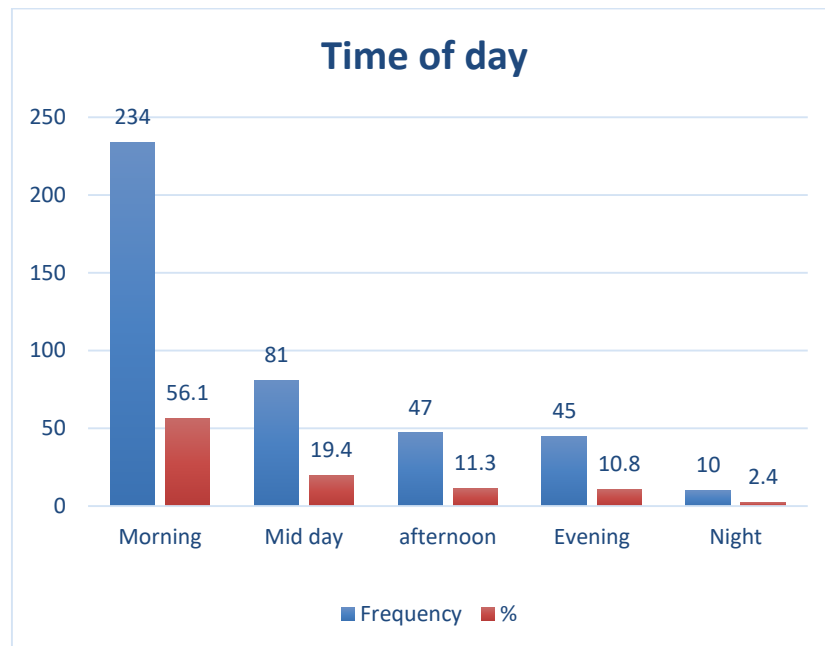


FIGURE 4- 8 TIME OF DAY USE DISTRIBUTION

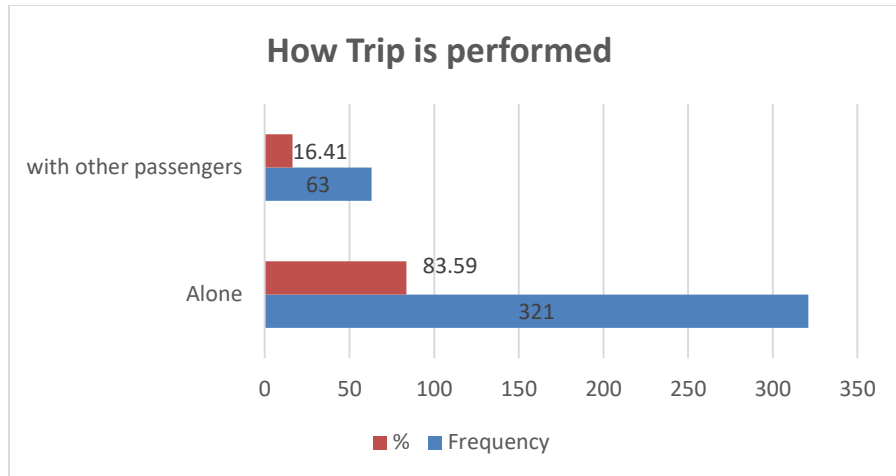


FIGURE 4-9 DISTRIBUTION OF HOW TRIP IS PERFORMED

4.2.3 Time saving

Time saving has been reported by passengers to be the major factor among others that describe the shift and hence it will be good to look at the extent of time saving that passengers got from replacing the respective modes they usually use with application-assisted taxi service. In order to do so, Passengers were asked to report the average time they spent for the trip they usually replace their original modes with app-assisted taxis by considering the origination and destination locations of the trip.

The time saving is found by deducting time spent by app-assisted taxis from the replaced mode and is presented in the figure below for the different mode types.

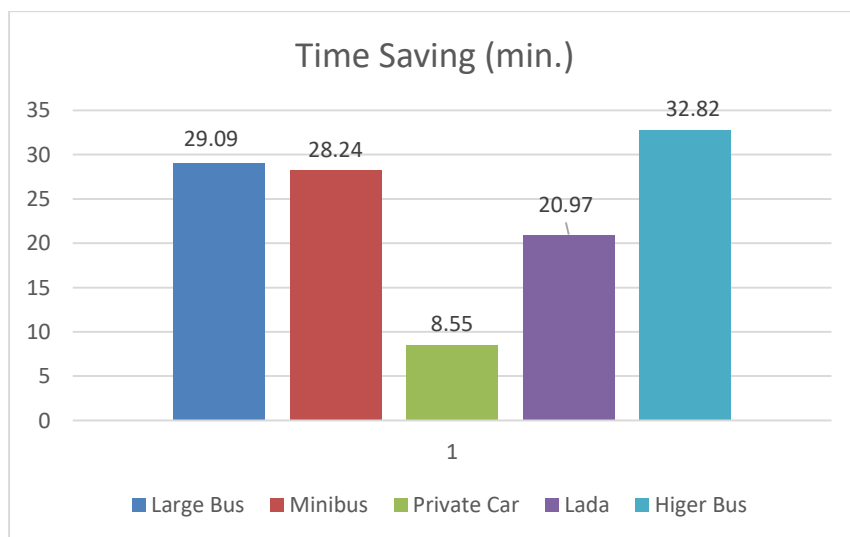


FIGURE 4 -10 TIME SAVING FROM DIFFERENT MODES

As can be seen from the figure above large time saving is got from the buses (higer buses and large buses each having a value of 32.82, 29.09 minutes respectively. This is true as those modes operate slowly as compared with the other and the waiting time to get them is high. The minibus taxi users reported a 28.24 minute time saving by replacing it with the app-assisted taxies which is also a high value. This resulted from the long waiting time to get them and the high number of passengers pick drop duties during the maneuver.

As to the traditional lada taxi users we got a time saving of 20.97 minute. The justification to this is out of vehicle travel time while searching for those service is high as compared with the app-assisted taxies which also is exacerbated by the speed reduction resulting from the vehicle conditions which also increased the in vehicle travel time.

The private car owners reported an average time saving of 8.55 minute which is small as compared with the others. The time saving in this respect is accounted for by the speed with which those transport modes operate to accomplish their trips which is usually high in the app-assisted taxies in addition to selection of alternative short routes which app-assisted taxies usually do.

4.2.4 Passengers View on Cost

As mentioned previously, the cost of this transport mode is fixed by the respective transport operator and passengers as such doesn't provide their view in this respect. Hence it is essential to look at passengers view on the cost of this transport mode in order to get sense of their satisfaction level in this respect and do the necessary adjustments.

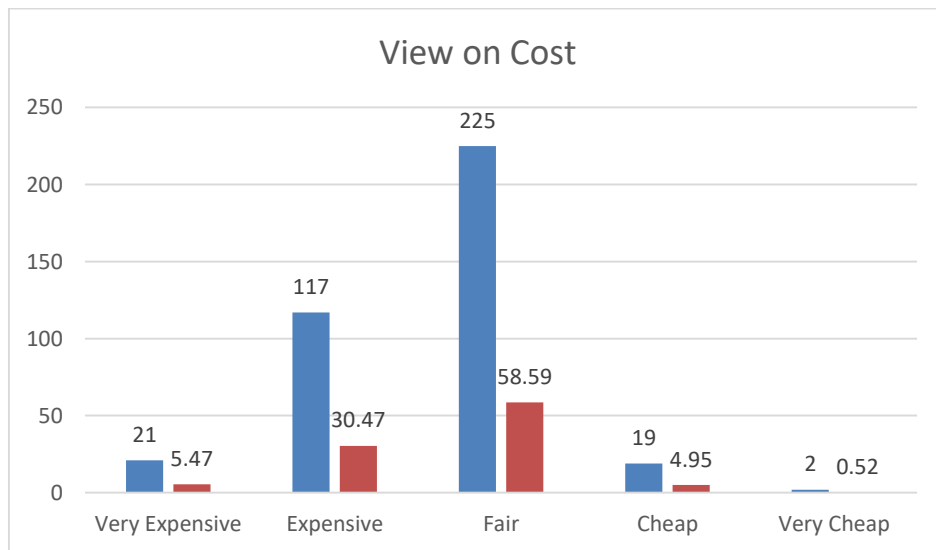


FIGURE 4-11 PASSENGERS VIEW ON COST

Observing the figure on passengers view on the cost, we see that most of the passengers are satisfied with the cost as 58.59 % of the respondents say that the cost is fair. 30.4% of the users perceive the cost to be expensive which is also high. This indicates that transport service operators providing those services should somehow reconsider their cost structure in order to satisfy passenger’s demands at a better level.

