URBAN HOUSEHOLD ROAD TRAVEL DEMAND AND TRANSPORT MODE CHOICE

The Case of Kampala, Uganda

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By

Susan Watundu

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy (Economics) of the University of Dar es Salaam

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by the University of Dar es Salaam a dissertation entitled: "***Urban Household Road Travel Demand and Transport Mode Choice: A Case of Kampala, Uganda"***, in partial fulfillment of the requirements for the degree of Doctor of Philosophy (Economics) of the University of Dar es Salaam.

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DECLARATION

AND

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I, **Susan Watundu**, declare that this dissertation is my own original work and that it has not been presented and will not be presented to any other University for a similar or any other degree award.

Signature: …………………………..

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DEDICATION

To my husband Noah Mwelu and our daughters Mariza Susan, Blessed Malyamu, Talituleka Hope, Peace Joy and Lucky Mercy.

LIST OF ABBREVIATIONS AND ACRONYMS

ADT	Average Daily Traffic
ASCLOGIT	Alternative Specific Conditional Logit
BRT	Bus Rapid Transit
CGBL	Court-Griliches-Becker-Lancaster
CLOGIT	Conditional Logit
D.C	District of Columbia
ECMT	European Conference of Ministers of Transport
GKMA	Greater Kampala Metropolitan Area
GMM	Generalized Method of Moments
GPS	Global Positioning System
GOU	Government of Uganda
HSR	High-Speed Rail
JICA	Japan International Cooperation Agency
KM	Kilometer
KMS	Kilometers
KCCA	Kampala Capital City Authority
KMTC	Kampala Metropolitan Transport Corridor
LIMDEP	Limited Dependent Variable Model
LUTI	Land Use Transport Interaction
MFPED	Ministry of Finance, Planning and Economic Development
MNL	Multinomial Logit
MoWT	Ministry of Works and Transport

NBR	Negative Binomial Regression
NEG	New Economic Geography
OECD	Organization for Economic Co-operation and Development
O-D	Origin-Destination Matrix
Prob	Probability
RSDP	Road Sector Development Program
UBOs	Uganda Bureau of Statistics
UK	United Kingdom
UMOT	Unified Mechanism of Travel
UNRA	Uganda National Roads Authority
URA	Uganda Revenue Authority
USA	United States of America
Ushs	Uganda Shillings
US$	United States Dollar
UTODA	United Taxi Operators and Drivers Association
VIF	Variance Inflation Factor

ABSTRACT

This study assesses the determinants of urban household road travel demand and transport mode choice. A negative binomial and ordinary least squares regression, and the alternative specific conditional logit model are estimated using survey data. Results consistently show that daily demand for travel is inversely related to the cost of travel and positively related to average monthly income. Trip volumes increase with household size, age, and education level of the household head, but decreases with car ownership and private sector employment as compared to public sector employment. Distance travelled falls with household size, age and education level but increases with car ownership. An increase in travel time by using a given transport mode reduces the probability of using that mode while the chances of choosing other modes increases. Relative to the chances of choosing a taxi (14-seater minibus), an increase in travel cost and income increases the chances of using a private car or *boda-boda* (motorcycle); the probability of choosing a private car or *boda-boda* is inversely related to trip length and average daily trip volume; rich households as compared to the poor and larger households prefer a private car instead of *boda-boda*; those with older heads prefer less of *boda-boda* and private car; unlike female headed households, male headed ones are more likely to choose *boda-boda* instead of a private car. A combination of solutions is required for sustainable travel demand and traffic management: provision of an efficient public transit system coupled with increased private car parking costs, promotion of car-pooling; road tolls for drive-alone private cars; limiting access times and sensitization programs geared towards reducing unnecessary and avoidable travels.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Cities and road traffic congestion have developed hand-in-hand since the earliest large human settlements (Organization for Economic Co-operation and Development (OECD)/European Conference of Ministers of Transport (ECMT), 2007)[1]. Increasing rural-urban migration and higher rate of population growth among other factors, have led to unbearable levels of road traffic congestion on urban streets, making it a challenge for all large and growing urban areas not only in developed countries but also in medium and small cities in developing countries in Africa. In Uganda, Kampala being the capital city and therefore the major business centre in the country, coupled with increased development, has drawn the desire and the need for people to frequently move to the city. Overtime, Kampala has experienced immense congestion on the city roads that has worsened by stretching into late hours in the night and almost for all days of the week.

Congestion is a negative externality accompanied with a range of high economic costs or loss in terms of time spent while waiting at "stages" (bus stands) and in the traffic jam. This can be regarded as loss of productivity to all sectors of the economy including households. A study by Armah *et al*. (2010) in Accra, Ghana indicate that traffic jams have both economic and health effects with an average of 2 hours lost

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[1] Congestion is a physical situation in which vehicles on the road slow down each others' forward movement due to increased demand for limited road space as the road approaches full capacity (OECD/ECMT, 2007).

between home and work and 1.5 hours lost between work and the nearest health centres. Basing on these results, it was concluded that employers pay 20 percent of wages for no work done.

Other costs include high fuel consumption which is a direct cost associated with frequent stops and long holds in the jam, increased public transport fare, fatigue to drivers especially in the evenings which may lead to unnecessary accidents and a direct cost of wear and tear of vehicles. Traffic congestion also increases air pollution levels, which are hazardous. Congestion has spill over effects in that events that cause congestion may also cause other events. Abnormally high congestions may shift traffic to other roads and may also cause travellers to leave later or go to other destinations, or choose to stay wherever they are. High congestion levels can also lead to an increase in traffic accidents due to closer vehicle spacing commonly known as bumper to bumper driving, and vehicle overheating. Alinange (2010) and Kiggundu (2007), attribute the traffic Jam[2] in Kampala to the structure of the city; that it is single centred and poorly planned, disorganised and outdated with an expensive transport system.

Despite the congestion, road transport is still the major travel mode used in Uganda, carrying over 90 percent of the transit and traffic in the country and 99 percent of the traffic in Kampala (Kampala Capital City Authority (KCCA), 2011). Given the increased development in Kampala, which is the major business town in Uganda that plays a key role in the economic growth of the country as a whole, traffic flow

[2] Road traffic jam is a situation where movement of vehicles frequently stalls for some period of time. Generally, traffic jam and traffic congestion are used synonymously.

towards the city is expected to increase at a much higher rate. As mentioned earlier, increased population, rural-urban migration, as well as improved urban development, cause congestion. The case of Kampala city is not any different given its features, demographic characteristics and improved development as explained in the following sections. These features can affect and influence urban travel.

1.2 Geographic and Demographic Features of Kampala

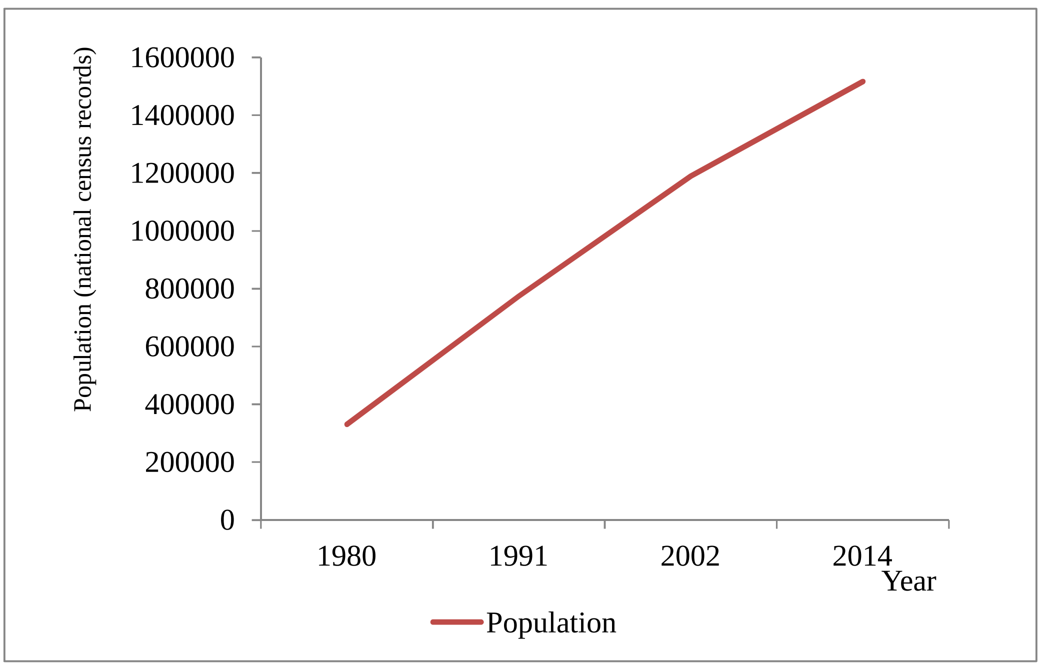
Kampala has a surface area of 189 km^2 with the land area of approximately 176 km^2 and water surface area of approximately 13 km^2. Kampala is divided into 5 geographical zones. It was originally built on 7 hills but expanded to more than 25 hills with steep slopes and wide valleys (Oonyu and Esaete, 2012). Kampala is under the jurisdiction of Kampala Capital City Authority, a legal entity established by Uganda Parliament in 2010 that is responsible for its operations. It hosts most of the government offices, large corporate and business entities, the biggest local markets in the country, and tourist places like the Uganda Museum, the Uganda National Theatre and headquarters for the largest religious organisations to mention a few; the Baha'i house of worship known as the mother temple of Africa as well as the largest mosque, the Catholic, Anglican, Orthodox, Adventist and Pentecostals among other churches. Kampala city is also home for the Buganda kingdom and hosts its ancestral sites that act as tourist attractions. All these increase the influx of people to Kampala city.

There has been an economic boom in Kampala and the country as a whole that has led to the mushrooming of both commercial and residential construction in all the 5 divisions of the city and surrounding districts of Mukono, Mpigi and Wakiso. However, due to either total disregard of existing laws governing construction or selective and lax enforcement of those laws, many buildings were built in road reserves, in gazetted wetlands and often without following established construction specifications. On a regular basis, buildings under construction collapse, killing or injuring construction workers, bystanders or both. Kampala's sewerage and drainage system is still lacking. Despite the rapid population expansion as shown in Figure 1.1, due to the general disregard of proper urban planning and failure to adhere to existing construction guidelines, only 10 percent of the city's population is connected to the sewer lines of the National Water and Sewerage Corporation (NWSC). The poor drainage has led to frequent flooding of the city roads. Given Kampala's hilly nature, the problem is worse during the rainy season. These are indications of no or little effort to mitigate the environmental degradation vested upon the city by the rapid population explosion, including the destruction of green spaces and wetlands. All these affect the flow of traffic on the city roads.

The population of Kampala has increased from 330,700 habitants in the 1980s to approximately 774,341 in 1991 and 1,189,150 in 2002 as shown in Figure 1.1. But mid-year projections prior to the national census indicate that the population of Kampala was approximately 1,788,600 habitants by 2013 up from 1,659,600 in 2011 (Uganda bureau of statistics (UBOS), 2012). However, from the recently concluded national census, the resident population of Kampala currently stands at 1,516,210.

The 2014 census ranks Kampala city as the second among the highly populated urban centres in Uganda after her neighbouring Wakiso (UBOS, 2014). Figure 1.1 shows an increasing population of Kampala from the 1980s to 2014. Basing on the national census carried out in 2002 and 2014, the population growth rate of Kampala has increased from 1.8 to 2 percent from 1980-2002 to 2002-2014 period. The growth rate shot up to 3.68 in the period 1991- 2002 but dropped to approximately 2 percent in the 2002-2014 period. The current total number of households in Kampala stands at 418,787 with an average household size of 3.5. Kampala's current gender population is approximately at 50 percent ratio with 722,638 males and 793,572 females.

Figure 1.1: Population Trends of Kampala City (1980-2014)



Source: Author's illustration from the National Census Statistics (1980-2014).

The demographic and health survey reports indicate that urban household members are more likely to be literate as compared to their rural counterparts (UBOS, 2010). In Kampala, adult literacy levels have increased from 92 percent in 2009/10 to 93 percent in 2012/13. In 2009/10, only 4.4 percent of Kampala residents were reported not to have obtained any formal schooling, and in 2012/13 registered the lowest proportion (6 percent) of household heads without formal education, and high (91 percent) literacy rates for women. Kampala has the highest proportion of working population (30 percent) as compared to other urban centres in the country.

The labor force participation rate in Kampala is increasing at 10 percent, a higher rate as compared to other regions in the country. In addition, the average income and expenditures of households in Kampala also increased from Ushs.347,900 and Ushs.462,550 in 2005/06 to Ushs.959,400 and Ushs.475,500 in 2009/10 respectively. This is an indication of improved and good welfare of Kampala households, which currently lies in the fifth quartile at 74.9 percent. Kampala has the lowest dependency ratio in the country. The distribution of household heads in Kampala indicates only 6 percent above 60 years, and a good percentage (32.2 percent) being female-headed (UBOS, 2010, 2013). All these are indications of a growing and busy city that imply more travel and increased pressure on road infrastructure.

Until 2014, Kampala capital city remained the primate urban centre in the country since 1991 (UBOS, 2014). However, it has been noted that the proportion of its total urban population has declined steadily from 41 percent in 1991 to 25 percent in 2014. This could be an indication that the neighboring urban areas are growing faster. Although these results may imply that Kampala's neighbouring city centres are also becoming highly urbanised, it may also mean that the centres could actually be residential areas for individuals working in Kampala, thus a high influx of people from these centres to Kampala is expected. UBOS (2014) notes that, urban centres like Kampala capital city have a high day-time population, since it includes people who work in the city but do not reside there. The study on Greater Kampala Metropolitan Area indicates that Kampala is a fast growing city with a day population of approximately 3 million people travelling to and from the city centre (KCCA, 2012)[3]. The day population is expected to double by 2024.

An increase in the population implies more urban travels and has been pointed out as one of the main causes of urban traffic congestion. Figure 1.1 attests to this fact and thus the rise in traffic congestion in Kampala may be attributed to population increase. It is expected that improved transport infrastructure and an efficient transport system can accommodate such demand. Transport infrastructure could be rail, road, water or air. However, the most commonly used transport infrastructure in Kampala is road that accounts for 99 percent of traffic. Therefore, it is necessary to know the state of the road network in Kampala as explained in section 1.3.

[3] Greater Kampala Metropolitan Area constitutes Kampala city and the surrounding urban centres of Mukono, Entebbe, and Wakiso.

1.3 The Road Network, Transport and Traffic Management in Kampala

Kampala's total road network is 1,217.9 km with 38 percent paved and 62 percent unpaved. However, 4.2 percent (51.7 km) of the paved roads are under the jurisdiction of the Ministry of Works, and Transport (MoWT) and the remaining 95.8 percent (1,166.2 km) under KCCA with 415.5 km of bituminous type and 750.6 km of gravel. In regard to the condition of paved roads in Kampala, 20 percent are regarded as good, 28 percent fair and 52 percent are poor. But for the gravel type, only 1 percent were good, 10 percent were fair and the remaining 89 percent were in a poor state (KCCA, 2010). In the year 2011, the average daily automobile traffic flow on these roads was estimated at 181,216 vehicles (KCCA, 2011).

Most of Kampala's roads were constructed in the 1940s and 1950s and majority of them have never undergone any serious repairs or renovations. The city's roads outside the central business district are largely potholed and in a high state of disrepair. Although the government of Uganda (GOU) had implemented the structural adjustment policy in 1987 and developed the Public Investment Plan (1996/97-1998/99) with the development goal of continuous economic growth, little was seen to change in the city. Whilst Kampala city, which is the heart of the economy of Uganda, had long been faced with problems of increased road traffic volumes and accidents, as well as frequent flooding of roads and junctions.

Under these circumstances, with the request of the GOU, the Japan International Cooperation Agency (JICA) conducted a study from December 1996 to November

1997 as part of a 10-year program about "The Improvement of Trunk Road at Kampala Urban Interface Sections". Based on this study, several traffic congestion alleviation projects in Kampala city were implemented including those projects supported by Japan, and drainage improvement projects supported by the World Bank. These projects were expected to alleviate heavy traffic congestion around junctions in the city centre but to no avail. This therefore, raises the need to find out more about road transport and traffic management in Kampala.

Road Transport and Traffic Management

In Uganda, road transport is the most commonly used means of transport carrying about 95 percent of the country's goods and about 99 percent of passengers (Sanya, 2011). Uganda has different road transportation modes used nationwide as well as in the capital city of Kampala. These include buses, "taxis" (15-seater mini-buses), private cars (own) and "*boda-boda*s" (motorcycles). Taxis constitute 21 percent of all the transport modes on the road and they transport 82.6 percent of the passengers. Private cars constitute 36.6 percent and transport 8.8 percent of passengers while *boda-boda*s constitute 42.2 percent and they transport 8.5 percent of the passengers (KCCA, 2011).