4.2.5 Use Frequency

In order for us to look at how frequent this service is being used by passengers, a question regarding the number of time they used it in a week is raised and the following result was found. Those trips having a frequency of 2 and less have been classified to be infrequent trips while those from 3 to 5 are defined frequent tips and those above 5 to be high frequent once.

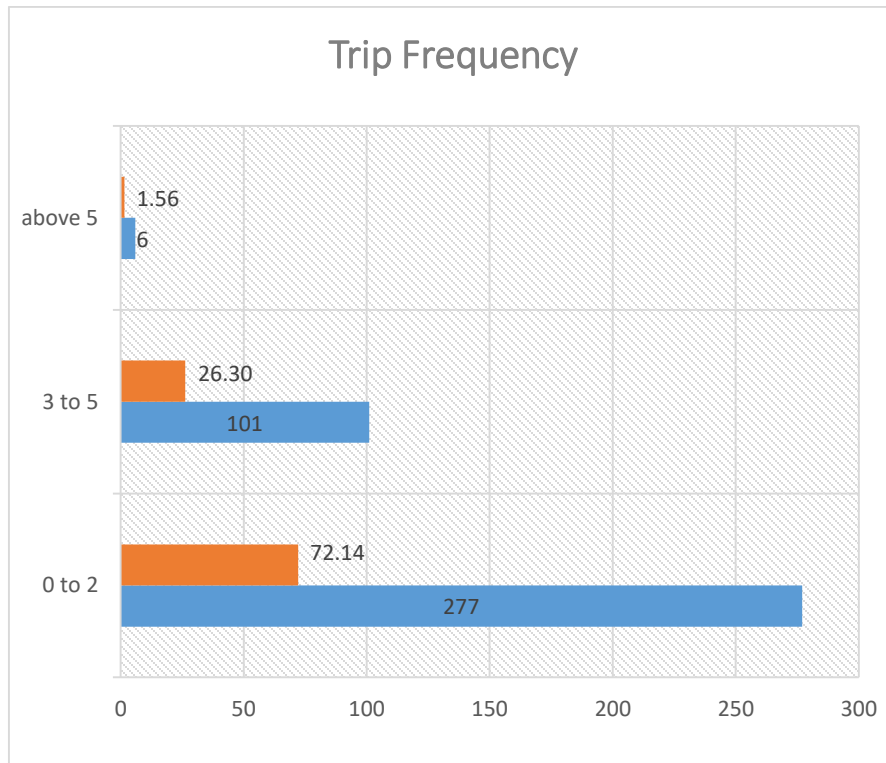


FIGURE 4-12 TRIP FREQUENCY IN PROPORTIONS

It is evident from the figure above that 72.14 % of the trips that app-assisted taxi service are used for infrequent trips while the frequent trips accounts only for 26.3 percent. It is unlikely that passengers use this mode at high frequency as only 1.56 % of the trips fall in this range.

4.3 Mode Substitution

One of the main aim of the research is to look at the relative proportions of trips that are replaced by app-assisted taxies from the different modes. This is important in order to look which mode will be highly affected by app-assisted taxi presence and make the required recommendations accordingly.

The modal substitution effect of application- assisted taxies on the different modes is presented with the following graph showing the percent frequency of users that shifted from the different modes.

The mode substitution vs. complementary effect is first checked by comparing the percentages of passengers who used the ride for the whole trip and those who used it to access to other public transport modes.

The finding indicates that 96.35 percent of the trips are undertaken using App-assisted taxi service for the whole trip and the 3.65 percent trips performed by app assisted taxi service are used as a feeder to a public transport which shows that app-assisted taxi service act as substitutes for other modes.

This implies that they should be treated as an independent mode of transport competing with other transport modes.

TABLE 4-2 TRIP PROPORTION OF APP-TAXI UTILIZATION

Trip Proportion App Taxi used	Frequency	Percentage
Whole Trip	370	96.35
Connecting to Public Transport	14	3.65
Total	384	100

The following figure shows the different modes substituted by App-assisted taxi service for the trips made by passengers.

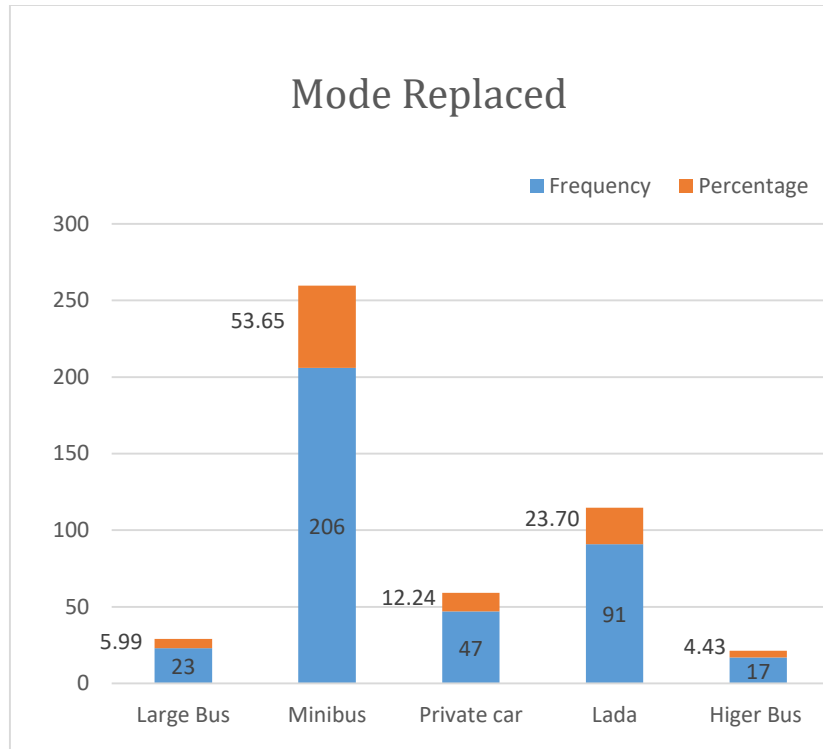


FIGURE 4-13 PROPORTIONS OF ALTERNATIVE MODE REPLACED

The result indicates that minibus taxis are the most replaced modes followed by the traditional lada taxis, private car, large bus and higer bus each with percentage value of 53.65, 23.7, 12.24, 5.99 & 4.43 respectively. Hence while devising policy directions it is needed that more focus be given to the factors affecting the shift from the minibuses taxis in order to cater the effect of this new mode of transport on the utilization of minibus taxis which is regarded as a mode of transport supporting the public.

A replacement from the traditional (lada) taxis which also is high is evident as it is the main mode competing with app-assisted taxis giving similar service to passenger but characterized with a much lower level of service.

We see a lower replacement from the large bus and higer bus. The reason for this could be passengers using those service are mostly classified in the low income levels and could not as such afford the cost of travel by app-assisted taxis. Looking at the private car users, we see 12.24 % of those who replaced their original modes comes from this mode. Different variables have been found to be the reason for this replacement and are described in the next section which are identified using the appropriate modeling technique.

4.4 Modelling application-assisted modal shift influencing factors

In this section: we will look at how the model is developed and make a discussion on the significant variables we found in the final model. Multinomial logistic regression is used as a modelling tool in this analysis. The base outcome selected in the modelling task is Private car. Private car has been selected as the base case for the reason that we want to trace the effect of application-assisted taxi service on the public transport modes which can be seen easily by fixing private vehicle as the base case.

Light rail, leg and other modes have been excluded from the modelling task since they only constitute 6, 5 and 0 choices among the choice set which is small as compared to the remaining modes and can safely be dropped.

The model is developed with the following procedure. First, all possible relevant factors that can influence the shift from the different modes has been considered in the development of the initial model. A series of models is then constructed by making successive elimination of the factors that are not significant in the predicted models using backward elimination technique of model development until we got the final model which only constitutes the significant once.

Those variables having a P-value greater than .05 are dropped from the predicted model according to their magnitudes. The variables which are very far from being significant are first dropped by retaining those which have p-values close to significance levels. This is done successively until we get all variables that have a p-value $< .05$ which confirms their significance.

The model development has been done using a **Python Biogeme Software** package and the final model is presented in the following table that has been extracted from the .html file produced. The collected data has been imported and codes for utilities written using the software with suitable format and an estimation on the coefficients is done by initiating the estimate command of the software.

Description of the codes for the variable names as used in constructing the different model is shown below.

TABLE 4-3 DESCRIPTION OF VARIABLE

Variable	Description of Variables
HBUS	Alternative specific constant for Higer bus
LADA	Alternative specific constant for Lada Taxi
LBUS	Alternative specific constant for Large bus
MBUS	Alternative specific constant for Mini bus
Income.L	The contribution of Income level to the modal shift
Edu.L	The contribution of Education level to the modal shift
Lack.pt	The contribution of Lack of public transport to the modal shift
Time.Saving	The contribution of Time saving to the modal shift
Economy	The contribution of being Economical to the modal shift
Park.prob	The contribution of Parking problem to the modal shift
Comfort	The contribution of comfort seeking to the modal shift
Congestion	The contribution of Congestion to the modal shift
Covid	The contribution of Covid to the modal shift
Work.tp	The contribution of Work trip to the modal shift
School.tp	The contribution of School trip to the modal shift
Home.tp	The contribution of Home trip to the modal shift
Reacr.tp	The contribution of Recreational trip to the modal shift
Other.tp	The contribution of Other trip purpose to the modal shift

4.4.1 Model Estimation

The model estimation report for the utility defined for the final model which has been constructed including the significant variables that do explain the shift from the different modes to app-assisted taxi is displayed below. As described before Private car has been taken as the base case in this estimation.

Backward elimination technique has brought us with the significant variables we used in the final model. The variables that are included in the specification for the model are: Education level, Income level, Lack of public transport, Time saving , Seeking comfort, Presence of covid 19, parking problem, traffic congestion, Work trip, Home trip, School trip, Recreational trip and other trip purposes.

Accordingly the final model consisting the variables which only are significant has been estimated using these attributes and the result for the coefficient value for each mode is presented in table 4-4 below.

Model Estimation report

Number of estimated parameters:	26
Sample size:	384
Excluded observations:	0
Init log likelihood:	-618.0242
Final log likelihood:	-365.6981
Likelihood ratio test for the init. model:	504.652
Rho-square for the init. model:	0.408
Rho-square-bar for the init. model:	0.366
Number of iterations:	100
Number of function evaluations:	301
Number of gradient evaluations:	101
Optimization time:	0:00:05.064681

TABLE 4-4 MODEL ESTIMATION RESULT

Mode Replaced	Variable	B_Value	Std err	t-test	p-value
Higer Bus	HBUS	-1.29	0.748	-1.73	0.0838
LadaTaxi	LADA	1.26	0.425	2.96	0.00306
Large Bus	LBUS	-1.54	0.755	-2.04	0.0411
Mini Bus	MBUS	1.82	0.459	3.97	7.29E-05
Higer Bus	Income.L3	-2.63	0.782	-3.36	0.000787
	Lack.pt	1.79	0.603	2.98	0.00291
	Work.tp	1.62	0.626	2.59	0.00953
LadaTaxi	Income.L3	-1.47	0.466	-3.15	0.00163
	Comfort	0.652	0.306	2.13	0.0328
	Covid	0.9	0.436	2.06	0.0391
	Home.tp	0.714	0.29	2.46	0.0139
	School.tp	1.11	0.552	2.01	0.0439
	Park.prob	-1.07	0.438	-2.45	0.0143
Large Bus	Income.L3	-2.85	0.768	-3.71	0.000204
	Lack.pt	2.19	0.575	3.81	0.000139
	Work.tp	2.01	0.613	3.29	0.00101
Mini Bus	Edu.L5	-0.944	0.347	-2.72	0.00656
	Income-L3	-1.33	0.461	-2.89	0.00389
	Work.tp	0.947	0.298	3.18	0.00149
	Lack.pt	1.17	0.314	3.72	0.000202
	Congestion	-1.73	0.703	-2.45	0.0141
	Park.prob	-2.63	0.683	-3.85	0.00012
	Other.tp	-1.51	0.725	-2.09	0.0369
	Reacr.tp	-0.992	0.385	-2.58	0.00992
	School.tp	1.08	0.536	2.02	0.0431
	Time.saving	0.626	0.265	2.36	0.0183

As can be seen form the results found : the model is capable of explaining the modal shift with a rho-square value of .408 which is a good value as compared with the null hypothesis which gives a coefficient value of 0 for all the variables in the model specified. Hence we will use this model to construct the utility functions used to explain the modal shift from the different modes to app-assisted taxi.

The model developed for each modes containing the significant factors as formulated by extracting the coefficient values from the table above are put as under

$$U \text{ large bus} = -1.54 - 2.85 * \text{Income.L3} + 2.19 * \text{Lack.pt} + 2.01 * \text{Work.tp}$$

$$U \text{ Mini bus} = 1.82 - 0.94 * \text{Edu.L5} - 1.33 * \text{Income.L3} + 1.17 * \text{Lack.pt} + 0.63 * \text{Time.saving} - 1.73 * \text{Congestion} - 2.63 * \text{Park.prob} + 0.95 * \text{Work.tp} + 1.08 * \text{School.tp} - 0.99 * \text{Reacr.tp} - 1.51 * \text{Other.tp}$$

$$U \text{ Lada} = 1.26 - 1.47 * \text{Income.L3} + 0.65 * \text{Comfort} - 1.07 * \text{Park.prob} + 0.9 * \text{Covid} + 1.11 * \text{School.tp} + 0.71 * \text{Home.tp}$$

$$U \text{ Higer bus} = -1.29 - 2.63 * \text{Income.L3} + 1.79 * \text{Lack.pt} + 1.62 * \text{Work.tp}$$

As it is shown in the model specified, the factors which are significant in explaining the shift from the different modes to app-assisted taxi service are those related to Socio-Economic, Reason for adoption and Travel purpose and are further discussed under.

4.4.2 Socio-Economic Factors

As can be seen in the table, socio-economic factors that have significance in explaining the shift to application-assisted taxies from the different alternative modes we have are Educational and Income levels. Education level laying in the fifth level that corresponds to masters and above explains the shift from the minibuses with a negative value. This indicates that peoples with Education at the fifth level are less likely to shift from minibuses and more likely to shift from the private car.

Passengers with Income level classified at the highest (> 15000 birr) are less likely to shift from all modes as indicated by their coefficient value of (-2.85, -2.63, -1.47 and -1.33) for large busses, higer busses, lada and minibuses respectively. This shows that those passengers will be more likely to shift from the private cars for this income level.

4.4.3 Adoption reasons

According to the result found we see that Lack of public transport, Time saving , seeking comfort ,traffic congestion, parking problems and presence of Covid are the significant adoption reasons explaining the shift. As expected, lack of public transport is the reason for the shift from all modes except the traditional lada taxies having the highest value for large busses followed by higer bus

and minibuses with a coefficient value of (2.19,1.79 and 1.17) respectively. This is in line with the situation of transport system on ground which is characterized by long queues of passengers waiting for those transports for such a long time especially on peak traffic hours. It is evident from these observations that the demand for the public transport is much higher than the supply which is why people's shift to app-assisted taxies to satisfy their needs.

As to the minibuses, we found that Time saving which has a coefficient value of .626 is a significant reason in addition to the lack of public transport mentioned. Long waiting time accompanied with high number of passengers pick drop duties has made the travel time by minibuses to be high which can't satisfy passengers demand especially on situations when they want to reach to their destination at instant. This has made them to shift to app-assisted taxies in order to satisfy those needs.

Traffic congestion and parking are the variables which are negatively associated with the shift from minibuses. This means that passengers mentioning those reasons for the modal shift are less likely to be minibus users and more likely to come from the private car. Private car owners indicated these reasons to be the critical once to adopt the app-based taxies for their trips. The traffic condition observed on the road and the difficulty to find parking space are the reason for this situation which is seen on most of the road segments in the city.

Traditional Lada taxi users replace it with app-assisted taxies mostly for comfort seeking and presence of Covid reasons with a coefficient value of .652 and 0.9 respectively as could be seen from the result above. The traditional taxies which are mentioned as lada taxies in this research has served for more than 40 years. This is the main reason for the drop of their comfort level and at present peoples do not like to use them unless in emergency situations.

One of the concern of this research has been to look at the effect that Covid 19 has on transport especially the mode shift. In this regard the author has first expected the shift could come from transport modes serving high number of passengers like the busses and minibuses. However the result shows that the shift comes from the lada taxies. This could be explained by the fact that some app-assisted taxies are taking protecting measures for Covid 19 by installing glass like materials that separates the passengers from the drivers which is not seen on the traditional taxies.