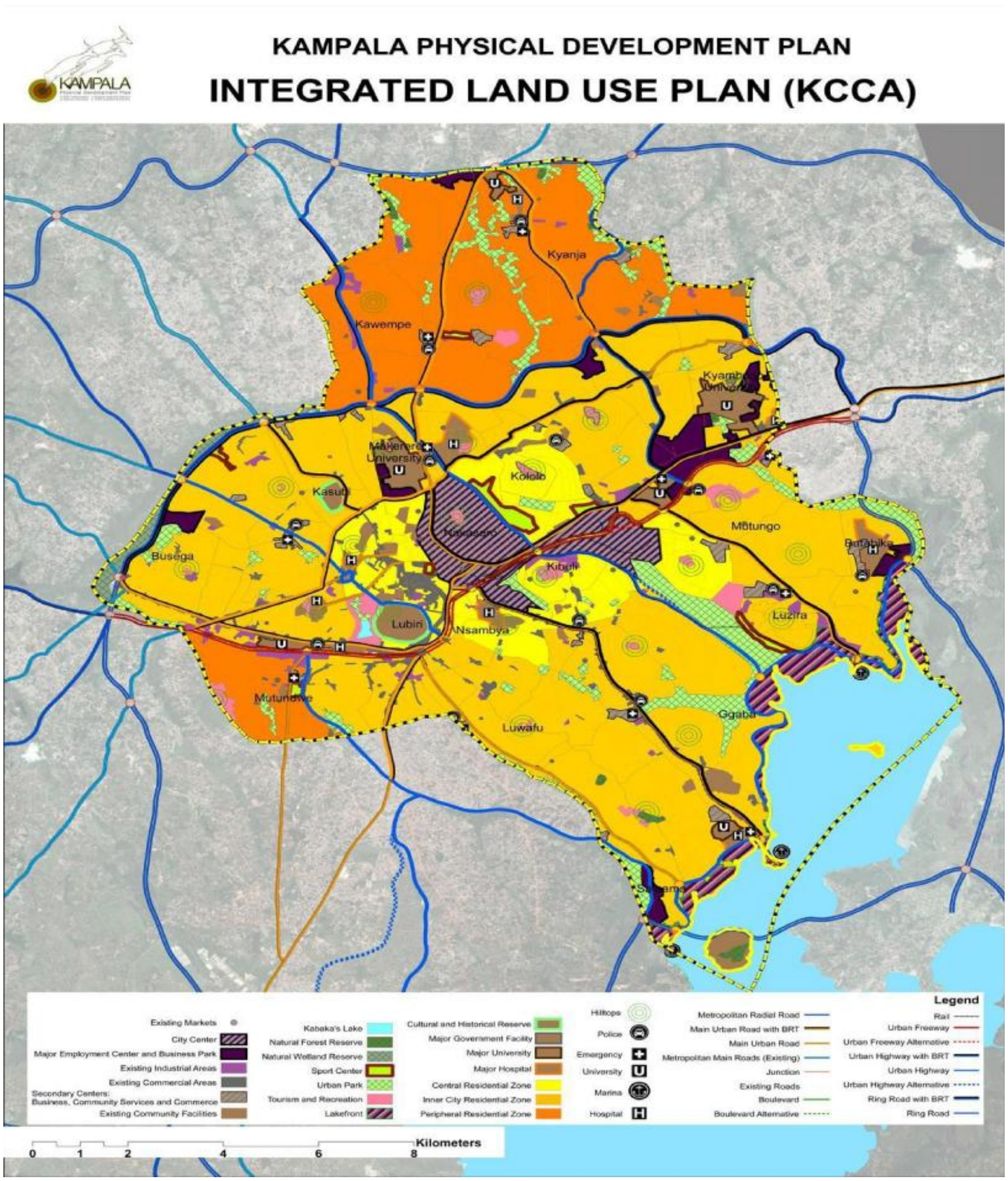
There were over 500,000 registered vehicles in Uganda by the end of the 2011. Kampala, being the capital city and largest urban centre in Uganda, had registered, approximately 50 percent of the vehicles. This implies that for every 100 people, 8.7 people own cars. The number of newly registered vehicles increased by 18.16

percent to 125,518 vehicles in 2011 from 106,224 in 2010 (Uganda Bureau of Statistics (UBOS, 2012).

According to the statutory planning framework, planning and management of roads in Uganda is based on structure plans and detailed layout plans. These plans were introduced by the Physical Planning Act, 2010. The structure plans are prepared by KCCA and provide overall strategies for development of an area, including the full integration of land use and transport (see a sample of the structure plan in Appendix 1A). As shown in Appendix 1A, Kampala proposes to extend its planning area to the neighbouring districts of Mukono and Wakiso among others. In addition, the plans for road proposals are dealt with at the highest level of the hierarchy that is, the structure plan primary network. These plans include proposed road schemes that KCCA intends to commence within 10 years. Part of these schemes is the proposed plan for reconstruction and improvement of the road network (see Appendix 1B).

Figure 1.2 shows a sample of the integrated land use and road transport development plan that was as a result of several studies including Travel Habit Surveys, departures and Passengers Count, Traffic Count, Corridor Count, Routes and Stages, GPS to identify the alignment and operational speed of all taxi routes, road systems' attributes and others for the improvement of roads and traffic in Kampala (KCCA, 2012). The plan shows the existing roads, major transport corridors, highways, as well as the proposed Bus Rapid Transit (BRT) routes.

Figure 1.1: Integrated Land Use Plan including Transport Network



Source: KCCA, 2012

1.4 Motivation of the Study

The state of affairs of Kampala roads is not good. Most of the paved roads have outlived their design life while the gravel roads are mostly in a state of disrepair. The drainage system for the road network is mostly dysfunctional resulting in flooding situations even after a small downpour. This state of affairs has left most of the road infrastructure assets in a waning condition. Also to note are stray cattle, goats, sheep, dogs, and chicken, that are common on Kampala roads. These animals pose traffic and other environmental concerns as well as health risks. It can also be attributed to poor planning and lax enforcement of existing traffic regulations. This coupled with the poor road networks pause risk and threaten the livelihoods of the now 3 million people who depend on it for personal movement.

The government has deliberately decided to reverse this trend of events in order to improve access to economic opportunities and social services in Kampala. The government is working out to provide an efficient, safe, sustainable and environmentally friendly road transport system in Kampala. A number of strategies laid down by the government of Uganda towards solving traffic congestion in Kampala began in 2006, with the establishment of the Uganda National Roads Authority (UNRA), to manage the provision and maintenance of the road network in a more efficient and effective manner (Republic of Uganda, 2006). In 2008, the Uganda Roads Fund was also set to ensure a stable, adequate and timely flow of funds to UNRA for improving the condition of the road network and reducing the road maintenance backlog. A Road Sector Development Program (RSDP) was also launched in 2009 to provide a safe and efficient road network by removing the existing major transport flow constraints from the network (Republic of Uganda, 2009). The outer ring road of northern by-pass was constructed in 2009 with the main aim of diverting the would-be traffic through the city centre.

According to KCCA (2011), a study was carried out and it recommended short-term actions to be implemented over a period of five years. These were, among others, reconstructing and rehabilitating dilapidated paved roads, upgrading unpaved roads to bitumen standard, improving facilities for pedestrians and cyclists and upgrading single carriageway roads to dual-carriageways as well as increasing the paved road network, reconstruction of footways, and provision of combined pedestrian/cycle facilities on all roads proposed for improvement. The planned improvement map showing the length of roads to be reconstructed and upgraded is shown in Appendix 1B. These efforts have seen a few roads paved to good roads as shown in Appendix 1C.

Other short term attempts by KCCA to solve the problem of traffic congestion include reorganising the road network by creating one way routes, traffic signal-control points and making use of traffic police. The United Taxi Operators and Driver's Association (UTODA) has also recruited traffic wardens stationed mainly at junctions and points vulnerable to congestion to jointly work with the traffic police for effective operation. A number of bus operators including Pioneer bus and "Awakula enumme" have been contracted to provide cheaper and better public transport services to passengers en route to and out of the city centre with the expectation of reducing the city jam. Traffic control signals have been installed at major junctions in the city and with the help of traffic policemen, traffic jam at these junctions is expected to be controlled and reduced. KCCA has also banned street business because it tended to overspill to the road-ways and has been partly contributing to traffic congestion especially in downtown parts of the central business district of Kampala. KCCA has gone further to decongest the taxi and bus parks previously located in the central business district of Kampala by creating other parking areas for all the main transport corridors. Despite all these attempts, the congestion problem has worsened over time.

At the same time, UNRA and KCCA in conjunction with the World Bank proposed the implementation of the Bus Rapid Transit (BRT) project for Greater Kampala Metropolitan Area (GKMA) to improve transit efficiency and movement of people. This project is in advanced stages of implementation. However, there are problems sighted with the BRT route given its width of less than 30 metres and the expected usage of the roads that includes other public transport vehicles. This has raised concerns that it may not have a big impact on traffic congestion and mobility in GKMA (KCCA, 2012). Such efforts would be part of the solution to the congestion problem in Kampala.

Other weaknesses of the BRT project arise from the proposed fares and operations as well as parking management. Setting BRT fares similar to what is being charged by the UTODA taxis may not be attractive to some of the travellers since BRT will work by schedule and yet taxis move at their own convenience as long as they get full. Taxis are at an advantage since they take only 14 passengers. Therefore the cost policy may actually work against the BRT system. Operating on full cost recovery basis as suggested in the BRT project may lead to higher fares. Worldwide, it is only Bogota, Columbia that operates on full cost recovery, and yet the income levels of the majority of the Uganda public transport users are also lower than those of the users in Bogota. Therefore there is need to review the assumptions used. Besides, this report does not give a way forward on street parking in the central business district of Kampala, and yet this may be crucial in decongesting the city. Therefore, a supplementary study that has a bearing on parking cost to reduce excess automobile traffic to the city is necessary.

Despite the different measures by the government of Uganda and KCCA to reduce and manage road traffic congestion in Kampala, there is still heavy traffic jam on the city roads for most of the day extending to late hours in the night. Traffic congestion in Kampala has become a phenomenon for all weekdays. It has become chronic and intractable that it can even lead to a drag on the country's economy. However, studies across the world suggest that, appropriate analysis of travel demand is expected to guide in designing solutions to transport problems including traffic congestion (Gopalakrishna *et al.* 2012; Schreffler *et al.* 2012; Ashiabor *et al.* 2007a and Goodwin, 1992).

It is argued that congestion results from an imbalance between the supply of and demand for road space, thus, creating excess traffic. Therefore, reducing congestion means either increasing the supply of road space or reducing the demand for automobile travel. But increasing supply implies providing more infrastructures, which requires huge sums of money and may take longer to be actualised. In addition, increasing infrastructure supply may induce traffic and over time, become a temporary solution to the problem (Lee, 1998; Sanghi, 2014). This emphasises the need to approach the congestion problem from the demand side through managing and controlling travel demand. Hitge *et al*., (2009) also emphasise that to have a balanced and sustainable transport, travel demand management is critical.

1.5 Problem Statement

Increased development in Kampala has drawn the desire for more people to frequently move to the city centre, leading to immense congestion on the city roads for all days of the week. The heavy traffic congestion on Kampala roads has captured the attention of city authorities and the government of Uganda who have and are still trying out solutions to this problem. Despite the measures put forward by KCCA and GOU in terms of road rehabilitation, creation of new parks to decongest the taxi and bus parks in the city centre, recruitment of traffic wardens and police at congestion prone junctions, construction of an outer ring road, banning street businesses and introduction of buses on the major arterials as well as rearranging traffic flow on some city roads, congestion is still immense. Though traffic congestion arises from an imbalance between supply and demand of road space, studies emphasise that in situations of limited supply and for long-term solutions, sustainable demand management policies are required.

However, all the solutions provided so far are from the supply side that might be a short-term solution given the fact that good road infrastructure may instead induce congestion. The fact that congestion is excess demand for road space raises the need to also find ways of managing and/ reducing excess auto demand. Pertinent questions therefore are; What are the drivers of demand for travel and auto mode choice? Can the amount of auto travel be reduced at the household level? If yes, what are the likely solutions that can reduce auto traffic on the city roads?

A few studies carried out on traffic congestion in Kampala have focused on providing causes and likely solutions to the road traffic congestion problem, without considering travel demand as an important element in planning[4]. This is evidenced by the solutions provided so far that are mainly from the supply side. Thus, this study intends to bridge this gap by assessing the drivers of household road travel demand and transport mode choice in Kampala.

[4] Kiggundu (2007, 2009), UNRA (2009), KCCA (2011)

1.6 Objectives of the Study

The main objective of this study is to explore the demand side of urban road travel and transport mode choice focusing mainly on demand at a household level in order to derive probable solutions to the congestion problem or excess traffic. Thus, the specific objectives of this study are;

(i) To assess the determinants of the level of urban household road travel demand in Kampala.

(ii) To evaluate the determinants of urban household road transport mode choice in Kampala.

1.7 Significance of the Study

While focus has been mainly on development and improvement of road infrastructure as a solution to traffic congestion problems, findings that will arise from this study will be equally important in determining solutions to this problem, given the accelerating population and business growth in KCCA. High levels of road travel demand are highly recognised as one of the major causes of traffic congestion and it has been known that the solution to traffic congestion lies there. This study is important in the sense that it would act as an eye opener to policy makers, implementers, and individuals on the drivers of travel demand and transport mode choice in order to derive possible solutions for managing excess road traffic at a household level.

Assessing the drivers of household travel demand gives a clue on the mechanisms to be used to reduce household travel in the city. The study of the determinants of mode choice decisions provides guidance to transport planners towards managing and provision of the necessary modes of travel that may lead to minimisation of congestion in the city. Therefore, policy makers can incorporate information about household decisions on travel demand and mode choice in designing policies to manage and control excess demand.

1.8 Scope of the Study

This study focuses mainly on urban road travel in Kampala since it is the capital city of Uganda and the only urban centre with high levels of street congestion as compared to other urban centres in the country. The main focus is on households because they are the main initiators or originators of most of the travel plans.

1.9 Organisation of the Study

The dissertation consists of five chapters. Apart from this chapter, Chapter Two exploits the theoretical and empirical literature on determinants of urban travel demand and transport mode choice. Chapter Three and Four are stand alone empirical chapters that answer the objectives of the study. The chapters also indicate the methodology and data used as well as the discussion of results. Chapter Three presents the first empirical chapter on determinants of urban household road travel demand in Kampala. In this chapter, the methodology and data used are presented. Results are also estimated and discussed. Chapter Four presents the second empirical chapter on the drivers of urban household road transport mode choice in Kampala. In this chapter, the methodology and data used are presented. Results are also estimated and discussed. Chapter Five presents the summary of findings, conclusion and policy implications.

CHAPTER TWO

URBAN TRAVEL DEMAND AND TRANSPORT MODE CHOICE: THEORY AND EMPIRICAL EVIDENCE

2.1 Introduction

This chapter looks at the theoretical and empirical literature on urban travel demand and transport mode choice. The organisation of the chapter is as follows: Section 2.2 gives a general discussion on transport modelling in economics while section 2.3 and 2.4 reviews the theories that apply to urban travel demand and transport mode choice analysis respectively. The theoretical background for models used to assess factors that affect households' decision making on how much to travel and the modes to use is also presented. The theoretical literature reviewed particularly relates to decision-making given the available choices and constraints. Section 2.5 reviews the empirical literature for urban travel demand and transport mode choice. The empirical literature mainly focuses on the factors that affect travel demand and transport mode choice. Empirical studies from both developed and developing countries are reviewed. Section 2.6 provides the summary of the literature.

2.2 Transport Modeling in Economics

"Economics of transport are fundamental problems of economics, but applied to a particular sector which has some very specific characteristics ... Transport does not require a unique economics based on paradigms and mechanisms that differ from other sectors of the economy. But transport is characterized by certain specific features"(McFadden in Lindsey *et al*., 2011 *pp xv*).

Some of the specific features that characterise transport include; the role of space, time and the multiplicity of decisions that have to be made. Eminent decisions to be made are about the choice of transport mode, choice of destination, departure time, routes as well as long-term decisions about vehicle ownership, residential location and workplace. Transport studies date back to the late 1700s during the study of an inquiry into the nature and causes of the wealth of nations and specifically looking at how the scale of production is limited by the extent of the market size (Smith, 1776). The study recognised the central role of transport economics to economic activity. He pointed out the fact that transport costs including cost of delivering the raw material factor into the price of every good that is manufactured and surely affects the scale of production and profits that accrue.

Lindsey *et al.* (2011) also appreciate the importance of the transport sector and points out that it holds a special place in economics. They argue that studies on development and transport policy issues are the origin of the widely used concepts in economic analysis. In addition transport costs are central in different economic fields. Transport economics plays a greater role in the economy. Its role in spatial economics especially in decisions regarding location choices and the new economic geography cannot be ignored (Weber, 1909; Krugman, 1991). Transport is distinguished from other economic sectors by the importance of external costs both absolute and relative.

The importance of transport modelling of the relationship between transport and the rest of the economy has gained centre stage in the New Economic Geography (NEG). Land use transport interaction (LUTI) models have been mainly used in studying the links of transport with local urban and regional economies. However, the NEG models are said to provide a more formal economic modelling of such relationships (Lindsey *et al*., 2011). These modelling approaches are pointed out as of great importance given the vast interest about the role of transport costs in determining the magnitude and patterns of international trade.

2.3 Urban Travel Demand Theories

Given the fundamental and dynamic behaviour of travel demand, construction of a comprehensive and embracing theory of urban travel and formulation of quantitative models has not yet been accomplished (Kitamura, 2009). Theories advanced by scholars to explain urban travel demand and behaviour have evolved with time in both the field of engineering and economics. In economics, estimation of travel demand bases broadly on consumer theory and it may be regarded as direct or derived demand depending on how it is estimated. Some of the theories that can be used to explain why and how individuals decide on how much more or less to travel are described in the sub-section that follows.