Some passengers have also mentioned that the psychological impact of the neatness level has made them to prefer app-assisted taxies than the traditional once for fear of Covid 19.

It is also possible to see from the result that parking problem is associated negatively with the shift from lada taxies as compared with the private car which also means that private cars users will be more likely to be associated with the shift to app-assisted taxies for lack of parking space reason. Difficulty to find parking space is cited to be the reason for this situation.

4.4.4 Travel purpose

Going to work and school are the trip purpose variables which do affect the shift choice from minibus taxies to app-assisted taxies. We also see passengers shifting from large buses and the higer bus use those services for work trip mostly. This can be explained by the fact that there is a high demand of public transport service for those trip purposes which took the highest proportion of passenger trip demands. Hence passengers tempt to shift to app-assisted taxies in order to fill this gap.

Lada taxies show a replaced demand for School trip and Home trip. App-assisted taxies being easily accessible to the passengers at ease is the main reason for replacing home trips. This also is the time when a high demand for transport exists during the afternoon and evening periods. App-assisted taxies bidding for work using applications made it easier for passengers to replace home trip which otherwise could be taken by the lada taxies with the perceived low level of service.as to the school trip, college and university student that once use lada taxies replace those trips with app-assisted taxies in order to get a good level of service offered by the newer taxi services.

Recreational and other trip purposes are negatively associated with the shift to app-assisted taxies from minibuses having a coefficient value of -.992 and – 1.51 respectively.

On the other hand this means that private car users will be more likely to shift to app-assisted taxies for recreational and other trip purpose reasons and the shift form minibus will be less likely to happen due to these reasons.

Avoiding drinking while driving is the main reason that explains this situation for recreational trips which could be cited as the main advantages of app-assisted taxies. Peoples also shift to this mode from private cars due to other trip purposes that are not included in our survey list such as going to garages for maintenance.

4.5 Implications to the Transport system

We have been able to see that the service rendered by app-assisted taxi has an impact on the passenger's mode choice behavior and different factors do contribute to the modal shift. This phenomena has its own implication to the transport system. In order to see this effect, we will look at what quantity of vehicles will be added to the system for a specified amount of trips replaced by app-assisted taxis.

We will consider 1000 trips to be carried out by app-assisted taxis. 1000 trips are considered in order to ease our calculations for a proper interpretation of our finding. According to the results found in previous section 53.65, 23.7, 12.24, 5.99 and 4.43 percent of replaced trips by app-assisted taxis comes from minibuses, traditional lada taxis, private car, large bus and higer busses respectively. We also found that 83.59% of the trips undertaken by app-assisted taxis are alone trips. Considering those situations we will then have

$.5365 * 1000 * .8359 = 449$ alone app-assisted trips that could have been taken by minibuses

$.237 * 1000 * .8359 = 198$ alone app-assisted trips that could have been taken by lada taxi

$0.1224 * 1000 * .8359 = 102$ alone app-assisted trips that could have been taken by private vehicle

$0.0599 * 1000 * .8359 = 50$ alone app-assisted trips that could have been taken by large busses

$0.0433 * 1000 * .8359 = 36$ alone app-assisted trips that could have been taken by Higer busses

The trips that could have been taken by Private vehicle and lada taxis are not considered in the next comparison we make since they have similar modal characteristics with app-assisted taxis in terms of the number of passengers they can carry.

Assuming a nominal capacity of 11 passengers for minibuses, 100 passenger for large bus and 35 passengers for higer busses, the above trips could be accommodated by

$449 / 11 = 41$ minibuses $50 / 100 = 0.5$ large bus $36 / 35 = 1$ higer bus

This means that the transport system suffers from hosting $449 + 50 + 36 = 535$ **app-assisted vehicle alone trip** that could have been taken by **41 minibuses, 1 large bus and 1 higer bus** for every 1000 total trips replaced by app-assisted taxis. This is a high number that could add to the traffic congestion on the road. Those high number of alone trips could also result in the increase of traffic accidents. Environmental pollution due to an increased fuel consumption will be highly likely to occur.

5. Conclusion, Recommendation & Future Research Direction

5.1 Conclusion

The introduction of application assisted taxi service as a new mode of transport has raised a lot of questions in different countries where this mode is operating and the questions raised have come up with results which are making us to have a better knowledge about this mode and its interaction with the transport system especially with the sustainable public transport modes. In this research an attempt has been made to device question related to the mode choice impact of application-assisted taxi service in Addis Ababa context. We made a focus on four specific objectives under this general objective and come up with results that led us to the following concluding remarks.

Characterization of app-assisted taxi service users have been done in order to look whether this service is serving the majority of passengers or a segment of it and we were able to find that young to middle aged passengers falling in the age range between 18-45 are the once that mostly adopt this service. Females took the highest percentage with regard to the gender distribution (52.6 %) whereas males account for 47.4 % of the users. It is also seen that passengers who utilize this service are those that earn mid to high income and having Education that is at the highest level. Employment status is also an important indicator to the utilization level showing those who are fully employed use them in most occasions.

Commuting trip to work and home are found to be the travel needs that most application-assisted taxi service passengers use them for. School trip, Shopping/marketing and Recreational trip took the next level among travel adoption reasons each with a percentage value of 11.35, 11.15 and 10.18. Trip to health center and other trip purposes are found to be the travel needs with the smallest proportions (5.68 and 2.94 respectively). This indicates that when devising policies, consideration should be given to improve the public transport operations especially at the time at which commuting trips are performed.

The relative mode substitution effect of app-assisted taxies has also been addressed with the aim to look at the effect of their introduction on more sustainable modes of transport. The analysis made utilizing the question which transport mode the user would have used had app-assisted taxies are not functioning in the transport system showed that minibuses are the most replaced once

followed by conventional lada taxies, private car, large bus and higer busses each with 53.65 ,23.7, 12.24,5.99 and 4.43 percent frequencies respectively.

Modelling using multinomial regression have been used in order to indicate which factors do tell us to be the reasons for the shift from each specific available travel modes to app-assisted taxies. This has been done to make us aware of which factors we should focus at in order to curb the potential substitutive impact of app-assisted taxies on more sustainable public transport modes. Private car has been selected as a base case during the modelling task. Accordingly, we were able to find that the variables related to socioeconomic factors, adoption reasons and travel needs are the significant once that explain the shift from the different modes with different significance levels. Income level 3(> 5000birr) explain the shift from all modes with significant negative values indicating that passengers with those income levels will be more likely to shift from private cars. Education level 5 (masters &above) is a less likely reason for the shift from the minibus and more likely to be associated with passengers shifting from private car.

Among the adoption reasons: Lack of public transport and time saving explain the shift from the minibus taxies positively. On the other hand parking and traffic congestion has a significant negative value for the shift indicating passengers will be less likely to shift from minibus for these reason and more likely to be associated with the shift from private cars .Work and school trips are the travel purposes that do affect the shift from the minibuses positively. Recreational and other trip purposes do affect the shift from minibus negatively indicating passengers will be more likely to shift form private cars for these reasons.The traditional lada taxies are replaced with app-assisted taxies for seeking comfort and presence of covid adoption reasons with positive value while parking explain the shift with negative values. School and home trips are associated significantly with positive value for the shift from traditional lada taxies. Large busses and higer busses are replaced with app-assisted taxies for Lack of public transport and work travel reasons.

5.2 Recommendation

The result of mode choice issue that have been raised in this research indicated that a shift from the minibuses and large busses to app-assisted taxies has come mainly as a result of lack of public transport and time saving reasons. The question to passengers as to how they make the trip showed that 83.59% of the trips are undertaken alone indicating that application-assisted taxies are serving like single occupancy vehicles (**SOV**) for most of the cases which could result in several negative externalities like traffic congestion and environmental pollution.

The recommendation to the transport authority here is that an effort should be made to increase the supply of the public transport and make the travel time by the minibuses to be lower especially during commuting to work and home trip times (morning and afternoons) by implementing transport policies that suit for this purpose.

Providing additional attractive incentives to associations engaged in public transport services and others preparing to engage in this service sector in order to increase the supply could do well in this respect. The provision of funds on attractive loan terms by making collaboration with banks is one means of achieving this objective. Doing so will make these transport modes accommodate more passengers and decrease the long waiting time to get these service. The timely provision of BRT system which is going to be operational in the near future will also add to the solution.