2.3.1 Consumer Theory

Consumer theory in its broad sense asserts that every consumer has a consumption set that is expected to have non-negative units of each good. This set should have alternative plans that are conceivable and achievable given the consumer's economic situation. The consumer is also expected to have the ability to perceive situations involving his choices and tastes. Therefore, the consumer seeks to indentify and select an available alternative that is most preferred in the light of his personal tastes. Thus, the assumptions of the consumption set, feasible set, preference relation and behavioural assumption.[5]

In addition, the consumer is also assumed to have a fixed money income and time that he/she uses to buy the bundle of goods he chooses. The time constraint is assumed to enter directly in the utility function of a consumer (Becker, 1965). Every commodity consumed has its price that is strictly positive hence the expenditure on the goods should not be more than the available income. Demand for travel is just like consumption of any other good or service and therefore is subject to both time and money constraints (Beckmann and Golob, 1972). This leads us to the theory of demand to clearly discuss travel demand. However, McFadden (1974) argues that the complex and multifaceted nature of travel behaviour that involves non-marginal choices is a challenge in bringing economic consumer theory to bear.

[5] Consumer theory is well detailed in Jehle & Reny (2011)

2.3.2 Theory of Demand

The theory of demand assumes that a consumer has preferences that satisfy the three properties of completeness, transitivity and strictly non-decreasing (monotonicity). The consumer's demand function is also expected to be homogeneous of degree zero in all prices and income and satisfy the budget balancedness. In addition, the consumer's demand behaviour can be deduced from observable characteristics that result from such behaviour. This theory asserts that demand for a commodity or service depends on its price, consumers' income and the price of substitutes among others.

Likewise, demand for travel is just like consumption of any other good or service. Therefore, transport cost is critical in the process of decision-making (Wohl, 1963; Beckmann and Golob, 1972). Thus, demand for travel is expected to increase as transport costs decrease. Demand for travel is generally regarded as indirect or direct demand. McFadden (1974) argues that travel is not normally an end objective of the consumer but rather a concomitant of other activities. However, Niedercorn and Bechdolt (1969) argue otherwise. Anas (2007) alludes to the idea of travel demand being direct demand arguing that travel and consumption of other goods are some kind of complements or substitutes and thus treats them in a unified manner. He agrees to the fact that travel demand can be measured in terms of the number and kind of trips taken and to what destination over a period of time. There are three theoretical approaches that can explain how individuals choose how much to consume and why.

2.3.3 Utility Maximisation Theory as Applied to Travel Demand

According to the theory of utility maximisation, a rational consumer only chooses a bundle of goods that maximises his/her utility. Two approaches have been developed for modelling urban travel demand using the theory of utility maximisation. It is under this framework that the contradiction of travel demand being an induced demand or direct demand is brought forward. These include the Utility-Theory Travel Demand model by Golob *et al.* (1981) and the Gravity approach of utility maximisation by Niedercorn and Bechdolt (1969).

Utility-Theory Travel Demand Model

Golob *et al*. (1981) argues that an individual makes a travel choice that maximises his/her utility depending on the activities he is to undertake. Thus travel is induced demand and not a need in itself. The consumer faces both money and time constraints and allocates his expenditures on various consumption goods including travel and leisure. Speed is also considered as another determinant of travel since it can affect the total distance travelled in a given time period. Therefore, the consumer maximises utility (u) subject to the two budget constraints. Thus,

$$\begin{aligned} &\max\ u(x,c,t) \\ &s.t \\ &\quad p_x x + p_c c \le Y \\ &\quad t_x x + t + t_c c \le \hat{T} \end{aligned} \qquad \text{---} \ (1)$$

Where,

x is the amount of travel, c is the consumption of non-travel goods and services and t is leisure time. Among the assumptions u is expected to be monotonically increasing and quasi-concave in the domains of goods and services. Y and T are the money and time budget constraints respectively. p_x and p_c are price indices for travel and general consumption respectively. t_x and t_c are given time per unit distance travelled and time for general consumption respectively.

This approach suggests that travel is expected to increase as income, available time and speed increases and decrease with increasing costs emphasizing that the demand curve for travel is always downward sloping. This is of course only true if travel is assumed to be a normal good but may not obviously be true if travel demand exhibits characteristics of other types of goods. An example is, if we consider travel to work where individuals have no option other than travelling for work, it would mean that travel is a necessity. Then, the elasticity of demand for travel to cost of travel may not necessarily be negative.

All the above are in line with the neo-classical theory of consumer behaviour that ignores the fact that consumption (activities) cannot be fulfilled without incurring travel costs. However, travel can explicitly be treated as an activity that competes for resources and thus subject to both the money and time constraints (Sultan and Khan, 2012). This is in line with the gravity approach of utility maximisation as put forward by Niedercorn and Bechdolt (1969), who suggest that demand for travel is direct demand that is based on the individual trips taken irrespective of the desire to fulfil some activities.

The Gravity Approach of Utility Maximisation

In this approach, trip making is viewed as some kind of resource allocation behaviour such that both monetary and travel time budgets act as constraints in decision-making on how much travel should be consumed (Niedercorn and Bechdolt, 1969). This implies that travel is a need in itself and thus it is a direct demand. Travel demand estimation in this case is based on the gravity model of trip[6] distribution. This approach bases on the origin–destination (O-D) characteristics with an individual located in the originating zone taking a trip to a given destination. This individual is assumed to derive a positive amount of utility with repeated trips taken. The utility derived is subject to the monetary constraints. The cost of a trip, income and distance are considered important in decision-making. Distance and cost are considered as impedance factors (see derivation in Appendix 2A). Thus, the total number of trips taken is inversely proportional to the total distance travelled and cost of travel but positively related to income the traveller is willing to spend on travel.

Gravity Model Theory - Other Derivations

Nanda *et al.* (2012) and Bierlaire (1995), cites gravity model theory generated from an analogy with Newton's gravitational law as introduced by Casey (1955). Travel demand is determined by factors related to the impedance[7] such as travel time and/or

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[6]A trip is a one-way move from an origin to a destination thus from one zone to another involving a public infrastructure (Shafer, 2000). For example, an individual moving from home to work is a trip and from work to home is another trip.

[7]Impedance represents the generalized cost of travel between two zones. The basic component here is travel time thus impedance will be expressed in time units.

cost of travel between zones as well as the number of trip-making activity in both the origin and destination zone, and the socio-economic factors. Aggregate mathematical models such as the gravity model can be used to quantify travel. In this model adjustments are done using a friction factor[8], which in this case is cost of travel (time/money) from one zone to another. This implies that as the cost of travel increases, the likelihood of travelers making trips of the expected length reduces.

The number of trips T_{ij} between origin i and destination j is proportional to the number of people leaving i (O_i), to the number of people reaching j (D_j), and inversely proportional to the square of the (generalized) cost C_{ij} of travelling between zones i and j;

$$T_{ij} = \sim \frac{O_i D_j}{C_{ij}^2} \quad \text{-----} \quad (1)$$

C_{ij} being the deterrence/impedance factor

Based on the deterrence function $f(C_{ij})$, equation (2) can be used;

$$T_{ij} = \sim O_i D_j f(C_{ij}) \quad \text{-----} \quad (2)$$

The typical form of a gravity model for travel demand is given as;

$$T_{ij}^{p} = P_i^{p}\left[\frac{A_j^p * F(t_{ij}) * K_{ij}}{\sum_{j \in zones} A_j^p * F(t_{ij}) * K_{ij}}\right] \quad \text{-----} \quad (3)$$

Where;

T_{ij}^{p} =Total trips taken from zone i to zone j

[8]A friction factor is a factor that fails individuals to make their desired trips

P_i = Total trips taken from zone *i* for purpose *p*

A_j = Total trip destined to zone *j* for purpose *p*

$F(t_{ij}) = \frac{C}{t_{ij}^n}$ = Friction factor, a function of travel cost and travel distance between zone *i* and zone *j*

t_{ij} = Distance between the zone *i* and *j*

K_{ij} = Effects of other variables on travel demand other than travel distance

C = Cost of travel between the zones

n = Number of zones

2.3.4 Revealed Preference

Whereas under utility maximisation approach, estimation of consumer demand begins with assumptions on unobserved preferences, the revealed preference approach suggests prediction of consumer behaviour from his/her observable choices themselves (Samuelson, 1947). This approach suggests that if a consumer buys one bundle instead of another affordable bundle, then the first bundle that has been bought is revealed preferred to the second[9]. Thus we can deduce consumer demand behaviour by beginning and finishing with the observable behaviour. Therefore, one can deduce the travel behaviour of households from the frequency of travels taken. Thus observing their travel behaviour may be important in analysing travel demand.

9 A detailed description of the revealed preference approach is found in Jehle and Reny (2011).

2.3.5 Choice under Uncertainty

Both the utility maximisation and revealed preference approaches assume that the consumer knows with certainty the prices of all goods and services as well as the feasible consumption bundles. That may not be true in the real world. Jehle and Reny (2011) specify that many economic decisions have some an uncertainty element and argue that in the real world, the operation of economic agents cannot always operate under such pleasant conditions. This is in line with Von Neumann (1953) and Morgenstern (1944) who state that the end result of the decisions taken by a consumer may not be known until it occurs despite the consumer's knowledge of the possible probabilities of the different possible outcomes.

2.3.6 Other Travel Demand Approaches and Theories

Activity-based Approach

From this approach, travel demand may be derived or direct (Mitchell and Rapkin, 1954; and McNally, 2000). Travel demand may arise from the activities that an individual traveller wants to undertake. This means that people only travel to carry out certain activities in different places at different times of the day and thus derive utility from the activities taken. However, when travel demand is measured in terms of the volume of trips, it might be regarded as direct. The population and employment levels at the destination, car ownership at the origin and the distance from origin to destination determine the volume of trips (Ashiabor *et al.*, 2007; Mathew and Krishna, 2006). Button (1976) adds that travel is not demanded for itself except for joy-riders but as a derivative of buying some other good or service. Travel demand is affected by the characteristics of the transport system itself and the socio-economic factors. Bhat and Lawton (2000) add that the need to participate in activities is the basic reason for travel. Their study emphasises primary focus on activity participation and schedules taking a whole day as a unit of analysis to estimate a more realistic model and understand how people adapt to a changing travel environment. Knowing how people modify their travel activities can help in managing congestion problems.

Unified Mechanism of Travel (UMOT) Approach

The UMOT assumes a constant household travel budget in estimating urban travel (Zahavi and McLynn, 1984). It considers money expenditure per household and travel time as the major constraints in travel demand. This approach maximises the daily spatial and economic opportunities per household in terms of daily travel distance subject to money and time budget constraints. However, it does not specify how travel time and monetary budgets are ascertained.

2.4 Transport Mode Choice Theories

Theories on mode choice decision-making mainly base on the individual consumers' behaviours. They range from economic theories of choice, utility maximisation, as well as those based on reasoned action and planned behaviour.

2.4.1 Rational Choice theory

Neoclassical economists assume that an individual consumer is rational and can choose among available choices (Mas-Colell, 1995). According to the axiom of classical economic choice theory, an individual is the basic decision-making unit and can rank possible alternatives in order of preference and will always choose from available alternatives the option that he considers most desirable Davidson (1996). Thus, rational choice theory assumes that individuals have preferences among the available alternatives (Mas-Colell, 1995). These preferences are expected to be complete and transitive. Thus, a consumer faced with a list of alternatives should be able to have an opinion on which one he/she likes most. The consumer's choices are also expected to be consistent. The consumer should be capable of comparing two alternatives at a time and the pair wise comparisons should be consistent.

Some scholars have criticised the transitivity axiom for not being true in real life situations or for real human beings (Davidson, 1996; Levin *et al.*, 2004). Despite the criticism, the inconsistence in the preferences would imply some peculiarity in them (Jehle and Reny, 2001). In light of this theory therefore, an individual is expected to rank and make decisions regarding the specific mode of transport to use among the available alternatives. McFadden (1999) refers to rationality as a complex behavioural theory.

2.4.2 Theory of Utility Maximization as Applied to Transport Mode Choice

The theory of utility maximisation states that travellers’ choice of mode of travel depends on the benefit they perceive to derive from travelling using that mode. This implies that an individual’s choice of transport mode depends on the utility derived by using that mode of transport. Utility maximisation is a way of operationalizing the rational choice theory. Using the theory of utility maximisation, estimation of travel demand in the face of discrete alternatives can be explained (Domencich and McFadden, 1975). Individuals’ mode choice is considered rational in that an individual is able to rank them and weigh the personal benefit derived from the alternatives. It is argued that an individual’s travel demand utility is a function of different attributes.

Generally, people prefer to choose the mode of travel with the smallest sacrifice in terms of money and to some extent, less time as well to ensure that the personal benefit is not encroached on severely. Benefits accrue from factors such as travelling time, transport fare, comfort, as well as quality of service. In line with this is the Court-Griliches-Becker-Lancaster (CGBL) consumption-activity household-production framework which assumes that an individual has a series of basic needs and thus is assumed to have a "utility" function defined for certain levels of satisfaction of his needs. An individual chooses an activity from a given location that maximizes the derived utility defined by a vector of attributes that specify his observed transport demand behaviour. Factors such as transport mode, travel frequency, destination, income and time of day, as well as one's occupation among others affect an individual's travel behaviour.

Utility Maximisation based on Psychological theory

In addition to utility maximisation, the classical psychological theory asserts that an individual's behaviour is assumed to arise from some level of deprivation of the basic wants (McFadden, 1974). For this reason, a utility function that summarises the sense of wellbeing of an individual as a decreasing function of the level of deprivation he faces is set. Based on McFadden (1974), two assumptions are considered. First, is that an individual's horizon is infinite and second, that he has a set of *B* mutually exclusive alternative choices. The utility (*U*) of an individual as a discounted sum of daily utilities is given as;

$$U = \sum_{v=0}^{\infty} \delta^{v} u(D_v) \text{ -- } (1)$$

Where,

δ is the discount factor

$v = 0, 1,$ .... is a sequence of short periods over which an individual exists

$D_v = (D_{v1}, ..., D_{vk})$ is the set of deprivation levels faced by an individual in period v and k is the number of drives or wants. The individual is faced with constraints in terms of time and costs. The mode choice attributes considered are travel time, cost, and comfort.

Assuming each member $X \in B$ as a vector $X = (x_0, x_1, ...)$ with x_v a sub-vector of attributes associated with the decision made in period *v*, an individual faces both long-run decisions on residential location and auto ownership, and short-run decisions on timing of trips and mode choice. The relationship between the consumer's choice and evolution of deprivation levels over time is determined by the definition of drives and the nature of household production technology. This is defined as;

$D_{v+1} = (D_v, x_v)$ -- (2)

Therefore, the consumer maximises utility (*u)*

$$U = \sum_{v=0}^{\infty} \text{¢}^{\,v} u(D_v)$$

Subject to

D_0 = Initial deprivation level --- (3)

$D_{v+1} = f(D_v, x_v)$

Assuming that utility is linear in deprivation levels $u(D)_v = - \;{}' D_v$ --------------- (4)

and that the deprivation levels are evolving in the linear first order difference equation $D_{v+1} = \Gamma D_v + g(x_v)$ --- (5)

Pre-multiplying equation (5) by $\text{¢}^{\,v+1}$, summing over *v* and also assuming that the last term in the sum exists leads to;

$\sum_{v=0}^{\infty} \text{¢}^{\,v+1} D_{v+1} = \text{¢}\Gamma \sum_{v=0}^{\infty} \text{¢}^{\,v} D_v + \sum_{v=0}^{\infty} \text{¢}^{\,v+1} g(x_v)$ ---(6)

Therefore, solving equation (3) and substituting the sum of equation (4) and (6) summed over *v* reduces the utility maximisation problem to equation (7) since the first term is a constant;

$$MaxU = -\min_{X=(x_o,x_1,..)\in B} {}'(I - ¢T)\sum_{v=0}^{\infty} ¢^{\,v+1} g(x_v)$$ [10]---(7)

2.4.3 Revealed Preference

Revealed preference approach suggests that if a consumer buys one bundle instead of another affordable bundle, then the first bundle that has been bought is revealed preferred to the others[11]. Thus we can deduce consumer demand behaviour by beginning and finishing with the observable behaviour. It can imply that if an individual chooses a given mode of transport instead of the other available and affordable alternatives, then it is revealed that he prefers it as compared to others.

2.4.4 Theory of Reasoned Action

The theory of choice is also linked to the theory of reasoned action that links people's attitudes with their behaviour (Fishbein and Ajzen, 1975). The theory assumes that individual behaviour is determined by the behavioural intention to emit the behaviour. It is expected that the stronger the intention to engage in a given behaviour, the more likely that it will be done. In other words, the stronger the individuals desire to travel, the more likely that he will travel. Figure 2.1 shows the conceptual framework of the basic theory of reasoned action and moral behaviour.

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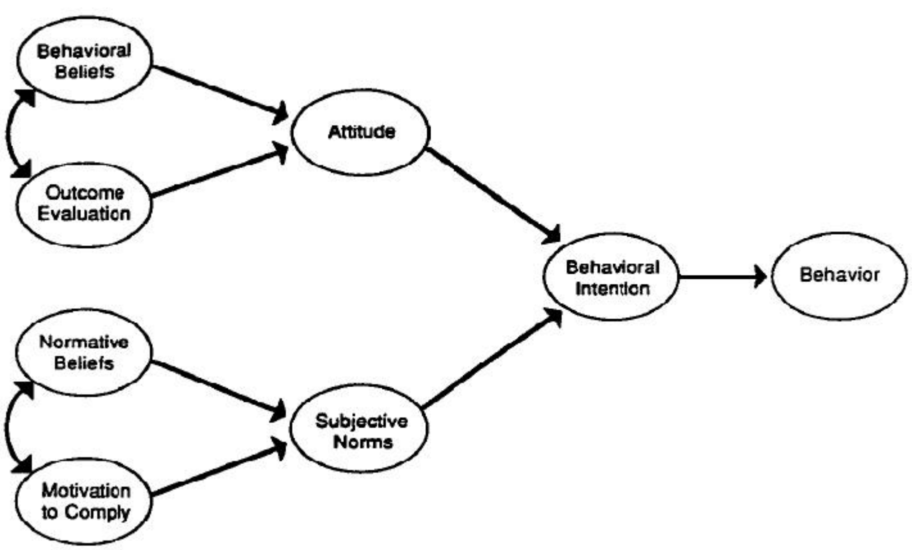
[10]A detailed derivation can be found in McFadden (1974).
[11]A detailed description of the revealed preference approach is found in Jehle and Reny (2011).