The strict implementation of zoning system for trip origination and destination locations for minibus taxis with appropriate travel cost adjustments for long distance travel will reduce the in vehicle travel time which ultimately reduces total travel time .

As to the Application –assisted taxi services, transport Authority should devise policies that urge them to increase the vehicle occupancy by giving operational permissions only for those who accommodate more passengers like 3 or more on peak traffic hours in order to mitigate the problem of congestion that can be associated with the utilization of SOV.

The traditional (lada) taxi owners should look on ways to shift to technologically assisted services as their comfort level is way lower than the application-assisted taxi services which is making them unable to compete with the newer taxi services.

It is also important that the transport Authority should make cooperation's with these transport service operators for data sharing in order to get a better information for future research work related to this mode of transport.

5.3 Future Research Direction

The following areas could possibly be explored in Addis Ababa context in order to further expand our understanding about this mode of transport and their interaction with the future transport system we envisage to have.

- 1:- The effect of Application-assisted Taxi Service on passenger's car purchasing interest.
- 2:- The possibility of integrating Application-assisted taxis with public transport modes.
- 3:- Quantitative analysis of Application-assisted taxi service effects on environmental pollution.
- 4:- A detail analysis of the traffic congestion effects of Application-assisted taxi service.

6.0 References

- Acheampong, R. A., Siiba, A., Okyere, D. K., & Tuffour, J. P. (2020). Mobility-on-demand: An empirical study of internet-based ride-hailing adoption factors, travel characteristics and mode substitution effects. *Transportation Research Part C: Emerging Technologies*, 115(October 2019). <https://doi.org/10.1016/j.trc.2020.102638>
- Aga, M.T. (n.d.). *10 Best Uber-Like Ride & Taxi Service Companies in Ethiopia* — *allaboutETHIO*. [online] allaboutethio.com. Available at: <https://allaboutethio.com/10-best-uber-like-ride-and-taxi-service-companies-in-ethiopia.html> [Accessed 6 June 2021].
- Al-Salih, W. Q., & Esztergár-Kiss, D. (2021). Linking mode choice with travel behavior by using logit model based on utility function. *Sustainability (Switzerland)*, 13(8). <https://doi.org/10.3390/su13084332>
- Aloulou, F. (2018). The Application of Discrete Choice Models in Transport. *Statistics - Growing Data Sets and Growing Demand for Statistics*. <https://doi.org/10.5772/intechopen.74955>
- Barnes, S. J., Guo, Y., & Borgo, R. (2020). Sharing the air: Transient impacts of ride-hailing introduction on pollution in China. *Transportation Research Part D: Transport and Environment*, 86(2020). <https://doi.org/10.1016/j.trd.2020.102434>
- Bashir, M., Yousaf, A., & Verma, R. (2016). Disruptive business model innovation: How a tech firm is changing the traditional taxi service industry. *Indian Journal of Marketing*, 46(4), 49–59. <https://doi.org/10.17010/ijom/2016/v46/i4/90530>
- Clélie Nallet, “The Challenge of Urban Mobility : A Case Study of Addis Ababa Light Rail, Ethiopia” , *Notes de l’Ifri*, Ifri, February 2018.
- Clewlow, Regina R. Mishra, G. S. (2017). Disruptive Transportation: The Adoption, Utilization, and Impacts of Ride-Hailing in the United States. *Genome*, 44(3), 401–412.
- Contreras, S. D., & Paz, A. (2018). The effects of ride-hailing companies on the taxicab industry in Las Vegas, Nevada. *Transportation Research Part A: Policy and Practice*, 115(xxxx), 63–70. <https://doi.org/10.1016/j.tra.2017.11.008>
- Conway, M., Salon, D., & King, D. (2018). Trends in Taxi Use and the Advent of Ridehailing, 1995–2017: Evidence from the US National Household Travel Survey. *Urban Science*, 2(3), 79. <https://doi.org/10.3390/urbansci2030079>

- CURRY, D., 2021. *Ride Hailing Taxi App Revenue and Usage Statistics (2021)*. [online] Business of Apps. Available at: <<https://www.businessofapps.com/data/ride-hailing-app-market/>> [Accessed 6 June 2021].
- de Souza Silva, L. A., de Andrade, M. O., & Alves Maia, M. L. (2018). How does the ride-hailing systems demand affect individual transport regulation? *Research in Transportation Economics*, 69, 600–606. <https://doi.org/10.1016/j.retrec.2018.06.010>
- Dell’Orco, M. and Ottomanelli, M. (2012) “Simulation of Users Decision in Transport Mode Choice Using Neuro-Fuzzy Approach,” [online] <https://www.researchgate.net>. Available at: <https://www.researchgate.net/publication/235948146>
- Dias, F. F., Lavieri, P. S., Garikapati, V. M., Astroza, S., Pendyala, R. M., & Bhat, C. R. (2017). A behavioral choice model of the use of car-sharing and ride-sourcing services. *Transportation*, 44(6), 1307–1323. <https://doi.org/10.1007/s11116-017-9797-8>
- Dong, Y., Wang, S., Li, L., & Zhang, Z. (2018). An empirical study on travel patterns of internet based ride-sharing. *Transportation Research Part C: Emerging Technologies*, 86(October 2017), 1–22. <https://doi.org/10.1016/j.trc.2017.10.022>
- Du, M., Cheng, L., Li, X., & Yang, J. (2019). Investigating the influential factors of shared travel behavior: Comparison between app-based third taxi service and free-floating bike sharing in Nanjing, China. *Sustainability (Switzerland)*, 11(16). <https://doi.org/10.3390/su11164318>
- Eisenmeier, S. (2018). Case study Ride-sharing platforms in developing countries : effects and implications in Mexico City Background Paper. *Pathways for Prosperity Commission, University of Oxford, Background(3)*, 1–28.
- Erhardt, G. D., Roy, S., Cooper, D., Sana, B., Chen, M., & Castiglione, J. (2019). Do transportation network companies decrease or increase congestion? *Science Advances*, 5(5). <https://doi.org/10.1126/sciadv.aau2670>
- Etminani-Ghasrodashti, R., & Hamidi, S. (2019). Individuals’ demand for ride-hailing services: Investigating the combined effects of attitudinal factors, land use, and travel attributes on demand for app-based taxis in Tehran, Iran. *Sustainability (Switzerland)*, 11(20). <https://doi.org/10.3390/su11205755>
- Gallego, G., & Li, A. (2017). Attention, consideration then selection. *57th Annual AGIFORS Symposium, 2017-October*, 1–40. <https://doi.org/10.2139/ssrn.2926942>
- Giddy, J. K. (2019). The influence of e-hailing apps on urban mobilities in South Africa. *African*

- Geographical Review*, 38(3), 227–239. <https://doi.org/10.1080/19376812.2019.1589732>
- Graehler, M., Mucci, R. A., & Erhardt, G. D. (2019). Understanding the Recent Transit Ridership Decline in Major US Cities: Service Cuts or Emerging Modes? *98th Annual Meeting of the Transportation Research Board, January*, 1–19.
- Guo, Y., Li, X., & Zeng, X. (2019). Platform Competition in the Sharing Economy: Understanding How Ride-Hailing Services Influence New Car Purchases. *Journal of Management Information Systems*, 36(4), 1043–1070. <https://doi.org/10.1080/07421222.2019.1661087>
- Harrell, F. E. (2015). Transform-Both-Sides Regression 16.1 Background. In *Regression Modeling Strategies*. <https://doi.org/10.1007/978-3-319-19425-7>
- Henama, U. S., & Sifolo, P. P. S. (2017). Uber: The South Africa experience. *African Journal of Hospitality, Tourism and Leisure*, 6(2), 1–10.
- Henao, A., & Marshall, W. E. (2019). The impact of ride-hailing on vehicle miles traveled. *Transportation*, 46(6), 2173–2194. <https://doi.org/10.1007/s11116-018-9923-2>
- Hensher, D. A., & Greene, W. H. (2002). Specification and estimation of the nested logit model: Alternative normalisations. *Transportation Research Part B: Methodological*, 36(1), 1–17. [https://doi.org/10.1016/S0191-2615\(00\)00035-7](https://doi.org/10.1016/S0191-2615(00)00035-7)
- Koppleman, F. S. & Chandra, B., 2006. A Self Instructing Course in Mode Choice Modeling: Georgia: s.n.
- Kropko, J. (2008) “Choosing Between Multinomial Logit and Multinomial Probit Models for Analysis of Unordered Choice Data.” Available at: <https://cdr.lib.unc.edu/concern/dissertations/d217qp57h> (Accessed: February 16, 2021).
- Kwak, C., & Clayton-Matthews, A. (2002). Multinomial logistic regression. *Nursing Research*, 51(6), 404–410. <https://doi.org/10.1097/00006199-200211000-00009>
- Li, Z., Hong, Y., & Zhang, Z. (2016). An empirical analysis of on-demand ride sharing and traffic congestion. *2016 International Conference on Information Systems, ICIS 2016*, 4–13. <https://doi.org/10.24251/hicss.2017.002>
- Moody, J., & Zhao, J. (2020). Adoption of Exclusive and Pooled TNC Services in Singapore and the US. *Journal of Transportation Engineering, Part A: Systems*, 146(9), 04020102. <https://doi.org/10.1061/jtepbs.0000438>
- Mourdoukoutas, E., 2021. *Africa's app-based taxis battle Uber over market share*. [online]

- Africa Renewal. Available at: <<https://www.un.org/africarenewal/magazine/august-november-2017/africa%E2%80%99s-app-based-taxis-battle-uber-over-market-share>> [Accessed 6 June 2021].
- Oviedo, D., Granada, I., & Perez-Jaramillo, D. (2020). Ridesourcing and travel demand: Potential effects of transportation network companies in Bogotá. *Sustainability (Switzerland)*, 12(5), 1–16. <https://doi.org/10.3390/su12051732>
- Rayle, L., Shaheen, S., Chan, N., and Dai, D. (2014) App-Based, On-Demand Ride Services : Comparing Taxi and Ridesourcing Trips and User Characteristics in San Francisco.
- Shamshiripour, A., Rahimi, E., Shabanpour, R., & Mohammadian, A. (Kouros). (2020). How is COVID-19 reshaping activity-travel behavior? Evidence from a comprehensive survey in Chicago. *Transportation Research Interdisciplinary Perspectives*, 7. <https://doi.org/10.1016/j.trip.2020.100216>
- Shen, H., Zou, B., Lin, J., & Liu, P. (2020). Modeling travel mode choice of young people with differentiated E-hailing ride services in Nanjing China. *Transportation Research Part D: Transport and Environment*, 78(December 2019), 1–17. <https://doi.org/10.1016/j.trd.2019.102216>
- Tang, B. J., Li, X. Y., Yu, B., & Wei, Y. M. (2020). How app-based ride-hailing services influence travel behavior: An empirical study from China. *International Journal of Sustainable Transportation*, 14(7), 554–568. <https://doi.org/10.1080/15568318.2019.1584932>
- Tarabay, R., & Abou-Zeid, M. (2020). Modeling the choice to switch from traditional modes to ridesourcing services for social/recreational trips in Lebanon. In *Transportation* (Vol. 47, Issue 4). Springer US. <https://doi.org/10.1007/s11116-019-09973-x>
- Tirachini, A. (2020). Ride-hailing, travel behaviour and sustainable mobility: an international review. In *Transportation* (Vol. 47, Issue 4). Springer US. <https://doi.org/10.1007/s11116-019-10070-2>
- Tirachini, A., & Gomez-Lobo, A. (2020). Does ride-hailing increase or decrease vehicle kilometers traveled (VKT)? A simulation approach for Santiago de Chile. *International Journal of Sustainable Transportation*, 14(3), 187–204. <https://doi.org/10.1080/15568318.2018.1539146>

- www.macrotrends.net. (n.d.). *Addis Ababa, Ethiopia Metro Area Population 1950-2020*. [online]
Available at: <https://www.macrotrends.net/cities/20921/addis-ababa/population>
- Young, M., & Farber, S. (2019). The who, why, and when of Uber and other ride-hailing trips: An examination of a large sample household travel survey. *Transportation Research Part A: Policy and Practice*, 119(June 2018), 383–392. <https://doi.org/10.1016/j.tra.2018.11.018>
- Zhang, Y., Guo, H., Li, C., Wang, W., Jiang, X., & Liu, Y. (2016). Which One is More Attractive to Traveler, Taxi or Tailored Taxi? An Empirical Study in China. *Procedia Engineering*, 137, 867–875. <https://doi.org/10.1016/j.proeng.2016.01.327>
- Zhong, J., Ye, X., Wang, K., & Li, D. (2018). A Modeling Analysis of Impact from E-Hailing Service on Non-Work Travel Mode in Shanghai, China. *Transportation Research Record*, 2672(47), 125–134. <https://doi.org/10.1177/0361198118792324>

7.0 Appendix

7.1 Questionnaire

A: - Questionnaire in English

Dear participant, please help us by taking some time to answer the questions presented under which will be used for doing transportation research for a thesis project titled Influence of Application-Assisted Taxi service on passenger's mode choice behavior (case of Addis Ababa Residents) . Please note that the information will only be used for scientific research and will be kept confidential. You are required to be a permanent resident of Addis Ababa in order to fill in the questionnaire. Your participation is valuable for the research finding which will be an input to device policies for the provision of sustainable transport in the capital. Thanks in Advance!

(Please note that Application-assisted taxi service are defined as taxies which give service based on a request made by mobile applications. Examples are: - (Ride, Zyrider, Feres, Seregela, Hello ...etc) taxies. You can fill in the questionnaire if you have used it at least once in the past month.

Part 1:- Socio Economic Characteristics

1. Sex

1.1 Male 1.2 Female

2. Age

2.1 18-29 2.2 30-45 2.3 46-60 2.4 > 60

3. Educational status

3.1 8th grade and below 3.2 completed preparatory and high school (Grade 9-12)

3.3 Completed Diploma 3.4 Completed degree

3.5 Completed Graduate Studies and above

4. Marital status

4.1 Single

4.2 Married

4.3 Divorced/ Widowed

5. House hold size

6. Income level

6.1 Less than 1, 000 Birr

6.2 from 1, 000 to 3, 000 Birr

6.3 From 3,001 to 5,000

6.4 from 5,001 to 10, 000

6.5 From 10,001 to 15,000

6.6 from 15,001 to 20,000 Birr

6.7 From 20,001 to 30,000

6.8 above 30,000 Birr

7. Employment status

7.1 Employed- Full time 7.2 Employed -Part time 7.3 Self - Employed

7.4 Student 7.5 Unemployed 7.6 Retired

8. Do you have a private car?

8.1 Yes

8.2 No

9. What is special name of your House hold location?

Part 2:- Trip related Characteristics

Please Answer Question 10-18 based on information from most of the trips you made by application-assisted taxi service.

10. What is your Reason for using application assisted taxi service? You can choose more than one reason from the lists available for this question.

10.1 Lack of public transport

10.2 Time saving

10.3 Being Economical (cheaper)

10.4 Parking problem

10.5 seeking Comfort

10.6 Traffic congestion

10.7 Presence of Covid 19

10.8 Other

11. What is the travel purpose of most of the trips you made using an application assisted taxi?

Please select only the frequent ones.

11.1 Work Trip

11.2 School Trip

11.3 Trip to Home

11.4 Shopping/marketing

11.5 Accessing Health centers

11.6 Recreational Trip

11.7 Other.....

12. What travel mode would you have generally used if there is no an application-assisted taxi

Service for most of the trips you made? Please select one.

- 12.1 Large Bus 12.2 Minibus 12.3 private car 12.4 Lada (Traditional) taxi
12.5 Rail 12.6 Walking 12.7 Higer Bus 12.8 other.....

13. What will be the average Travel Time of Alternative mode you would have used in
Question 12 for most of the trip?

14. What travel time do you spend using an application-assisted taxi for most of your trip on
average?

15. Please fill the following information by selecting only your most frequent trip

Trip Purpose: - To go to

- a. Work b. school c. shopping/marketing d. Health Center e. Recreational Trip

Origination Location special Name..... Destination Location Special Name.....

16. What time of day do you use application-assisted taxi for most of your trips?

- a) Morning (5–10am) b) Midday (10am–3pm) c)Afternoon (3–7pm)
d) Evening (7–11pm) e) Night (11pm–5am)

17. Do you use application-assisted taxi alone or you share it with others?

- 17.1 I use it alone 17.2 I share it with others

18. How do you use app-assisted taxi service for your trip mostly?

- 18.1 For the whole trip. 18.2 To connect to public transport.