The theory points out attitude and social (norms) factors as the major determinants of behavioural intentions. The person's attitude towards a specific behaviour is suggested to be a function of salient beliefs about the perceived consequences of performing a given behaviour and its outcome evaluation. The individual's perception of what the society or important reference individuals consider as the right thing he should do plays a major role. Thus, an individual tries to comply with the societal norms. The theory further assumes that people have a free choice and thus make decisions given their attitude towards the available alternatives but adds that their perceptions of societal norms still play a great role.

Figure 2.1: The Conceptual Framework of the Basic Theory of Reasoned Action and Moral Behaviour



Source: Fishbein and Ajzen, (1975).

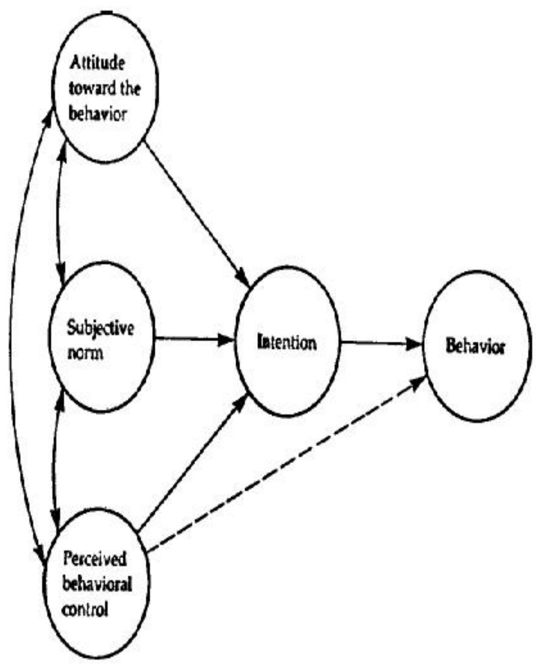
This theory would better apply to transport mode choice decisions if only an individual actor's attitudes are considered. Whereas some individuals in developing countries may make transport mode decisions for esteem reasons especially as their income levels increase, societal norms may not be such an important factor. Therefore, coupling individual's attitude and perception of societal norms may provide a vague basis for transport mode choice decisions. This theory seems to apply best in moral behaviour studies.

2.4.5 Theory of Planned Behaviour

Ajzen (1985) came up with the theory of planned behaviour as an improvement on the theory of reasoned action by including perceived behavioural control as a variable. This theory assumes that an individual’s choice is also dependent on the individual’s perception of his or her ability to implement certain behaviour as shown in Figure 2.2. It also assumes that individuals are rational and make decisions consciously. Therefore, an individual's behaviour will depend on the availability of requisite opportunities and resources in terms of time and money among others. A combination of these factors represents an individual's actual control over their behaviour. Thus, this theory suggests that individual consumer behaviour depends on both the intention and ability to perform as planned.

However, the two attitude-based theories have been criticised due to the fact that it is difficult to know whether attitudes control travel mode choice or vice-versa (Olsson, 2003). People may not act as stated and thus predictions cannot be made given variations in time and service quality of the available transport modes.

Figure 2.2: The Conceptual Framework of the Theory of Planned Behaviour



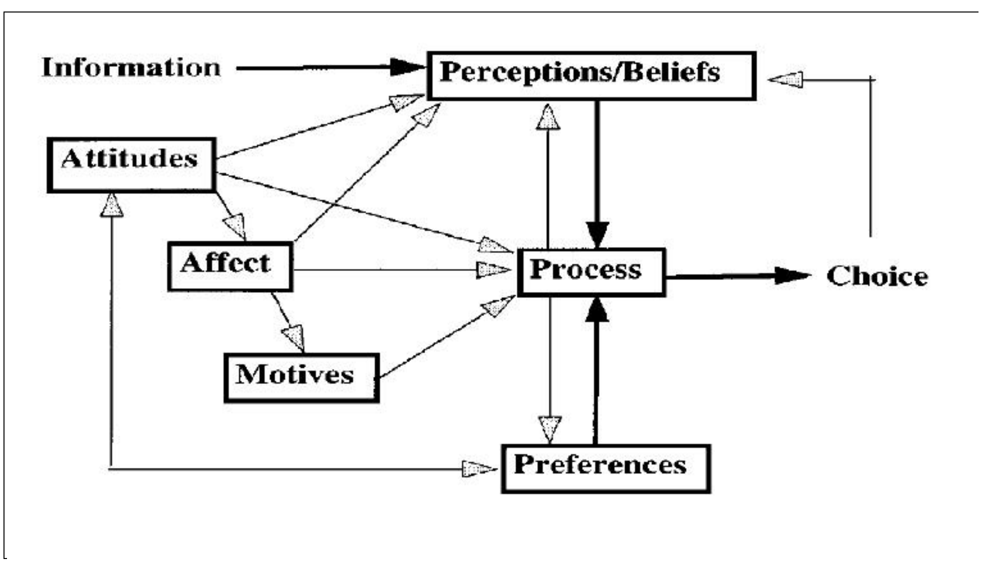
Source: Ajzen (1985).

2.4.6 Theory of Discrete Choice

The theory of discrete choice was seminally developed to understand and predict individual choices of transport mode (McFadden, 1994). The theory was later fully developed McFadden (1999). This theory unlike the rational choice theory that suppose perfect information, assumes that transport-related decisions are part of a much wider set of decisions relating to the choice between a range of choices, between a range of activities or the sequential decisions determined by experience or memory. Figure 2.3 shows the structure of the process of decision making. The decisions are all filtered by psychological attitudes. The theory assumes that the choice behaviour of consumers is characterised by a decision process that is informed by perceptions and beliefs. These perceptions and beliefs are based on information. They are also influenced by affect, attitudes, motives and preferences.

Perception refers to the cognition of sensation while beliefs are mental models of the world particularly probability judgements. Attitudes, often defined as latent variables are the stable psychological tendencies to evaluate particular activities or outcomes with favour or disfavour. Affect is the emotional state of the decision-maker and its impact on cognition of decision task. Motives are drives directed towards the perceived goals. Preferences are comparative judgements between entities. This theory further explains the cognitive process for decision making as a mental mechanism that defines the cognitive task and role of perceptions, beliefs, attitudes, preference and motives in performing this task to produce a choice.

Figure 2.3: The Process of Decision Making



Source: McFadden, (1999).

The theory of discrete choice appreciates the fact that the primary focus of psychologists is to understand the nature of these decision elements, how they are established and modified by experience, and how they determine values, while the primary focus of economists is on the mapping from information inputs to choice. McFadden (1999) refers to preference maximization as a synonym for choice. In the development of this theory, it is stated that preferences may be volatile and context-dependent and therefore, what is missing from the theory of rational choice is an explanation for the process that generates this volatility. The theory further recognises the fact that an object or activity can have no value unless it has utility (Taussig, 1912). It is expected that nobody can buy anything unless it yields him satisfaction. However, sometimes people buy things to please a moment’s fancy; but at least they think at the moment that there is a wish to be gratified.

2.4.7 Theory of Choice Under Uncertainty

There are two theories that have been developed to model choice under uncertainty. These include the expected utility theory and the prospect theory. Both theories are gaining ground in modelling traveller's choice behaviour under uncertainty.

Expected Utility Theory

This is another theory used to model the individual's choice of alternatives under uncertainty. Von Neumann (1953) and Morgenstern (1944) developed the expected utility theory that assumes that individual travellers have the ability to assign probabilities to the outcomes of every available choice from which decisions-making is based. In this theory, the decision in solving the uncertain situation is the maximum expected utility. The maximum expected utility rule assumes that travellers can choose the alternative that maximises the expected values of an approximately defined utility. This approach has been criticised that in real life, individual choices may not satisfy maximum expected utility (Kahneman & Tversky, 2000).

Prospect Theory

This theory is used to model choices under uncertainty. The theory states that people make decisions based on the potential value of gains and losses rather than the final outcome. The prospect theory was developed as a criticism of the expected utility theory (Kahneman & Tversky, 2000). It is suggested to be a psychologically more accurate description of decision-making, compared to the expected utility theory. This theory is used to model real-life choices, rather than optimal decisions. Prospect theory explains the behaviour of consumers while choosing between probabilistic alternatives that involve risk. It also assumes that the probabilities of each outcome are known. Rather than the expected utility theory that assumes that individuals experience losses and gains equally, the prospect theory states otherwise.

Prospect theory further contradicts the expected utility theory in the way individuals assess the probability of outcomes. It states that individuals are poor at assigning probabilities in contrast with the expected utility theory that states otherwise. The theory also assumes that individuals are able to edit and evaluate the losses and gains using certain heuristics. In editing, individuals are expected to arrange the outcomes of a decision and order them according to a certain heuristic. While in evaluating, individuals behave as if they would compute a value or utility based on the potential outcomes and their respective probabilities. It is at this stage that the alternative with the highest utility is chosen. The theory states that during the evaluation stage, utility (*U*) is given as;

$$U = \sum_{i=1}^{n} w(p_i)v(x_i)$$ [12]-- (1)

Where,

U is the overall expected utility of outcomes for an individual making the decision;

x_i is the potential outcome for a given alternative *i*; p_i the respective probabilities of the outcomes; *v* is the function that assigns a value to an outcome; and *w* is a probability weighting function that captures the idea that people tend to over react to small probability events, but under react to large probabilities. Unlike as it is in the expected utility theory, where a rational consumer is indifferent to the reference point and only cares about absolute wealth, not relative wealth in any given situation, the prospect theory assumes a value function that passes through a reference point. This implies that relative wealth is important. The theory assumes that the value function is s-shaped and asymmetrical.

[12]A full derivation of this theory can be obtained from Kahneman & Tversky (1979).

Prospect theory has mainly gained root in financial economics as compared to other economics fields. Whereas the application of this theory in transport studies has been criticised that it lacks the necessary set of mechanisms and concepts to serve as a comprehensive theory of repeated travel choices under uncertainty (Timmermans, 2010), other studies have used it in modelling travellers' choice behaviour on departure time choice (Senbil and Kitamura, 2004).

This study is based on consumer theory, and specifically uses the utility maximisation theory. This is because consumer theory is more elaborative and has been applied in many empirical studies in transport modelling including mobility and mode choice analysis. The approaches used under this theory give room for modification to include household socio-economic factors for analysis. The theory also allows for a micro-analysis at a household level.

2.5 Empirical Literature

In this section, empirical literature for urban travel demand and transport mode choice is presented in separate sections. Section 2.5.1 and 2.5.2 presents the empirical studies on urban travel demand and transport mode choice respectively.

2.5.1 Urban Travel Demand

Determinants of urban travel demand involve both the spatial dimension and the socio-economic dimension. Socio-economic factors have been found to greatly influence travel behaviour (Van Acker *et al.*, 2007). Spatial factors are in terms of land use, density, diversity, and design among others, in which travel demand is considered as derived and utility is attained from the need for activities to be undertaken. The socio-economic factors include structural factors, population characteristics and mode characteristics[13].

De Jong and Van de Riet (2008) in the study of the driving factors of passenger transport identify passenger demand parameters in terms of transport volumes (number of trips and trip length or distance), mode shares (private motorised, private non-motorised and public modes), and traffic distribution (spread over day and transport network). Trip volumes and distance travelled are considered as good indicators of travel practices for urban dwellers. Travel practices of urban dwellers

[13]Structural factors are price, income and quantity of goods or services, while population characteristics are household size, population size, income, age distribution, gender roles, education level, labour participation and ethnicity. While mode characteristics include availability of public and private mode, service characteristics, vehicle capacity, travel costs and travel time.

also characterise urban transport systems. They can also be used in profiling the different cities. Using an unbalanced panel of 22 countries that include developed and developing countries, estimates of the pooled sample OLS and a generalised least squares in Limited Dependent (LIMDEP) variable model, show that disposable income is the most significant driver of passenger mobility among other factors.

The income elasticity of per capita kilometre travelled is approximately 1 and positive implying an almost 100 percent positive effect of income on per capita kilometre travelled. However, results for these countries' urban centres indicated a positive but lower income elasticity of mobility (0.2) as compared to the country results. A combined income elasticity of mobility on the number of tours and total passenger kilometres travelled was as lower as 0.2 but still significant and positive. Other studies also conform to the findings of the influence of income on daily travel. Ayeni (1974) established that households with higher incomes make more trips and travel greater distances as compared to the poor.

The other significant factors that influence mobility include car ownership with a positive elasticity, and transport costs with a negative elasticity. This implies that travels are likely to increase for households that own cars as compared to those who do not own any but reduces with an increase in transport costs. Population density was pointed out as another significant factor affecting urban mobility with a negative influence. Household size is found to greatly increase the number of tours as well as their length. Small households also generated more social travels than larger households. Age is also considered significant in generating travels with higher work journeys among the 18 to 65 year old cohort. The elderly starting at age 55 generate more recreational and social tours compared to the young. This study also suggests that people with higher education are likely to have longer commuting distances due to having more specialized and spatially concentrated jobs compared to the less educated. Other studies that highlight the influence of personal characteristics on travel demand include Kansky, (1967), Doubleday, (1977), Goeverden and Hilbers, (2001). They all establish that auto-owners make more trips than non-auto owners while the non-educated people make more trips than the more educated. However, age has an ambiguous effect on travel demand due to the socialising effect. It is expected to increase with more social activities but could be less for other activities.

Location and race/ethnicity have also been pointed out as significant factors in determining travel characteristics of travellers. Giuliano (2003) in the study on travel, location and race/ethnicity in the US found that in some countries, race and ethnicity also influence travel demand due to social discriminations, culture as well as extended family relationships that may create ethnic neighbourhoods. These lead to more but shorter social tours and longer work tours. Using a stepwise regression model, the results show individual characteristics accounting for most of the variability in travel with significant differences in travel characteristics across race/ ethnic groups. One finding to note is that to the contrary, residing within the central city is not associated with less travel distance.

In line with this, Nanda, (2012) and Garling *et al*, (1994) also argue that total personal trips also base on the distance between zones confirming that location is an important factor in travel demand analysis. Using an activity-based approach, trips produced at an origin and attracted to a destination are directly proportional to the total trips from one zone to another and the total attractions at the destination. The increase in travel times between the zones reduces the likelihood of travelers making trips of the expected length. Time is therefore an ‘impedance’ factor to frequency and length of travel. Travel between zones is also inversely proportional to the distance between these zones.

In addition, demand for transport itself involves an input of time by the traveller or the one who offers transport services (Lindsey *et al*., 2011). The value of travel time in transport demand has been pointed out as one of the significant determinants of demand for transport. Travel time values are expected to be different among individuals given the different purposes of travel. Savings from travel time is a user benefit that accrues from transport improvements in terms of both infrastructure and service supply.

Empirical evidence by Giuliano and Dargay (2006) from the study of car ownership, travel and land use that compared the US and Great Britain modelled daily travel conditional upon car ownership. A model excluding car ownership was estimated using a pooled sample for both countries and results indicated demographic factors, household income, as well as cost of car ownership as the most significant factors influencing daily distance travelled. Travel is seen as a positive function of employment and income, and by gender, females travel more than males. It however, reduces with age implying that older people travel less than the young. Travel also declines with an increase in the number of adults in a household. The metropolitan size has no clear-cut sign but it is expected to have an inverse relationship for smaller metropolitan size given the few alternatives available. It was also seen that higher transport costs promote an economising behaviour in Great Britain as compared to the US.

Despite the global growth and henceforth the expected changes, structural factors are still considered as the major determinants of urban travel demand as indicated by studies in North American, developed Asian and European countries (Souche, 2010). Using 2SLS, SUR and 3SLS2 models as well as Chow's stability test, user costs of trips and urban density profoundly come out as the main factors influencing urban travel demand. However, the empirical evidence of the activity-based approach by Jones *et al.* (1990), Gaudry (2002), and Yan *et al*. (2009) indicate that important variables to consider in modelling travel demand are mode selection, destination, time of day, route choice and traffic flows. These are supported by a study by Krista *et al.* (2004) that asserts that such variables are crucial in travel demand management and adds that demand estimations and forecasts are based on current conditions, future households' predictions, and employment characteristics.

However, Litman (2013), while emphasising the significant influence of demographic factors, commercial activity, transport options, land use, demand management and prices on urban travel demand, argues that most of these factors do not work in unison. For example, the demographic factors may affect the choice of mode used and thus the frequency of travel, whereas automobile travel may also be a complement to vehicle parking and a substitute to transit travel rendering cross elasticities very crucial in modelling travel demand. Factors like prices are expected to have a negative effect on travel demand but sometimes, depending on the value attached to particular trips, this effect may not exist.

Whereas in most empirical studies, survey data is used, a few studies have used time series data in modelling and forecasting of freight transport demand (Shen *et al.*, (2009). Results show that the composition of the economy has an influence on income elasticities of demand for road and rail freight, bearing in mind other trend effects. In our study, we use cross-sectional data that has no trend effects and due to the fact that recent data is also more likely to give a better picture of what is likely to happen in the near future.