19. How many times have you used application-assisted taxi service on last week?

20. What is your view on the cost?

- 20.1 Very Expensive 20.2 Expensive 20.3 Fair
20.4 cheap 20.5 very cheap

B - Questionnaire in Amharic

ይህ መጠይቅ የሞባይል አፕልኬሽንን ተጠቅመው የሚያገኙት የታክሲ ትራንስፖርት አገልግሎቶች በመጓጓዣ አመራረጥ ላይ ያላቸውን ተፅእኖ በመገምገም ተመስርቶ ለሚዘጋጅው ጥናታዊ ፀሁፍ መረጃ ለመሰብሰብ የተዘጋጀ ነው። መረጃው ለሳይንሳዊ ጥናት አገልግሎት ብቻ የሚውል መሆኑን ተረድተው የሚከተሉትን ጥያቄዎች በጥንቃቄ እንዲሞሉልን እንጠይቃለን። መጠይቁን ለመሙላት ቋሚ የመኖሪያ አድራሻዎ እና የስራ ቦታዎ አዲስ አበባ መሆን ይኖርበታል።

በዚህ የትራንስፖርት አማራጭ ውስጥ የሚከተሉት የሞባይል አፕልኬሽንን ተጠቅመው የሚያገኙት የታክሲ ትራንስፖርት አገልግሎቶች ናቸው(ለምሳሌ ራይድ፣ዛይራይድ፣ፈረስ፣ሰረገላ፣ሄሎ አና.... የመሳሰሉት)። የእርስዎ መረጃ በከተማው ውስጥ ለሚስተዋለው የትራንስፖርት ችግር ዘላቂታዊ መፍትሄ ለመስጠት ለታሰበው ስራ ግብአት እንዳለው በመረዳት ጥያቄዎቹን እንዲሞሉልን በትህትና እንጠይቃለን ። ባለፈው ወር ቢያንስ አንድ ጊዜ አገልግሎቱን ከተጠቀሙ መጠይቁን መሙላት ይችላሉ።

መረጃውን በመሙላት ሰለተባበሩን በቅድሚያ እናመሰግናለን።

ክፍል 1 :- ማህበራዊ እና ኢኮኖሚያዊ ባህሪያት

1. ፆታ

- 1.1 ወንድ 1.2 ሴት

2. እድሜ

- 2.1 : 18-29 2.2 : 30-45 2.3: 46-60 2.4 ከ 60 በላይ

3. የትምህርት ደረጃ

- 3.1ስምንተኛ ክፍል እና ከዚያ በታች 3.2 ከሁለተኛ ደረጃ እስከመሰናዶ (ከ9-12 ክፍል)
- 3.3 ሰርቲፊኬት እና ዲፕሎማ 3.4 ዲግሪ 3.5 ማስተርስ እና ከዚያ በላይ

4 የትዳር ሁኔታ

- 4.1 ያገባ 4.2 ያላገባ 4.3 የፈታ/የትዳር አጋር የሞተበት

5 የቤተሰብዎ ብዛት ስንት ነው?

6 ወርሃዊ የቤተሰብዎ ገቢ ስንት ነው?

- 6.1 ከ 1,000 ብር በታች 6.2 ከ 1,000 እስከ 3,000 ብር
- 6.3 ከ 3,001 እስከ 5,000 ብር 6.4 ከ 5,001 እስከ 10,000 ብር
- 6.5 ከ 10,001 እስከ 15,000 ብር 6.6 ከ 15,001 እስከ 20,000 ብር
- 6.7 ከ 20,001 እስከ 30,000 ብር 6.8 ከ 30,000 ብር በላይ

7 የስራ ሁኔታ

- 7.1 ሙሉ ጊዜ ቅጥረኛ 7.2 ከፊል ተቀጣሪ 7.3 የግል ሰራተኛ
- 7.4 ተማሪ 7.5 ሥራ ፈላጊ 7.6 ጡረታ የወጣ/የወጣች

8. የግል መኪና አሎት?

- 8.1 አዎ 8.2 አይ

9. እባክዎን የመኖሪያ ሰፈርዎን ልዩ ስም ይግለጹልን?

ክፍል 2 :- የጉዞ ባህሪያት

እባክን የሚቀጥሉትን ከ.ተ.ቁ 10-18 ያሉትን ጥያቄዎች የሞባይል አፕልኬሽንን በሚጠቀም የታክሲ አገልግሎት ተጠቅመው ባደረጉት አብዛኛው የጉዞ ታሪክዎ ተመስርተው ይመልሱልን ::

10. የሞባይል አፕልኬሽንን የሚጠቀም የታክሲ አገልግሎት ለአብዛኛው ጉዞዎ የተጠቀሙበት ምክንያት ምንድን ነው:: ለዚህ ጥያቄ ከአንድ በላይ አማራጭ መምረጥ ይችላሉ::

- 10.1 የህዝብ ትራንስፖርት ማጣት 10.2 ጊዜ ለመቆጠብ 10.3 ዋጋው ተመጣጣኝ በመሆኑ
- 10.4 የፓርኪንግ ችግር በመኖሩ 10.5 ምችት ለማግኘት 10.6 የትራፊክ መጨናነቅ ስለሌለ
- 10.7 ኮሮና በመኖሩ 10.8 ሌላ.....

11. የሞባይል አፕልኬሽንን የሚጠቀም ታክሲ ለአብዛኛው ጉዞዎ የሚጠቀሙበት የጉዞ አይነት ምንድን ነው? እባክዎ በተደጋጋሚ የሚጠቀሙባቸውን ብቻ ይምረጡ::

- 11.1 ወደ ሥራ ለመሄድ 11.2 ለትምህርት 11.3 ወደ ቤት ለመሄድ
- 11.4 ለእቃ ግብይት 11.5 ለመዝናናት 11.6 ለህክምና 11.7 ሌላ.....

12. የሞባይል አፕልኬሽንን የሚጠቀም ታክሲ አገልግሎት ባይኖር ኖሮ ጉዞዎን በአብዛኛው በየትኛው የትራንስፖርት አማራጭ ያከናውኑ ነበር? እባክዎ አንድ ምርጫ ብቻ ይምረጡ።

- 12.1 በትልቅ ባስ 12.2 በሚኒባስ 12.3 በግል መኪና 12.4 በላዳ
- 12.5 በባቡር 12.6 በእግር 12.7 በሀይገር ባስ 12.8 ሌላ.....

13. በተራ ቁጥር 12 በተጠቀሰው የትራንስፖርት አይነት ቢጠቀሙ ኖሮ ለሚያደርጉት አብዛኛው ጉዞዎ የሚወስድባት ጊዜ በአማካይ ምን ያህል ይሆናል?

14. አፕልኬሽንን የሚጠቀም ታክሲ አገልግሎት ተጠቅመው ለአብዛኛው ጉዞዎ የወሰደባት የጉዞ ጊዜ በአማካይ ስንት ነው?

15. እባክዎ የሚቀጥለውን መረጃ በተደጋጋሚ የሚያደርጉትን አንድ የጉዞ አይነት ብቻ በመምረጥ ይመልሱልን። የጉዞው ምክንያት

- 15.1 ወደ ሥራ ለመሄድ 15.2 ለትምህርት 15.3 ወደ ቤት ለመሄድ
- 15.4 ለእቃ ግብይት 15.5 ለመዝናናት 15.6 ለህክምና 15.7 ሌላ.....
- የመነሻ ቦታ ልዩ ስም..... የመድረሻ ቦታ ልዩ ስም.....

16. አብዛኛው ጉዞዎን በየትኛው ጊዜ ያደርጋሉ?

- 16.1 ጠዋት(11:00- 4:00) 16.2 ቀን (4:00- 9:00) 16.3 ከሰዓት በኋላ (9:00- 1:00)
- 16.4 ማታ (1:00- 5:00) 16.5 ለሊት (5:00- 11:00) ሰዓት

17. አብዛኛውን ጊዜ ጉዞውን የሚያደረጉት ብቻዎን ነው ወይስ ከሌሎች ሰዎች ጋር?

- 17.1 ብቻዬን 17.2 ከሌሎች ሰዎች ጋር

18. የሞባይል አፕልኬሽንን የሚጠቀም ታክሲ ለምን ያህል የጉዞ አካል ይጠቀማሉ?

- 18.1 ለሙሉ ጉዞ 18.2 ወደ ህዝብ ትራንስፖርት ለመገናኘት

19. ባለፈው ሳምንት የሞባይል አፕልኬሽንን የሚጠቀም ታክሲ አገልግሎት ለምን ያህል ጊዜ ተጠቅመዋል?.

20. ስለዋጋው ያሎት አስተያየት ምን ይመስላል?