Despite emphasis by several studies of the significance of economic factors in determining household travel demand, other researchers suggest that future demand for travel is mainly affected by demographic factors that include population growth and the ageing of the population (Giuliano and Dargay, 2006; Souche, 2010; Litman, 2013); Metz (2011, 2012). A study carried out in Great Britain attributes the shift in urban travel demand to high levels of access and choice (Metz, 2012). However, Uganda being a developing country still struggling to reach the middle-income level with less accessibility and choice, economic factors cannot be ignored.

Most studies discussed above have been conducted in the developed world with a few from Latin America, South and East Asia. A few studies carried out in Africa also emphasise the importance of socio-economic factors in analysis of travel behaviour. There could be some socio-economic factors affecting urban travel in urban centres for developed countries that may not greatly affect travel in urban centres of the developing world. Likewise, the magnitude and direction of these influences may differ given the different development stages the two types of countries are in just like in the case of South and East Asia.

A study on urban travel in Ogun State, Nigeria using a multiple regression model established that socio-economic factors are very significant in influencing intra-urban travels especially trip generation by households (Olayiwola, 2014). It is however, noted that the influence varies among urban centres basing on their level of development. However, some factors are pronounced in more urban centres as compared to others. The most pronounced include number of workers in a household, mode of travel, auto ownership, rent, income and length of stay. Others include education level, occupation category, occupation, marital status, age and sex. While income, number of working adults, car ownership, mode of travel and age among others have a positive influence in all urban centres, the influence of occupation and length of stay varies not only in magnitude but also direction. However, the analysis of travel including mode choice and car ownership in the same model with all the individual characteristics affects the precision of the results. The problem of endogeneity may greatly affect the robustness of the model especially with the use of a multiple regression.

2.5.2 Transport Mode Choice

Although some studies examine transport mode choice and sometimes specifically private car use jointly with private car ownership (Commins and Nolan, 2011, 2010; Nolan, 2003; De Jong, 1990; and Lerman and Ben-Akiva, 1976), others generally analyse transport mode choice irrespective of car ownership (Buehler, 2011; McFadden, 1974; and Lave, 1970). Auto-ownership is considered as one of the significant variables affecting transit mode choice. Whereas some studies consider auto-ownership as exogenous to the mode-choice (Warner, 1962; and Quarmby, 1967), others consider it as endogenous (McFadden, 1974; and Lave, 1970).

Socio-economic characteristics play an important role in decision making for both individuals and households. Individual's decisions to travel depend on a number of factors both monetary and non-monetary that also determine which mode to use for each trip taken. Monetary costs are reflected in the price and income while non-monetary costs may be in terms of time spent travelling, personal safety, convenience and service quality among others. Economic theory emphasises that consumptions decisions are based on income and especially disposable income of the decision maker. Thus, the expenditure on consumption of any good or service depends on the available income.

Likewise, in making travel decisions, Nolan (2003) emphasises the importance of income and socio-economic factors on car and public transport use decisions. In the microeconomic study of the determinants of urban households' transport decisions using Irish data, Probit and Tobit estimates indicate the significant role of income on car ownership and use as well as public transport use. Household car use is positively related to income, suggesting the importance placed on time saving and comfort by higher income households as compared to poorer households. The car use demand comes out as more of necessity than luxury given a low positive elasticity of 0.51. Though this kind of pattern may not be expected for a developing country like Uganda, the importance of income in decision making cannot be under looked.

McFadden (1974) regards travel cost and time as the most significant and key factors in transport mode choice decision-making. Alluding to this fact are empirical studies that followed. Hausman and Wise (1978), in a comparative study of the conditional logit and probit models, analyze the travel mode choice decisions on commuters to the central district of Washington D.C and also emphasize the significance of cost and travel time in making such decisions. Though Hausman and Wise (1978) focus mainly on the criticism of the conditional logit as a multiple choice model given the Independence of Irrelevant Alternatives (IIA) assumption with extreme values and emphasizes the use of the conditional probit, the importance of travel cost and time in transit mode choice decision-making is not disputed. Despite disputing the use of the conditional logit choice model, they still agree that it is adequate for many problems except for those that contain alternative modes that are close substitutes.

There is some level of consistence in literature about the importance of time in transport decision-making. Lindsey *et al*. (2011) states that demand for transport itself involves an input of time by the traveller or the one who offers transport services. Travel time affects transport decisions concerning the choice to travel as well as the mode of transport to be used. The value of travel time in transport demand has been pointed out as one of the significant determinants of demand for transport. These values are expected to differ among individuals given the different purposes of travel. Savings from travel time is a user benefit that accrues from transport improvements in terms of both infrastructure and service supply.

An empirical study by Ashiabor *et al,* (2007) using nested and mixed logit models analyze national level intercity transportation in the United States and estimate travel demand by automobile and commercial airline between all counties and commercial service airports. The explanatory variables used in the utility functions of the models are travel time, travel cost, and traveler's household income. Findings show that as travel times and costs increases for a given mode, an individual's utility of this mode decreases irrespective of the type of mode.

De Jong and Van de Riet (2008) in a study of the driving factors of passenger transport, identify travel time and the relative costs of the various modes available for a specific tour as key determinants of mode choice. In the study involving 133 developed and developing countries as well as 90 cities, it was found that the importance of travel time relative to transport costs increases with income. As people's income rises, their desire for faster and comfortable modes increases thus leading to a shift towards automobiles reducing the desire for trains and sometimes dropping non-motorised modes. This is observed in developed countries. In South and East Asia, a rise in incomes leads to a shift first from non-motorised to scooters and motorcycles at middle-income levels and then to cars at higher income levels. Low-income people generally take public transit. However, in Latin America and Africa, an increase in income automatically leads to a rise in car use.

Muller *et al.* (2007), models travel-to-school mode choice and school choice patterns in urban areas in German, using a multinomial logit model. In their study, a new variable of weather is factored in among the traditional factors that affect transport mode choice. They found out that in addition to proximity that is location of the school from home (distance), private car availability, weather significantly influence modal-shifts. Whereas students would prefer cheaper transport modes, factors like proximity and weather may force them to switch from low cost transport modes like cycling to higher cost modes for example buses. Likewise, availability of a private car for use may lead to a shift from cheaper modes.

Cambridge Systematics (2005) carried out a corridor study on traffic analysis zones (TAZs) looking at car, air, rail and high-speed rail (HSR) modes. Access egress is considered including drive, drop-off, rental, taxi, transit and walk/bike. Using a multinomial logit model, the significant explanatory variables are employment, household attributes, and trip purpose/distance class, level of service, accessibility, region and travelling party size. A different approach that considers time of day choice brings in a new variable of the number of cars owned by a household as explaining mode choice decisions (Jin and Horowitz, 2008). The National Household Transport Survey enhanced with the use of a preference survey conducted by email or by face-to-face interviews in the United States is used. Two modes of transport car, and air modes of travel are used. The purpose of travel (work, return home, personal business, and recreation) is also factored in as significant in decision-making. Other explanatory variables include level of service, travel companions, duration, age, gender, education, household income, household size, car ownership, and presence of a child.

Results of a multinomial logit model with time-of-day choice as the dependent variable show that income and number of household vehicles have significant effects even when all other household and personal-related variables are excluded (Cambridge Systematics, 2005). The age of the traveller has a significant negative effect on mode choice with more travel time. For the variable regarding travelling companions, only the number of non-household members significantly improves the model. The number of household members and total number of people travelling has no significant impact. In contrast however, other studies indicate that household size also affects mode choice in that average household size leads to lower car occupancy rates and hence less use (De Jong and Van de Riet, 2008). The effect of household size on mode choice may also depend on travel purpose especially when it comes to social and recreational tours.

Gender is also one factor that has been pointed out to play a great role in travel behaviour of households. Earlier studies argue that the mobility of women was previously limited by their lack of access and use of private cars despite living with households that own cars and thus tend to be more reliant on public transport (Pickup, 1984). But with more involvement of women in employment that provides them with an income, and can thus be able to own private cars, their mobility is expected to increase. Basing on a study carried out in Britain about women's gender-role and its influence on travel behaviour, a descriptive analysis indicated that the mobility of women is seen as limited by their gender roles. Women seem to be more marginalized given the female gender roles as compared to their male counterparts. These roles limit female members mobility. De Jong and Van de Riet (2008) also agree with the fact that gender affects mode choice with women choosing public transit more as compared to car driving. Despite a household owning a car, studies argue that marriage partners still relate to one another on traditional patriarchal lines which affect all aspects of women's life-style including the distribution of household travel mobility even in situations where domestic tasks are redistributed between household members for working women (Oakley, 1974).

The KCCA (2011) transport survey report indicates that no transport survey had been carried out in KCCA and KMTC for decades. From the descriptive analysis, results from this study show that taxis (14-seater mini-bus) constitute 21 percent of all the transport modes on the road and transports 82.6 percent of the passengers, private cars consist of 36.6 percent of the travel modes and transports 8.8 percent of passengers and *boda-boda* consist of 42.2 percent of the modes transporting 8.5 percent of the passengers. A much more extensive analysis is therefore required in order to improve on the validity and reliability of the study results.

2.6 Summary

2.6.1 Urban Travel Demand

Theory indicates that every consumer must have a consumption set that includes bundles of goods he is to consume. These goods may include among them travel. As expected of a rational consumer who must choose the best bundle that maximizes his utility, likewise a traveller chooses the amount of travel to undertake that maximizes his utility. It is clearly indicated that this utility may be indirect thus derived from the activities to be undertaken or direct from repeated trips taken. If indeed the observed number of trips taken indicates the individual travel behaviour, then this may bring in the notion of revealed preference where estimations of travel demand behaviour of the travellers begins with the observed variables not unobserved assumptions as in the case of the utility maximization approach.

From both theoretical and empirical point of view, travel demand is measured in terms of either total distance travelled or total number of trips taken over a given time period. Most studies on travel demand have used one measure at a time. However, in this study both measures are used to ascertain the consistence of the influence of the determinants of travel demand. Theoretically, travel is mainly affected by economic factors like the money income of the traveller, cost of travel, speed, as well as distance travelled. In this case, travel demand is positively related to the consumer's income and inversely related to the cost of travel and distance. It is also expected to be positively related to speed.

Generally, the aforementioned theoretical approaches do not incorporate the demographic factors that reflect the social dynamics that may highly influence urban demand for travel in developing countries. In addition, empirical studies have accentuated the importance of demographic factors in determining travel demand. Among these factors are household size, gender, age, employment sector, education level, and automobile ownership. Studies have concluded that travel demand increases with automobile ownership and household size. However, there are contradicting results on how demand for travel responds to attainment of higher education levels, employment sector and age. Therefore, this study will contribute to the empirical literature using the case of Kampala.

2.6.2 Transport Mode Choice

A number of theories on individual consumer choice behavior discussed above suggest that a consumer is rational and is able to rank and choose the best among the available alternatives. However, they emphasize that this choice is only subject to his capability to achieve the best alternative and thus both monetary and time constraints apply.

Literature shows that as travel times and costs increase for a given mode, an individual's utility of this mode decreases irrespective of the type of mode. Household attributes that include income and number of cars owned by a household have a positive effect on mode choice. The level of service, accessibility and location or region significantly affects mode choice. The purpose of travel is also considered significant for mode choice decision-making. The age of the traveller is inversely related to private car mode choice.

Some studies have carried out a joint analysis of car ownership and transport mode choice. Whereas others consider car ownership as exogenous to the model of transport choice, others consider it endogenous and therefore exclude it in estimations. The joint analysis is done with the assumption that households own more than one car. This is a common characteristic in developed countries depending on the number of adults in a household. The same pattern may not exist for households in developing countries even for those that live in Kampala, Uganda. Besides policies like car-pooling that restrict auto-alone do not only apply to households that own more than one private car but can still be used irrespective of the number of vehicles owned by a household. In this study, car use is analysed independent of car ownership due to the fact that the percentage of car owners in Kampala city is small as compared to urban centres and cities in the developed world where car ownership is almost a household necessity. This study therefore focuses on mode choice selection irrespective of car ownership.

CHAPTER THREE

DETERMINANTS OF URBAN HOUSEHOLD ROAD TRAVEL DEMAND: EVIDENCE FROM KAMPALA

3.1 Introduction

Management of urban travel has become one of the biggest challenges of urban planners and policy makers, and affects both individual firms and households. It has gained centre stage due to the preconceived idea that increased urban travel is the leading cause of traffic congestion on urban streets. This is sometimes attributed to increased development that induces urban travel and rural-urban migration. In reference to Kampala, there has been a noticeable improvement and increase in development activities that has drawn the desire for more people to frequently move to the city, leading to immense congestion on the city roads for all days of the week.

The struggle by city planners to find solutions to this problem has been evident in the number of short-term solutions provided as well as the procuring of quite a number of loans from the World Bank and Exim Bank of China to provide extensive transport modes for city travelers. However, extensive studies to this effect that can act as a basis for long-term solutions to this problem are hardly identified. The supply-side solutions especially in terms of improved and increased infrastructure only, may not solve the problem of congestion since this may actually induce congestion (Sanghi, 2014). De Jong and Van de Riet (2008) also state that the traditional approach to deal with the problems of traffic congestion is to expand the infrastructure. However, transport policy is a broad and versatile field whereby many different types of policy measures can be observed as shown by literature and practice and thus, it can be concluded that sound transport policy-making requires knowledge on the drivers of transport demand. Therefore, there is need to have extensive studies that can act as guidance to policy makers on such solutions. By assessing determinants of urban road travel, policy makers can have a strong basis in implementing combined policies that can stand as long-term solutions to urban congestion.

Though it is a fact that traffic congestion arises from an imbalance between supply and demand of road infrastructure, studies emphasise that in situations of limited supply and for long-term solutions, sustainable demand management policies are required. Himanen *et al.(*2005) argue that to achieve sustainable mobility and hence sustainable demand management policies, understanding the link between societal dynamics and mobility is crucial. This has not been addressed in the previous studies in Kampala. Thus, this study bridges the gap by assessing the determinants of urban travel demand with the main focus on the socio-economic factors to provide the link between societal dynamics and mobility in Kampala.

3.2 Objectives of the Study

This chapter answers the first objective that assesses the determinants of urban household road travel demand with the main focus on the socio-economic factors. The socio-economic factors include transport cost, income, distance, household size, private car ownership, age of the household head, education level, and employment sector of the household head.

3.3 Methodology and Data

In this section, the theory adopted, empirical methodology and data sources are presented as per the objectives of the study. The variables used are identified from literature and also based on the availability of data for Kampala.

3.3.1 Theoretical Framework

The utility maximisation theory is espoused. The utility theory-travel demand model as per the works of Golob, *et al.* (1981) and Niedercorn and Bechdolt (1969) has been so far the most elaborative and appealing for urban travel demand studies. However, the two have contradicting views in estimating travel demand. First is that travel is induced demand and thus a traveller has a number of activities to conduct from which he derives utility and hence travels to achieve them (Golob *et al.*, 1981). Second is that travel is a need in itself and thus a traveller attains utility from the frequent trips taken (Niedercorn and Bechdolt, 1969). Despite the controversy, both approaches end up measuring travel in terms of total distance travelled or the total number of trips taken by the traveller. However, both distance travelled and trips taken are observed over a given period of time to ascertain the travellers' behaviour. They are not based on answers to some hypothetical questions. This argument therefore, could presuppose the notion of revealed preference by Samuelson (1947) for empirical studies.

According to Golob *et al.* (1981), a consumer only chooses a bundle of goods including travel choice that maximises his utility (*u*) thus allocating his expenditures on various consumption goods including travel and leisure. Such that,

$u = u(x, c, t)$ -- (1)

Where,

x is the amount of travel, *c* is the consumption of non-travel goods and services and *t* is leisure time. Among the assumptions *u* is expected to be monotonically increasing and quasi-concave in the domains of goods and services. Given the price indices of these goods, an individual faces both money *(Y)* and time *(T)* budget constraints.

$$\begin{aligned} p_x x + p_c c &\leq Y \\ t_x x + t + t_c c &\leq T \end{aligned}$$ -- (2)

Where;

p_x and p_c are price indices for travel and general consumption respectively.

t_x and t_c are given time per unit distance travelled and time for general consumption respectively.

Thus a consumer maximise utility (*u*) subject to the two budget constraints.

$$\begin{aligned} &\max \ u(x,c,t) \\ &s.t \\ &\quad p_x x + p_c c \leq Y \qquad \text{---} \ (3) \\ &\quad t_x x + t + t_c c \leq \hat{T} \end{aligned}$$

Assuming a relatively constant time spent on general consumption over a range of consumption levels in the short-run, time available net of general consumption time is given as;

$$T = \hat{T} - t_c c$$

Given the additive assumption that states that the marginal rates of substitution among various goods and services within one commodity group are independent of the marginal rates of substitution among goods and services within any other commodity group, equation (3) becomes,

$$\begin{aligned} &\max_{x,c,t} = \max_{x,c,t} \left[¤(x) + \cdot\ (c) + ¶(t) \right] \qquad \forall x,c,t \geq 0 \\ &s.t \qquad p_x x + p_c c \leq Y - (4) \\ &\qquad\quad t_x x + t \leq T \end{aligned}$$

Where,

¤, · ,¶ are utilities due to travel, general consumption and leisure respectively.

Since income not consumed and time not allocated to some activity has no intrinsic value, then the constraints in equation (4) are binding and thus the inequality sign vanishes. Solving for *c* and *t* and substituting them in the utility function in equation (4) gives;

$$\max_{x} u = \max\left\{ ¤(x) + \cdot \left[\frac{Y}{p_c} - \left(\frac{p_x}{p_c} \right) x \right] + ¶(T - t_x x) \right\}_{x} \text{------------------------------------} (5)$$

Another assumption is that of existence of some optimal travel (x > 0) and also normalising p_c=1 since all monetary variables can be measured relative to a general consumption price index. Basing on these two assumptions, the necessary and sufficient condition for maximisation of equation (5) is given as;

$$¤'(x) - (p_x) \cdot\ '(Y - p_x x) - t_x ¶'(T - t_x x) = 0 \text{ ---} (6)$$

Basing on equation (6), it is revealed that the characteristics of utility functions are; travel (x) increases as income (Y), available time (T) and speed (S) increases; travel decreases with increasing costs (C), thus the demand curve for travel is always downward sloping. In conclusion therefore, travel is adjusted until the point where the marginal benefit gained is equal to the marginal cost incurred.

Thus, travel demand *(x)* is given as;

$$x = f(Y, T, C, S) \text{ --} (7)$$

Where,

Y = Income

T = Available time

C = Cost of transport

S = Speed

3.3.2 Hypotheses

Based on the reviewed theories, the following hypotheses have been constructed.

1. Demand for travel is inversely related to travel cost. It is expected that an increase in travel cost leads to a decrease in demand for travel. That is, the average number of trips taken by a household falls as the average cost per trip increases and likewise, on average, the total distance travelled by a household reduces.

2. Demand for travel is positively related to income. It is expected that an increase in monthly household income increases the desire to travel. Thus, when a household's disposable income increases, the frequency of travel is likely to increase and hence more distance travelled.

3. Demand for travel is inversely related to trip distance. The frequency of travel or number of trips is expected to decline if longer trips are to be taken.

In addition, based on the empirical literature, the following hypotheses are tested.

1. Demand for travel increases with household size. It is expected that an additional member in the household leads to an increase in travel demand. Both the number of school going children and adults affect travel frequency.

2. Households that own a private car(s) travel more than those who do not own one. It is expected that due to availability and convenience of a private car, households that own it tend to travel more as compared to those who do not own any.

3. Age of the household head has a significant negative effect on household demand for travel. It is also expected that the older the household head, the lower the amount of daily travel, excluding leisure travels or the socialising effect.

4. Education level of the household head has a significant effect on household daily amount of travel. It is expected that the higher the education level of the household head, the more travels taken by a household, but it has been found otherwise in some urban centres.

5. Employment sector of the household head has a significant influence on household daily amount of travel. It is expected that household heads in some sectors travel more as compared to those working in other sectors thus increasing the daily amount of travel taken by a household.

3.3.3 Data Source and Description of Study Variables

This section presents the type of data used and its source as well as the description of the study variables.

Data Source

This study uses data obtained from the KCCA transport and household travel habits survey that was carried out in 2011. A sampling plan consisted of 3000 households based on zonal system created in 2005 by the Greater Kampala Metropolitan Area (GKMA) Transport Master Plan Project. From the 22 super zones that were identified, 3 super-zones were defined from which 7 major corridors were chosen, and several representative transportation zones were selected for the super-zones. The zones and corridors chosen were located in Kampala city.

Households were randomly chosen from parishes that were stratified by residential typology. Households were sub-divided into 3 socio-economic groupings as low, medium and high based primarily on education levels as proxies. However, due to the fact that 50 percent of the population belongs to the low-income group who tend to exhibit similar travel behavior, the sampling rate for this category was reduced considerably, and only 1906 households were sampled. Both socio-economic characteristics and travel habits data was obtained. Information collected included household and personal attributes (income/expenditure, household size, employment status, education and car availability) as well as trips made by each household member during the day (trip purpose, trip mode, trip destination).

To minimize on data errors and ensure data quality, the Global Positioning System (GPS) was used where each household head was provided with a GPS logger for 24 hours. With this, each individual's coordinates were collected for every 3 seconds. The GPS trip data was compared against reported trips to allow for any corrections whenever there was need.

Description of Study Variables

In this section, the variables used in the analysis and model estimation are defined and described. The variables are grouped into dependent and independent variables.

Dependent Variables

In this study, two dependent variables have been used in estimating the determinants of urban household road travel demand. These include the daily trip volume and distance travelled.

Trip Volume

Both theoretical and empirical literature indicate that travel demand can be estimated in terms of trip volumes taken by an individual or household over a specified period of time. At a household level, trip volume indicates the frequency of travel by that household. It is a discrete count variable. In this study, the average daily number of trips taken by a household is considered. Since in the questionnaire, the average daily trips taken by individuals in a household is obtained, the average daily trip volume for a household was attained by summing the average number of trips taken by all members on a daily basis.

Daily Distance Travelled

Literature further indicates that demand for travel can be estimated using the distance travelled by a household and thus this measure was also used in this study. Distance travelled is in terms of kilometers (km). Given the non-availability of data on daily distance travelled by a household, two proxy measures have been identified;

i. Distance from Home to the City Centre

The fact that the city centre is a point of attraction for city dwellers, and since this study aims at suggesting solutions to the congestion problem in the city, distance travelled from the location of a household to the city centre is used. Alinange (2010) and Kiggundu (2007) also argue that Kampala is city centered with all the major services being in the city centre, thus making it inevitable for individuals to travel to the city centre. Distance from home to the city centre is also used as an independent variable in determining the frequency of daily travel by a household. It should be noted that there is no reverse causality expected between the daily trip volume and proximity to the city centre. It has been used as a continuous logarithmic transformed variable.

ii. Distance from Home to Work Place of the Household Head

This variable has also been considered as a proxy for distance travelled since it is inevitable in developing countries like Uganda for individuals to travel to their work place and is thus also considered as a major cause of congestion in the city. In this study, the distance to the work place of the household head is used. It has also been used as a continuous logarithmic transformed variable

Independent Variables

Trip Cost

Trip cost is the amount of money spent on each trip taken. Trip cost is recorded in Uganda shillings. The average transport cost per trip (tripcost) is used as measure of the transport cost incurred per trip taken. Average trip cost is obtained and used since daily travel demand is analyzed at a household level. The average trip cost is calculated as the ratio of the average daily trip volume to the average daily transport cost incurred by a household. This is considered as the price factor where demand for travel is measured in terms of trips taken per household. Because of suspected endogeneity in the model, alternative price variables in terms of transport cost per km have been calculated and used in the alternative model estimation. These are; average transport cost per km to the city centre and to the work place of the household head. Trip cost is first used as a continuous variable after logarithmic transformation and later used as a categorical variable to ascertain the degree of elasticity at different levels. The categories are: 0-1000, 1000.01-2000 and above 2000 all in Uganda shillings

Transport Cost per km (costpkm and costpkmw)

Using the two proxy measures of distance travelled mentioned earlier, average cost per km is estimated. It is estimated as the ratio of the average daily transport cost to distance from home to the city centre (costpkm), and also as a ratio of average daily transport cost to the distance from home to the work place of the household head (costpkm). These two costs are used in the estimation of the alternative measure of travel demand; that is, distance travelled. Transport per kilometer is recorded in Uganda shillings. The variable is first used after logarithmic transformation and as a continuous variable but later categorized into three groups. The categories are: 0-500, 500.01-1000 and above 1000. The three groups reflect lower costs, that is, below the average cost per km, then within the average range and above the average to signify higher costs respectively.

Income

This is one of the key economic factors used in assessing the determinants of urban household travel demand. Income of a given household is associated with the daily amount of travel taken by that household. The monthly income per household was collected. However, due to problems with individual's willingness to divulge the right information about their incomes, monthly expenditure was instead used. But in cases where monthly expenditure is not recorded, monthly income was used since it is expected that individuals spend what they earn. The variable is recorded in Uganda shillings. In the estimation income is used as a continuous logarithmic transformed variable.

Household Size (hhsize)

Household size is one of the imperative variables in assessing urban travel demand. Household size is associated with the daily amount of travel taken by that household. According to UBOS (2010), household size in Uganda refers to the number of usual members in a household and usual members are defined as those who have lived in the household for at least 6 months in the past 12 months including persons who may have spent less than 6 months during the last 12 months in the household but have joined the household with intention to live there permanently or for an extended period of time. Being a discrete variable, it is first used in its original form and later categorized into three groups. The categories are; 1-3, 4-6 and above 6, with 1-3 members as a base category. The three categories reflect households with few members, that is below the average urban household size, the within average range as well as above the average size implying larger households respectively.

Vehicle/Car Ownership

Vehicle ownership cannot be ignored in assessing urban travel demand. In this study, vehicle ownership refers to private car ownership for personal use. Private car ownership is associated with the daily amount of travel taken by a household. It is defined as 0 for households that do not own a private vehicle and 1 for those that own a private vehicle for personal use.

Age

Age is another important variable in assessing urban travel demand. Since the unit of analysis is a household, for such individual characteristics, those of the household head are considered. Therefore, the age of the household head is used in this study. This variable has been used in its original form and later categorized into five groups. The age groups used are; 15-24, 25-34, 35-44, 45-54 and above 54. The age group with 15-24years is the base category. These categories identify the teenagers, the youths, the adult youths and those approaching retirement as the pensioners and retirees.

Gender

Gender is another vital variable in assessing urban travel demand. Just like age, the gender of the household head is used in this study. The gender of the household head is associated with the daily amount of travel taken by that household. This variable has been used in its original form and it is defined as 0 for female and 1 for male. Female = 0 is used as a base category. Therefore, in the discussion of results, the terms used are female-headed and male-headed households.

Education Level

Education level is another variable that cannot be ignored in assessing urban travel demand. Just like age and gender, the education level of the household head is used. The education level of the household head is associated with the daily amount of travel taken by that household. This variable is categorized into four levels. They include; no education, primary, secondary and tertiary education levels. Tertiary education refers to post-secondary education.

Employment Sector

This is another essential variable in assessing urban travel demand. Just like age, gender and education level, the employment sector of the household head is used. The employment sector of the household head is associated with the daily amount of travel taken by that household. This variable is categorized into three sectors. They include: public, private, and other sectors. The private sector include the formal and informal sector while others include manufacturing, building and construction, transportation, agriculture, unemployed/job seeking, domestic service, pensioners and those not in labor force.

3.3.4 Model Specification

The estimation of travel demand has been adopted from Golob *et al.* (1981) and is augmented with other household socio-economic variables as suggested by Giuliano and Dargay (2006), Souche (2010), and Litman (2013). Added to the model is household size (*hhsize*), car ownership (*vown*), age, gender, education level (*edlevel*) and employment sector (*esect*). In this study, transport cost is captured in terms of average trip cost (*tripcost*) and alternatively as average cost per km to the city centre (*costpkm*) or work place (*costpkmw*). Speed, time taken and available time have not been captured in the model due to lack of data and higher chances of multi-collinearity since time taken is a function of speed. Besides, most studies on travel demand have treated available travel time as constant. This assumption may not give a clear explanation of the variability in travel behaviours among households.

Borrowing from Niedercorn and Bechdolt (1969), that emphasizes the inverse relationship between trip volumes and distance, distance from home to the city centre has also been added into the model. Travel demand (dt_i) is therefore given as;

$$dt_i = {}_0 + {}_1 trip\cos t_i + {}_2 income + {}_3 hhsize_i + {}_4 vown_i + {}_5 age_i + {}_6 edlevel_i + {}_7 e\sec t_i + {}_8 dist_i + {}_9 gender_i + e_i \quad \text{--} (8)$$

Where,

$_{1}, \; _{8} < 0, \; _{2}, \; _{3}, \; _{4} > 0, \; _{5}, \; _{6}, \; _{7}, \; _{9} >< 0$ as derived from theory and empirical literature.

e_i = error term

Where,

hhsize is household size, *vown* is private vehicle ownership, *edlevel* is the level of education, *esect* is employment sector and *dist* is distance from home to the city centre (proximity).

3.3.5 Method of Estimation

Demand for travel is measured in terms of number of trips taken or the total distance travelled (Giuliano and Dargay, 2006; Bacon, 1995; Gordon and Richardson, 2000; and Anas, 2007). In this study, both measures at a household level have been used using separate estimation methods. The major methodological problem that comes with the use of cross-sectional data in this study is that of unobserved heterogeneity that can be best solved with longitudinal studies. However, the only data set available is cross sectional. Therefore, it may be difficult to capture the complex inter-relationships among factors in our urban systems to allow detailed and sophisticated analyses of the urban phenomenon, just like in developed countries. This is one of the limitations in estimating demand models in developing countries.

Therefore, two approaches have been used in assessing the determinants of urban household travel demand given the two different measures for travel demand. A

Negative Binomial Regression (NBR) is estimated, with the total number of trips as a measure of daily demand for travel (dependent variable), while an Ordinary Least Squares (OLS) regression is used with distance travelled as a dependent variable/measure of daily demand for travel.

i. Negative Binomial Regression (NBR)

Although in estimations that deal with count data, the first assumed model is the Poisson, in this study an NBR is preferred due to the observed over dispersion. The dependent variable is the number of trips taken that is a count variable with a variance of 15.21 and the mean of 9.7. The variance is 57 percent above the mean, a sign of over dispersion and therefore justifies the use of the NBR. The maximum likelihood approach is used in estimating the NBR model. The superiority of NBR over other estimation methods for count data arises from its composition of the disturbance term and ability to account for over dispersion. The assumptions of conditional normality, homoskedasticity of the errors and independence have to be fulfilled to avoid biased standard errors. One problem with count data is that it is sometimes hard to achieve conditional normality and homoskedasticity of the error term. This is attributed to the fact that such data often exhibits increasing conditional variance with increases in the value of the predictor and tend to have positively skewed distributions (Gardner *et al*., 1995; and Long, 1997). This may have an effect on convergence of the model being estimated. However, the estimated NBR model converged well after 9 iterations.

In addition the NBR was preferred to a Poisson regression since the Poisson regression model does not allow for heterogeneity among individuals (Coxe *et al*., 2009). The Poisson distribution assumes that the conditional mean and conditional variance are the same. A Poisson regression model was also estimated for comparison purposes (see Appendix 6). Comparing Poisson regression estimates with NBR results in Table 3.4, it is clear that the Poisson regression underestimates the standard errors. However, the Negative binomial accounts for over dispersion with the assumption of existence of unexplained variability among individuals who have the same predicted value. That may lead to larger variation but with no effect on the mean (Greene, 2006; Hilbe, 2011 and 2007; Coxe *et al*., 2009; Long, 1997; Land *et al*., 1996 and Gardner *et al.*, 1995. The log-likelihood NBR function according to Greene (2006), Hilbe (2011) and Zwilling (2013), is given as;

$$\ln L(\sim,\;\;) = \sum_{i=1}^{n}\Big(y_i \ln\sim + y_i(x_i.\;\;) - \big(y_i + \tfrac{1}{\sim}\big)\ln\big(1+\sim e^{x_i.}\;\;\big) + \ln\Gamma\big(y_i + \tfrac{1}{\sim}\big) - \ln\Gamma(y_i+1) - \ln\Gamma\big(\tfrac{1}{\sim}\big)\Big)$$

-- (9)

Where; $x_1, x_2, \ldots\ldots\ldots, x_p$ are the given predictor variables and $\;_0,\;_1,\;_2,\ldots\ldots\ldots,\;_p$ are parameters to be estimated, *α*>0 is the heterogeneity parameter, *1/α* is the number of successes and the values of α and β are the maximum likelihood estimates. The theoretical negative binomial model is derived in Appendix 2B.

Alternative Approach

The OLS regression is also justified in estimating demand for travel with total distance traveled as the measure, and given that distance travelled is continuous and measurable. The assumptions of conditional normality, homoskedasticity of the errors and independence are tested to avoid biased standard errors. To this effect, a robust model is estimated. The OLS approach also allows for heterogeneity among individual observations, a characteristic of most cross-sectional data.

3.3.6 Descriptive and Summary Statistics

The primary purpose of travel to Kampala has been grouped into three. In this case, the purpose of the first trip taken by the household head on a daily basis is captured (see Appendix 3F). Approximately 81 percent of the first journey made by the household head is for the primary purpose of going to work, while 14 percent are for social services that include education, shopping, health and sports, only 5 percent reported the primary purpose as going back home. This result may imply that some people work at night since their first trip made on daily basis is for going home. However, it also indicates that most travels to Kampala city are for work purposes.

Approximately 90 percent of the households interviewed are within a radius of 9 kms from Kampala city center. However, 46 percent of these households reside within 3 to 6 km regardless of the household size. The fact is that as a characteristic of urban centres, the cost of living is expected to be higher in terms of housing and food, as one moves closer to the city centre and thus, larger households that need more space and food are expected to stay farther from the city centre. However, the case for households in Kampala is quite different. Larger households stay closer to the city centre. Fewer households with larger household size stay far from the city center[14]. Among these households, 28 percent own private vehicles for personal use.

Approximately 49 percent of the household heads have attained tertiary education, 37 percent have secondary education, 12 percent have primary education and 2 percent have no education. This is not surprising given that the literacy level for household heads in Kampala is over 90 percent. Approximately 59 percent of the respondents are in private sector employment, with 40 percent in private formal employment and 19 percent in private informal employment. Of those in the private formal sector, approximately 21 percent have tertiary education and 16 percent have secondary education. While for those in the private informal sector, approximately 10 percent have secondary education and 6 percent have primary education. Only 19 percent are in public sector employment, of which approximately 16 percent have tertiary education.