- 20.1 በጣም ውድ 20.2 ውድ 20.3 ተመጣጣኝ
- 20.4 ርካሽ 20.5 በጣም ርካሽ

7.2 Tables for Multi-Collinearity Checking

Correlations								
		Edu	Income	Lack.pt	Time.Saving	Economy	Par.pro	Comfort
Edu	Pearson Correlation	1	.277**	-.116*	-0.021	0.017	.193**	0.055
	Sig. (2-tailed)		0.000	0.024	0.681	0.744	0.000	0.284
	N	384	384	384	384	384	384	384
Income	Pearson Correlation	.277**	1	-.215**	0.087	0.017	.290**	.128*
	Sig. (2-tailed)	0.000		0.000	0.089	0.734	0.000	0.012
	N	384	384	384	384	384	384	384
Lack.pt	Pearson Correlation	-.116*	-.215**	1	-.199**	-.108*	-.279**	-.338**
	Sig. (2-tailed)	0.024	0.000		0.000	0.034	0.000	0.000
	N	384	384	384	384	384	384	384
Time.Saving	Pearson Correlation	-0.021	0.087	-.199**	1	-0.029	-.162**	-.118*
	Sig. (2-tailed)	0.681	0.089	0.000		0.576	0.001	0.021
	N	384	384	384	384	384	384	384
Economy	Pearson Correlation	0.017	0.017	-.108*	-0.029	1	0.020	-0.063
	Sig. (2-tailed)	0.744	0.734	0.034	0.576		0.694	0.216
	N	384	384	384	384	384	384	384
Par.pro	Pearson Correlation	.193**	.290**	-.279**	-.162**	0.020	1	0.043
	Sig. (2-tailed)	0.000	0.000	0.000	0.001	0.694		0.398
	N	384	384	384	384	384	384	384
Comfort	Pearson Correlation	0.055	.128*	-.338**	-.118*	-0.063	0.043	1

	Sig. (2-tailed)	0.284	0.012	0.000	0.021	0.216	0.398	
	N	384	384	384	384	384	384	384
Congestion	Pearson Correlation	0.098	.125*	-.202**	-0.079	-0.047	.131**	0.001
	Sig. (2-tailed)	0.055	0.014	0.000	0.121	0.356	0.010	0.988
	N	384	384	384	384	384	384	384
Covid	Pearson Correlation	0.078	0.040	-0.082	-0.036	-0.001	-0.012	0.036
	Sig. (2-tailed)	0.127	0.439	0.108	0.487	0.987	0.820	0.485
	N	384	384	384	384	384	384	384
Work.tp	Pearson Correlation	.182**	-0.037	0.065	0.001	0.040	-0.019	-0.065
	Sig. (2-tailed)	0.000	0.465	0.205	0.981	0.431	0.707	0.203
	N	384	384	384	384	384	384	384
School.tp	Pearson Correlation	-.213**	-0.008	-0.022	.106*	-0.039	-0.093	0.044
	Sig. (2-tailed)	0.000	0.876	0.662	0.038	0.449	0.069	0.395
	N	384	384	384	384	384	384	384
Home.tp	Pearson Correlation	0.024	0.006	0.056	0.066	0.014	-0.033	-0.038
	Sig. (2-tailed)	0.635	0.905	0.271	0.199	0.779	0.524	0.455
	N	384	384	384	384	384	384	384
Reac.tp	Pearson Correlation	-0.064	.183**	-.136**	0.092	0.010	0.064	0.051
	Sig. (2-tailed)	0.208	0.000	0.008	0.071	0.844	0.214	0.318
	N	384	384	384	384	384	384	384
Other.tp	Pearson Correlation	0.025	0.084	-0.043	-0.052	.111*	.195**	0.025
	Sig. (2-tailed)	0.629	0.100	0.397	0.313	0.030	0.000	0.629
	N	384	384	384	384	384	384	384

Correlations								
		Congestion	Covid	Work.tp	School.tp	Home.tp	Reac.tp	Other.tp
Edu	Pearson Correlation	0.098	0.078	.182**	-.213**	0.024	-0.064	0.025
	Sig. (2-tailed)	0.055	0.127	0.000	0.000	0.635	0.208	0.629
	N	384	384	384	384	384	384	384
Income	Pearson Correlation	.125*	0.040	-0.037	-0.008	0.006	.183**	0.084
	Sig. (2-tailed)	0.014	0.439	0.465	0.876	0.905	0.000	0.100
	N	384	384	384	384	384	384	384
Lack.pt	Pearson Correlation	-.202**	-0.082	0.065	-0.022	0.056	-.136**	-0.043
	Sig. (2-tailed)	0.000	0.108	0.205	0.662	0.271	0.008	0.397
	N	384	384	384	384	384	384	384
Time.Saving	Pearson Correlation	-0.079	-0.036	0.001	.106*	0.066	0.092	-0.052
	Sig. (2-tailed)	0.121	0.487	0.981	0.038	0.199	0.071	0.313
	N	384	384	384	384	384	384	384
Economy	Pearson Correlation	-0.047	-0.001	0.040	-0.039	0.014	0.010	.111*
	Sig. (2-tailed)	0.356	0.987	0.431	0.449	0.779	0.844	0.030
	N	384	384	384	384	384	384	384
Par.pro	Pearson Correlation	.131**	-0.012	-0.019	-0.093	-0.033	0.064	.195**
	Sig. (2-tailed)	0.010	0.820	0.707	0.069	0.524	0.214	0.000

	N	384	384	384	384	384	384	384
Comfort	Pearson Correlation	0.001	0.036	-0.065	0.044	-0.038	0.051	0.025
	Sig. (2-tailed)	0.988	0.485	0.203	0.395	0.455	0.318	0.629
	N	384	384	384	384	384	384	384
Congestion	Pearson Correlation	1	-0.033	0.051	0.077	-0.007	0.093	0.006
	Sig. (2-tailed)		0.524	0.319	0.130	0.889	0.070	0.911
	N	384	384	384	384	384	384	384
Covid	Pearson Correlation	-0.033	1	0.034	-0.014	.104*	-0.002	-0.009
	Sig. (2-tailed)	0.524		0.503	0.779	0.041	0.972	0.866
	N	384	384	384	384	384	384	384
Work.tp	Pearson Correlation	0.051	0.034	1	-.239**	-.167**	-.235**	-0.097
	Sig. (2-tailed)	0.319	0.503		0.000	0.001	0.000	0.057
	N	384	384	384	384	384	384	384
School.tp	Pearson Correlation	0.077	-0.014	-.239**	1	-0.047	0.003	-0.048
	Sig. (2-tailed)	0.130	0.779	0.000		0.362	0.952	0.353
	N	384	384	384	384	384	384	384
Home.tp	Pearson Correlation	-0.007	.104*	-.167**	-0.047	1	-0.072	0.027
	Sig. (2-tailed)	0.889	0.041	0.001	0.362		0.159	0.597
	N	384	384	384	384	384	384	384

Reac.tp	Pearson Correlation	0.093	-0.002	-.235**	0.003	-0.072	1	-0.001
	Sig. (2-tailed)	0.070	0.972	0.000	0.952	0.159		0.981
	N	384	384	384	384	384	384	384
Other.tp	Pearson Correlation	0.006	-0.009	-0.097	-0.048	0.027	-0.001	1
	Sig. (2-tailed)	0.911	0.866	0.057	0.353	0.597	0.981	
	N	384	384	384	384	384	384	384

Tolerance and Variance inflation factor

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.895	.352		8.220	.000		
	Edu	.043	.077	.030	.555	.579	.828	1.208
	Income	.024	.043	.031	.555	.579	.797	1.255
	Lack.pt	-.435	.160	-.167	-2.717	.007	.659	1.518
	Time.Saving	-.437	.145	-.169	-3.010	.003	.796	1.257
	Economy	-.203	.367	-.028	-.552	.581	.944	1.059
	Par.pro	.058	.203	.016	.284	.777	.760	1.316
	Comfort	.000	.175	.000	.001	.999	.803	1.245
	Congestion	.126	.289	.023	.436	.663	.882	1.134
	Covid	.230	.245	.048	.936	.350	.960	1.041
	Work.tp	-.199	.144	-.077	-1.381	.168	.799	1.251
	School.tp	-.014	.194	-.004	-.074	.941	.862	1.161
	Home.tp	.056	.151	.019	.372	.710	.916	1.091
	Reac.tp	.276	.202	.073	1.364	.173	.867	1.154
	Other.tp	-.137	.344	-.021	-.399	.690	.934	1.071

a. Dependent Variable: ModeRep