Table 3.1 gives the summary statistics and it indicates that the average household monthly income is Ushs.671,836.5 (approximately US$268.73) with the minimum monthly income of Ushs.18000 (approximately US$7.2). For this result, the number of households has dropped to 1511 because 35 households that earned an income of over Ushs. 3 million were excluded to avoid an exaggerated mean value, while 360

[14]Larger households are those with a household size greater than the National Urban average of 4 people per household. The National Rural average household size in Uganda is 5 and Urban average is 4 (UBOS, 2010).

households did not provide any information about their incomes or expenditures. The average household size is approximately 4 members, the same as the national average for urban areas (UBOS, 2010). The largest household has up to 15 people. The average number of daily trips taken by a household is approximately 10 trips with an average transport cost of approximately Ushs.534 (approximately US$0.22) per trip.

Results in Table 3.1 further show that, households in Kampala are located within an average distance of 5.5 kms from the city center with the closest being 1.8 kms away and the furthest at 17 kms. However, the average distance to the work place of the household head is 4.6 kms with the furthest work place being at 125 kms away from home. The average transport cost per km from the household location to the city centre is Ushs.772.5 (approx.US$0.31) while from the household location to the work place of the household head is Ushs.906.6 (approx. US$0.30). The number of households from which cost per km was calculated as a ratio of distance to work and transport cost has dropped to 1512. This is because, households with the cost above Ushs.3000 were left out to avoid the effect of outliers and again, most heads of the 394 household worked within the same locality as household location and thus by GPS, it is considered zero distance. The ratio of transport cost to zero distance is undefined. The average age of respondents is 38 years with the youngest and oldest being 19 and 90 years respectively.

Table 3.1 also shows the skewness and kurtosis of the study variables[15]. Results show all variables having a skewness > 0 and kurtosis > 3, implying that they are not normally distributed in their current form. The distribution of the number of trips has a skewness of 0.87 and kurtosis of 4.28 with the mean of approximately 10 that is greater than the median of 9, implying that it is skewed to the right with heavy tails. Likewise all the covariates have distributions skewed to right with heavy tails. Therefore, the data cannot be analyzed in its current form. There is need for logarithmic transformation of the data to ascertain normality and achieve robust model estimates.

[15] Skewness can also be used to assess the degree and direction of asymmetry, while kurtosis measures the heaviness of the tails of the distribution of the data set. Based on the symmetry of the distribution, one can ascertain if the data is normally distributed (Greene, 2006).

Table 3.1: Summary Statistics of the Selected Variables (in levels) [16]

Variable	N	Mean	Standard deviation	Minimum	Maximum	Skewness	Kurtosis
Average daily trips taken	1906	9.7	3.9	2	32	0.87	4.28
Average monthly income	1511	671836.5	525512	18000	3000000	4.72	33.2
Average trip cost	1906	533.9	635.3	0	8040	4.12	30.23
Age	1906	38	11.2	19	90	0.97	3.97
Household size	1906	4.2	1.6	1	15	1.09	5.76
Distance from home to city center	1906	5.5	2.8	1.8	17.1	1.41	5.7
Distance from home to work	1906	4.6	7.6	0	125	7.94	88.72
Cost per km based of distance to city centre	1906	772.5	687	0	3000	9.14	161.48
Cost per km based on distance to work	1512	906.6	713.9	0	3000	6.99	92.55

Excluded: monthly income greater than Ushs. 3000000, cost per km >3000

Source: Author's computation from KCCA 2011 survey data.

[16] 1. Exchange rate at the time of interview: the average nominal exchange rate for 2011 was 1 US$=Ushs.2500.

2. Households with zero distance to the work place of the household head are those whose heads work within the same locality as the household location. If the work place is within the same location as the household, the GPS gives zero as the average distance. Likewise the associated cost of travel is zero since most of them walk.

3. All individuals walking to their destinations have travel cost of zero in monetary values.

3.3.7 Correlation Analysis and Chi2 Measure of Association

Prior to model estimations, an exploratory analysis of the association between the covariates and the dependent variable is carried out as shown in Table 3.2 and Table 3.3. The covariates were tested for correlation to ascertain highly correlated variables in order to ascertain the best predictors of household travel demand. The results are presented in Table 3.2 and they show a relatively low (below 0.5) but significant correlation between most of the variables. A high coefficient of 0.74 between the logarithm of cost per km to the city centre and the logarithm of trip cost indicates a high positive correlation between the two variables. It may lead to spurious results if both variables are used in the same model. Therefore, the two could not be used in the same model and each one of them has been used in the model where it exhibited to be a better predictor of travel demand.

Results in Table 3.2 further show that the average number of trips taken by a household is negatively associated with an increase in the log of trip cost and distance to work place of the household head. However, it is positively associated with an increase in the log of monthly income, household size, and age. Furthermore, the log of distance traveled to work place is negatively associated with the log of the cost of travel per km and positively associated with the log of monthly income, household size, and age. Households with older heads travel less to the city centre as compared to those with young heads. Travels to the city centre are also negatively associated with larger households as well as higher incomes.

Table 3.2: Pair-wise Correlation Matrix of Some of the Variables used in Model Estimation[17]

Variable	hhtrips	logtripcost	logdwork	logproxcc	logcostpkm	logcostpkmw	loginc	hhsize
Log (trip cost)	-0.24							
	(0.00)							
Log (distance from home to work place)	-0.06	0.20						
	(0.02)	(0.00)						
Log (distance from home to the city centre)	-0.11	0.02	0.39					
	(0.00)	(0.43)	(0.00)					
Log (cost per km based of distance to the city centre)	0.26	0.74	-0.06	-0.52				
	(0.00)	(0.00)	(0.03)	(0.00)				
Log (cost per km based on distance to work place)	0.25	0.58	-0.58	-0.31	0.76			
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)			
Log (Monthly income)	0.26	0.12	0.07	-0.02	0.24	0.17		
	(0.00)	(0.00)	(0.01)	(0.45)	(0.00)	(0.00)		
Household size	0.54	-0.08	0.04	-0.02	0.17	0.13	0.34	
	(0.00)	(0.00)	(0.11)	(0.30)	(0.00)	(0.00)	(0.00)	
Age	0.30	-0.02	0.07	-0.02	0.13	0.07	0.26	0.43
	(0.00)	(0.52)	(0.00)	(0.29)	(0.00)	(0.01)	(0.00)	(0.00)

Significance levels are in parentheses

Source: Author's computation from KCCA 2011 survey data.

[17] hhtrips = total number of daily trips taken per household; tripcost = average trip cost; inc= monthly household income; hhsize= household size; proxcc = distance to the city centre; dwork = distance to work place of household head; costpkmw= average transport cost per km to work place costpkm= average transport cost per km to the city center; Age= age of household head.

Theoretically, in the estimation of urban demand model involving the number of trips as the dependent variable, distance travelled is considered as one of the most significant determinants given its expected effect on frequency of travel, and yet it can also be taken as a dependent variable. Thus, it is important to test for the significance of association between the two. Results in Table 3.3 indicate a significant association between the distance from home to the city centre and the daily number of trips taken by a household. It is expected that the further the location of the household from the city center, the fewer the number of average trips taken daily. There is also a significant association between distance from household location to the city centre and trip volumes. This is in line with the correlation results in Table 3.2, although in this case, the magnitude and direction of association cannot be ascertained.

Table 3.3: Chi2 Test of Association Between Distance from Household Location to the City Centre and Daily Trips Taken by a Household

Distance from home to the city center	Average household daily trips taken in Km (grouped)				
	0 - 4	5 - 8	9 - 12	Above 12	Total
0-3.0 km	21	137	139	88	385
3.01-6.0 km	59	329	300	195	883
6.01-9.0 km	26	179	157	82	444
Above 9.0 km	8	99	55	32	194
Total	114	744	651	397	1,906
Pearson chi2(9) 18.16 Pr=0.033					

Source: Author's computation from KCCA 2011 survey data.

3.3.8 Multi-collinearity and Heteroskedasticity Tests

Survey data is known for having weaknesses of collinearity and non-constant variance of the error term, which makes it eminent to test for the two. If collinearity is high and heteroskedasticity of the error term exists, then correction of this prior to model estimation is necessary to improve the robustness of the model. The use of a Collin test that gives a Variance Inflation Factor (VIF) as well as the tolerance level and other tests can be used in identifying such variables (Ender, 2010). The rule of thumb is that any individual variable with a VIF of greater than 10 needs to be checked (Marquardt, 1970). Likewise, if all variables are combined, an average VIF greater than 5 implies that the variables may exhibit some level of collinearity in the error term. Therefore, introduction of groupings and or use of other models other than OLS may be recommended. The tests are carried out with variables in their original form and results in Appendix 4 show that the average variance inflation factor (VIF) is greater than 10.

Such result may also arise from the variables having a non-constant variance. Therefore, if the model is estimated with the continuous variables in levels, serious multi-collinearity of the error term exists. The variables that exhibit multi-collinearity before transforming the continuous ones are daily transport cost, age, secondary education, tertiary education and private formal sector employment. After logarithmic transformation of the continuous study variables, the Collin test for the model variables was carried out to ensure that there is no serious multi-collinearity of the error term. Results in Appendix 8 show no individual covariate with a VIF of greater than 10 and the average VIF is 1.62 and 1.91 respectively for both the NBR and OLS covariates. This implies that there is no serious multi-collinearity of the error term if continuous variables are log-transformed before using them in model estimation. The tolerance for all the covariates is greater than 0.1, an indication of non-collinearity. Therefore, basing on these two results, each of the independent variables is considered a non-linear combination of other independent variables in the model. Therefore, the empirical models estimated do not suffer from serious multi-collinearity.

Further tests, after preliminary estimation of the variables in their original form, show that heteroskedasticity of the error term exists as indicated by the Breusch-Pagan test that gives the Prob > chi2=0.000. These results therefore lead us to reject the null hypothesis that the error term is homoscedastic. To solve the heteroskedasticity problem, logarithmic transformation of the continuous covariates is expected to reduce this risk (Greene, 2006; and Maddala, 2008). Thus, all continuous variables are transformed by taking their natural logarithm. In addition, to ensure that the standard errors from the estimated models are consistent with the heteroskedasticity assumption, robust models are estimated using the NBR and OLS regression.

3.3.9 Endogeneity

Estimation of most demand models is characterized by endogeneity problems especially with the price of the good and more so with survey data. This may be caused by measurement errors, regression with auto-correlated errors, omitted variables or reverse causality between the dependent and independent variables. In this study, it was expected that reverse causality might exist between the volume of trips taken and monthly income. Taking an example of people who work in the private sector say in sales; it would be expected that higher frequency of travel leads to more income earned unlike in those in the public sector who are typically salaried workers. Therefore, the assumption is that the higher the frequency of travel, the higher the income earned and vice versa.

A model was estimated for each sector separately to compare the income coefficient that turned out not to be significantly different (Appendix 9) from the estimates derived from the model that includes both sectors. In addition, an interaction term of income and public sector employment (log (income)*public sector dummy) was also introduced in the model and it turned out to be insignificant. This variable aimed at capturing any significant differences in the income effects on the amount of travel that may result from the fact that the household head is employed in the public sector and not the private sector. These results suggest that any endogeneity in the estimated model for this study may not result from reverse causality of the study variables.

The other variable that was expected to cause endogeneity is car ownership. It is expected that as household incomes increase, they are bound to buy a car for private use. However, due to data limitations, a model of car ownership could not be estimated to avoid the instrumental variable bias. Though introduction of an interactive term of income and vehicle ownership would have ruled out this kind of relationship, adding such a term brings about methodological issues of collinearity between the interactive term, vehicle ownership and income. Likewise, dropping income and vehicle ownership to capture only interactive effects gives insignificant results. The use of car ownership together with income as individual covariates in the model gives an insignificant result for car ownership. This is an indication that endogeneity may not exist between income and vehicle ownership in the data set we have used. This result may arise due the fact that in the sample used, car ownership by households in Kampala cuts across income groups with no big difference in numbers except for the poorest (see Appendix 3A).

Although the results may indicate that there is no endogeneity in the model, it cannot be completely ruled out especially with the unobserved characteristics of individual households and the determinants of the cost of travel. Travel is an individual's choice that can be subjective. Besides, the use of the generalized method of moments (GMM) models as an alternative given endogeneity yields consistent but inefficient results with larger standard errors as compared to the OLS regression which minimizes the standard errors hence giving unbiased and efficient results that reflect the true values of the estimates. Therefore, this study uses the NBR and OLS regression given that there are no variables identified to be endogenous in the model.

3.4 Model Estimation and Discussion of Findings

This section displays and discusses the model estimation results. Estimations results of both measures of travel demand are presented. The results of the NBR with number of trips as the measure of travel demand, and OLS regression results with distance travelled as the measure of travel demand are presented and discussed.

3.4.1 Estimation for Determinants of Urban Household Demand for Travel using the Number of Trips Taken as a Measure

The total daily number of trips taken by a household is considered as one of the measures of demand for travel. Individual travels are aggregated to get household frequency of travel. In the estimation process, an assessment of the individual influence of socio-economic factors on travel demand was carried out in isolation prior to assessing the combined effect. Thus, three model estimates are presented. In the analysis, the economic factors and one spatial factor of distance from the household location to the city centre are combined. In cases where individual characteristics are important, the characteristics of the household head are used since the household head is considered to be the decision maker for the entire household. Results of the NBR estimations shown in Table 3.4 indicate that trip cost, household monthly income, distance from the household location to the city centre, household size, age and employment sector of the household head significantly contribute to the variations in the daily demand for travel for households in Kampala. These affect the daily frequency of travel to the city centre.

Table 3.4: Negative Binomial Regression Results of Demand for Travel using Trip Volume as a Measure

Variables	(1) Economic factors	(2) Social factors	(3) All Socio-economic factors
Log (trip cost)	-0.123***		-0.098***
	(0.012)		(0.010)
Log (income)	0.155***		0.054***
	(0.015)		(0.014)
log(distance to city centre)	-0.046**		-0.042**
	(0.021)		(0.019)
Household size		0.112***	0.097***
		(0.006)	(0.006)
Age		0.003***	0.002***
		(0.001)	(0.001)
Gender		0.010	0.013
		(0.022)	(0.025)
Vehicle ownership		-0.056***	0.034
		(0.018)	(0.027)
Education level	Base = No education		
Primary		0.112**	0.040
		(0.052)	(0.064)
Secondary		0.116**	0.016
		(0.050)	(0.062)
Tertiary		0.116**	0.023
		(0.049)	(0.061)
Employment sector	Base = Public sector		
Private		-0.047**	-0.048**
		(0.023)	(0.024)
Others[18]		-0.054**	-0.061**
		(0.025)	(0.027)
Constant	1.073***	1.575***	1.776***
	(0.205)	(0.063)	(0.201)
lnalpha	-3.621***	-4.675***	-17.37
	(0.189)	(0.374)	(0.792)
N	1357	1906	1357
pseudo R^2	0.030	0.063	0.078
Walds Chi2(3;9;12)	732.52	613.45	218.04
Prob > Chi2	0.000	0.000	0.000

*Standard errors are in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Dependent Variable is the household average daily number of trips taken.*

Source: Author's computation using KCCA 2011 survey data.

[18]Employment sector Others includes manufacturing, building and construction, transportation, agriculture, unemployed/job seeking, domestic service and not in labor force including pensioners.

Economic Factors

According to the results in Table 3.4, trip cost and income have a significant effect on travel demand in both the first model where economic factors are isolated from social factors and even in the third model where socio-economic factors are combined. The inclusion of the spatial factor of distance does not change the magnitude and significance of the effect of these factors on household travel demand. Distance from the location of the household to the city centre has a significant negative effect on the volume of trips taken by households in Kampala, as indicated by estimates in model 1 and 3 in Table 3.4.

Trip cost has a significant negative effect on demand for travel in line with the findings by Souche (2010). This conforms with the law of demand for a normal good which asserts that an increase in the price of a normal good leads to a reduction in the quantity demanded for that good (Jehle and Reny, 2011; Varian, 2010). This implies that travel is a normal good. An increase in the average trip cost by 1 percent leads to a reduction in the difference of the logs of the expected daily demand for travel by 0.098 trips per household, holding other covariates constant. The price elasticity of travel is also expected to increase as prices increase. The estimations confirm this assumption. The results indicate that demand for urban travel is more elastic at higher prices above Ushs.1000 per trip and Ushs.500 per km (see Appendix 10).

Average monthly household income has a significant positive effect on demand for travel, which would be considered intuitively correct and it concurs with the findings by Giuliano and Dargay (2006). The results show that a 1 percent increase in the household monthly income leads to an increase in the difference of the logs of the expected daily demand for travel by 0.054 trips per household, holding other covariates constant. Although theoretically, income is expected to have a positive effect on trip volumes, some studies suggest that income elasticity of demand for travel differs with the mode used. This is attributed to the assumption that households' car and other automobile ownership and use increase with income (Litman, 2013).

Litman (2013) anticipates that the income elasticity of travel demand using public transit is negative and positive for private car use. However, an extensive analysis in this direction was not captured in this study because of lack of a distinct variable on mode choice in the data set used. Thus we cannot make such a conclusive statement since the analysis done considers all modes in general. But the introduction of the vehicle ownership covariate as a control for transport mode choice gives a non-significant relationship between vehicle ownership and trip volumes. An extended analysis of mode choice is carried out in Chapter Four.

In line with theory, distance traveled has a significant negative effect on trip volume. It is expected that households that stay far away from the city centre take less trips to the city centre while those staying closer take more trips. The results show that a 1 percent increase in the distance from the household location to the city centre leads to a reduction in the difference of the logs of the expected daily demand for travel by 0.042 trips per household, holding other factors constant. This implies that households that are located closer to the city centre frequently travel there as compared to others that stay farther. Therefore, the farther the household from the city centre, the fewer the trips taken.

Social Factors

Estimations of the effect of social factors on travel demand in exclusion of economic factors gives differing results from the model where both are combined as shown in Table 3.4. Basing on model 2 estimates, almost all the social factors have a significant effect on household travel demand except gender. While household size, age, and level of education have a positive effect, car ownership and employment sector have a negative effect on travel demand. Notably, households travel more as their heads grow older and those who own cars take less trips as compared to those who do not own cars; people travel more with attainment of education as compared to those who have no education; those employed in the private and other sectors take less trips as compared to those in the public sector. Although results in model 2 indicate the level of education significant, a combination of all the socio-economic factors show it insignificant in influencing urban travel demand. Household size, age of household head and employment sector remain as significant factors influencing urban travel demand.

Results in Table 3.4 model 3 indicate that household size has a significant positive effect on demand for travel. This implies that an additional member to a household leads to an increase in the difference of the logs of the expected household daily demand for travel by 0.097 trips holding other covariates constant. This effect increases with an increase in the household size as shown in Table 3.5 model 3.

Table 3.5: Negative Binomial Regression Results of Demand for Travel using Trip Volume as a Measure with Categorized Household Size and Age of the Household Head.

Variables	(1) Economic factors	(2) Social factors	(3) All Socio-economic factors
Log(tripcost)	-0.123***		-0.099***
	(0.012)		(0.010)
Log(income)	0.156***		0.064***
	(0.015)		(0.014)
Distance to city centre	-0.046**		-0.053
	(0.021)		(0.019)
Household size	Base = 1 - 3		
4 - 6		0.329***	0.281***
		(0.018)	(0.0204)
Above 6		0.587***	0.542***
		(0.065)	(0.0676)
Age (in years)	Base = 15 - 24years		
25 - 34		0.0769**	0.039
		(0.033)	(0.037)
35 - 44		0.149***	0.074*
		(0.035)	(0.039)
45 - 54		0.163***	0.078*
		(0.037)	(0.041)
Above 54		0.212***	0.147***
		(0.042)	(0.048)
Gender		0.021	0.021
		(0.022)	(0.025)
Car ownership		-0.0580***	0.031
		(0.018)	(0.028)
Education level	Base = No education		
Primary		0.111**	0.062
		(0.050)	(0.061)
Secondary		0.111**	0.026
		(0.048)	(0.059)
Tertiary		0.102**	0.020
		(0.048)	(0.059)
Employment sector	Base = Public		
Private		-0.0659***	-0.066***
		(0.0229)	(0.025)
Others		-0.060**	-0.070**
		(0.026)	(0.028)
Constant	1.073***	1.960***	1.962***
	(0.205)	(0.058)	(0.213)
lnalpha	-3.621***	-4.313***	-5.876***
	(0.189)	(0.281)	(1.424)
N	1357	1906	1357
pseudo R^2	0.029	0.054	0.070

*Standard errors are in parentheses; * p < 0.10, ** p < 0.05, *** p < 0.01 ; Dependent Variable is the household average daily number of trips taken.*

Source: Author's computation using KCCA 2011 survey data.

Compared to households with a smaller size of 1-3 members, results in Table 3.5 indicate a significant increase in the difference of the logs of the expected household daily demand for travel by 0.281 and 0.542 for the household size of 4-6 and above 6 members respectively at 1 percent level of significance holding other covariates constant. Thus, the more people in a household, the higher the number of daily trips taken, as well as the rate of change. In a typical African society where an average household is expected to have a spouse, a child and a household helper given its urban nature, travel demand is likely to increase especially if the household has school-going children and both spouses are employed. Irrespective of car ownership, where all members of a household may use the same means, the number of travels will still be more with the exception of cases where they all head to the same destination.

The age of the household head is another significant factor identified as having a significant positive effect on household daily demand for travel in Kampala which is in line with the findings by Metz (2011, 2012). The result implies that the older the household head, the higher the difference in the logs of the expected household daily demand for travel, with an increase of 0.002 trips, holding other covariates constant. Thus, the older the household head is, the higher the number of daily trips taken by a household. This result is confirmed by the estimations in Table 3.5 where age is categorized. Results in Table 3.5 indicate that households with older heads take more trips as compared to those with young heads.

Compared to households whose heads are 15-24 years old, those with older heads who are in the age group of 35-44, 45-54 and above 54 years, the difference of the logs of the expected household daily demand for travel significantly increase by 0.074, 0.078 and 0.147 respectively. These results are significant at 10 percent level of significance for the age group of 35-44 and 45-54 and at 1 percents for the age group of above 54 years. The result is with the exception of age group 25-34 years which could be attributed to the fact that age comes with responsibility as expected in African societies, implying that at this age, household heads have less responsibility. To affirm the results, descriptive statistics, indicate that the highest percentage of the household heads is in the active age group of 25-54 years (see Appendix 3E). These are expected to be working and having families, thus increased household travel demand. Despite this fact, results in Table 3.5 model 2 gives significant results for the age group of 25-34 when only the influence of social factors is estimated but yields insignificant results in model 3 that combines all factors.

The employment sector of the household head has a significant influence on the volume of trips taken by a household. Households whose heads work in the private and other sectors travel less times as compared to those in the public sector. Results in Table 3.4 indicate that working in the private sector reduces the difference in the logs of travel by 0.048 trips per household as compared to working in the public sector holding, other covariates constant. While working in other employment sectors reduces the difference in the logs of travel by 0.057 trips daily as compared to working in the public sector. The private sector includes both formal and informal sectors while other sectors include manufacturing, building and construction, transportation, agriculture, domestic, voluntary employees, as well as job seekers and students. Households whose heads work in the public sector may have more commuter travels due to the fact that government workers are compelled to report to work and are mainly salaried workers, whereas those in the private sector and other sectors may not necessarily be compelled to report to work. According to results in Table 3.4 and Table 3.5, the gender of the household head is consistently having an insignificant influence on household demand for travel.

3.4.2 Alternative Measure of Demand for Travel

As mentioned earlier, total distance travelled is also used as a measure of household demand for travel. In this study two proxies for distance traveled in terms of distance from the household location to the city centre and to the work place of the household head could be considered. Although both estimates have been made, only distance from the household location to the city centre has been discussed and the estimations using distance to work are given in Appendix 7A. Distance from household location to the city centre was chosen because the study is mainly focusing on travels towards the city centre. In addition, work travels may not necessarily lead to the city centre. Work travels are also necessary travels that give limited choice to the individual traveler since they have to report to work no matter the costs associated with the travel. Thus, in this case whereas an individual traveler may have a choice on the mode of transport, they may not have a choice on whether to reduce their work travels or not.

However, in estimating the model, transport costs to the work place of the household head was factored in as an explanatory variable. Intuitively, it is expected that since the household head is the decision maker, the daily costs he incurs may determine the frequency of travels to the city centre by the household members. Therefore, transport costs to work place of the household head is considered as costs for other goods and results are interpreted as a cross elasticity. Table 3.6 shows estimates for determinants of household demand for travel using distance traveled as a measure.

Three model estimates are reported by isolating economic factors from social factors, and then combining all the factors as shown in Table 3.6.

Table 3.6: OLS Results of Demand for Travel using Distance Travelled as a Measure

Variables	(1)	(2)	(3)
Distance to the city centre	Economic factors	Social factors	All Socio-economic factors
Log(cost per km to city centre	-0.330***		-0.333***
	(0.0193)		(0.0194)
Log(cost per km to work)	0.131***		0.133***
	(0.0195)		(0.0195)
Log(income)	0.0594***		0.0380**
	(0.0150)		(0.0184)
Household size		-0.0149**	0.00512
		(0.00720)	(0.00761)
Age of household head		-0.00180*	0.000245
		(0.00106)	(0.00122)
Gender of head		0.00419	0.00584
		(0.0283)	(0.0322)
Vehicle ownership		0.334***	0.0295
		(0.0253)	(0.0358)
Education level	Base = no education		
Primary		-0.0147	-0.129
		(0.0775)	(0.0808)
Secondary		0.0150	-0.159**
		(0.0744)	(0.0743)
Tertiary		0.0111	-0.0931
		(0.0743)	(0.0724)
Employment sector	Base = Public		
Private		0.0388	-0.00181
		(0.0294)	(0.0290)
Others		0.0657*	0.0181
		(0.0344)	(0.0354)
Constant	2.070***	1.579***	2.435***
	(0.199)	(0.0907)	(0.243)
N	1157	1157	1157
adj. R^2	0.248	0.092	0.249
F(3,1153; 9.1896; 12,1144)	132.71	21.11	35.28
Prob > F	0.000	0.000	0.000

*Standard errors are in parentheses * p < 0.10, ** p < 0.05, *** p < 0.01*
Dependent Variable is the distance from home to the city centre

Source: Author's computation using KCCA 2011 survey data.

The results in Table 3.6 indicate that transport cost per km of distance travelled to the city centre, transport cost per km of distance travelled to the work place of the household head, monthly income and education level significantly affect demand for travel.

Economic Factors

According to the results in Table 3.6, all the economic factors (cost per km and income) have a significant effect on travel demand in both the first model where economic factors are isolated from social factors and even where both are combined. They all show that own elasticity is negative and the cross elasticity is positive. From model estimates 1 and 3, transport cost per km to the city centre has a significant negative effect on demand for travel, whereby a 1 percent increase in transport cost per km to the city centre leads to a 0.33 percent decrease in the daily distance traveled by a household. Thus, the higher the cost of transport to the city centre, the fewer the travels to the city centre. This conforms to economic theory of demand and specifically the law of demand for a normal good where its quantity demanded is expected to decrease with an increase in its price. Thus, the price elasticity of demand is negative.

However, transport cost per km to the work place of the household head is also significant but positively related to the distance travelled by a household. Results show that, a 1 percent increase in the transport cost per km to work leads to a 0.13 percent increase in distance travelled. Since distance from household location to the city centre is being considered in this case, cost per km to work is taken as the price for other goods, yielding a positive cross elasticity. This would imply that when the cost to the work place of household head increases, individuals may choose to travel to the city centre instead of other places that would signify distance to the city centre and distance to work as substitutes. It may also justify a case for private sector employees who constitute over 50 percent of the population and more so the private informal sector. The results are contradicting in relation to the expectations. It is expected that when transport costs to work place of the household head increase, travels to the city centre falls. The results may arise due to the fact that most travels to the city centre might be actually work-related. Thus, travel costs for work-related travels may not negatively affect travels to the city centre. Besides, the result would also imply that the travel cost incurred by the household head to his work place does not reduce the distance traveled by a household but instead increases it especially with mandatory work travels.

Household monthly income has a significant positive effect on demand for travel whereby a 1 percent increase in household monthly income leads to approximately a 0.04 percent increase in distance travelled. This implies that households having higher incomes tend to travel more than those with lower incomes. These results concur with the findings by Giuliano and Dargay (2006) as well as with economic theory of expenditure, which asserts that with an increase in disposable income, individuals are bound to be involved in more activities and hence an increase in the daily demand for travel.

Social Factors

Just as in the NBR model, estimations of the effect of social factors on travel demand in exclusion of economic factors gives some differing results from the model where both are combined. Basing on results in Table 3.6 model 2, age, household size, and vehicle ownership have a significant effect on the distance travelled. In this case, household size and age of the household head have a negative effect, implying that distance travelled decreases with an increase in age and household size.

Private car ownership also has a positive effect on travel demand. Households that own private cars travel longer distances as compared to those who do not own cars. Although results in Table 3.6 model 3 indicate insignificant results for car ownership, they are still maintaining the expected positive sign, an indication of its positive influence on distance travelled. But when only social factors are considered, results are significant results at 1 percent significance level. This results is confirmed by results in Table 3.7. The same pattern of results is exhibited in Appendix 7A and 7B, where distance to work is used as a proxy for daily distance travelled.

Results in Table 3.6 model 2 where only social factors are used in model estimation, indicate that household size has a significant negative effect on distance travelled. Although combining all factors as per estimates in Table 3.6 model 3 gives insignificant results, categorizing this variable yields some significant results as shown in Table 3.7 model 3. Results show that as compared to households with 1-3 members, there is a significant difference in the distance travelled for households with 4-6 members. This implies that an additional member to a household leads to a significant increase in the household daily distance travelled. The result shows that an additional member leads to a 5 percent significant increase in the daily distance travelled by households of size 4-6 as compared to those with 1-3 members holding other covariates constant. However, results in both Table 3.6 and Table 3.7 model 3 indicate an insignificant effect of an additional member to households with over 6 members although the coefficient indicates a negative influence on distance travelled.

Education level also has a significant but negative effect on distance travelled according to results in Table 3.6 model 3 consistent with results in Table 3.7 model 3. Results indicate that for households whose heads have attained secondary education level, distance travelled is likely to be 0.16 times less as compared to those whose heads have no education. This is an indicator that more educated people travel less as compared to people without education. The same pattern of results is exhibited in Appendix 7A and 7B, where distance to work is taken as a proxy for daily distance travelled. This results may arise due to the fact that people with higher education are expected to have formal employment and take more of work-related trips to the city centre as compared to the less educated who may be unemployed or employed in the informal sector and thus take more non-work trips to the city centre.

Table 3.7: OLS Results of Demand for Travel using Distance Travelled as a Measure with Categorized Household Size and Age of Household Head

Variables	(1) Economic factors	(2) Social factors	(3) All Socio-economic factors
Log(cost per km to city centre)	-0.330***		-0.332***
	(0.019)		(0.019)
Log(cost per km to work)	0.131***		0.133***
	(0.020)		(0.020)
Log(income)	0.059***	-0.035**	0.036**
	(0.015)	(0.016)	(0.018)
Household size	Base = 1 - 3		
4 - 6		0.032	0.050*
		(0.026)	(0.027)
Above 6		-0.097	-0.019
		(0.091)	(0.095)
Age (in years)	Base = 15 - 24		
25 - 34		-0.055	-0.066*
		(0.039)	(0.039)
35 - 44		-0.032	-0.047
		(0.042)	(0.041)
45 - 54		-0.101**	-0.097**
		(0.046)	(0.047)
Above 54		-0.070	-0.019
		(0.056)	(0.060)
Gender		0.010	0.009
		(0.029)	(0.032)
Vehicle ownership		0.066*	0.030
		(0.037)	(0.036)
Educational level	Base = no education		
Primary		-0.022	-0.112
		(0.076)	(0.080)
Secondary		-0.011	-0.140*
		(0.073)	(0.073)
Tertiary		0.034	-0.077
		(0.073)	(0.072)
Employment sector	Base = Public		
Private		-0.013	-0.0058
		(0.030)	(0.029)
Others		0.019	0.007
		(0.035)	(0.036)
Constant	2.070***	1.961***	2.509***
	(0.199)	(0.223)	(0.248)
N	1157	1546	1157
adj. R^2	0.248	0.004	0.252
pseudo R^2			

*Standard errors are in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$*
Dependent Variable is the distance from home to the city centre

Source : Author's computation using KCCA 2011 survey data.

The age of the household head is another significant factor identified as having a significant but negative effect on household daily distance travelled. Results in Table 3.6 indicate a significant influence when only social factors are considered but an insignificant effect when all factors are combined though maintaining the negative directional sign. However, a categorization of age yields significant results at age groups 25-34 and 45-54 years as shown in Table 3.7. Results in Table 3.7 model 3 show that as compared to households with young heads aged 15-24 years, there is a significant fall in the distance travelled for households with heads aged 25-34 and 45-54 years. The fall in the daily distance travelled for households with heads aged 25-34 and 45-54 years fall by 6.6 and 9.7 percent respectively, holding other covariates constant. These results are significant at 10 percent significance level. The results may imply that households with older heads travel less as compared to those with young heads. This could be attributed to the family size for older heads since if married, it implies more commitment to family and reduced travel due to costs involved given more members as compared to the young who could be alone or if married with only wife and husband.

It can be noted from the results of both the NBR and OLS regression results that the pseudo R-squared and the coefficient of determination (R-squared) are small (see Table 3.5, Table 3.6, Table 3.7, and Table 3.8). This is not new since it is not uncommon for survey data to have low R-squared. Besides in cross-sectional studies, the most important results of interest are the estimates, not R-squared. Therefore, the interest is on the behaviour of the covariates in the model, that is, the value of the estimates. Despite the low value of R-squared, the estimated models are still robust.

3.4.3 Comparison of NBR and OLS Results

Using both measures of urban travel demand, that is, daily average trip volume and distance travelled, the effect of economic factors is consistent, implying strong emphasis on them for policy making. Comparing both the NBR and OLS results, the significant factors that affect travel demand in Kampala are; transport cost in terms of both trip cost and cost per km of distance traveled, and household monthly income. Household frequency of travel is inversely related to trip cost while daily distance travelled is also inversely related to cost per km. Both NBR and OLS indicate that household travel is positively related to the monthly income, implying that the higher the income of a household, the more the daily frequency of travel as well as the distance travelled.

Likewise, both NBR and OLS results show that household size significantly affects travel demand. Furthermore, in analyzing the influence of only social factors on household travel demand excluding economic factors, results of the NBR and OLS confirm this relationship. While the NBR results suggest a positive relationship between the daily trip volumes and household size, OLS results indicate a negative relationship between the daily distance travelled and household size. The relationship implies that the larger the household size, the more trips expected but shorter distance travelled. The results may be attributed to the proxy used for household daily distance travelled. It thus implies that the larger the household size, the shorter the distance travelled to the city and this result may be explained by the fact that larger households stay closer to the city centre.

While analyzing only the effects of social factors on travel demand, OLS results indicate that vehicle ownership has a positive effect on daily distance travelled but NBR results show that it negatively affects the frequency of travel. Thus, households that own cars may take longer distances but fewer trips. The NBR results further show that the older the household head, the more trips taken, but OLS results show that shorter distances are travelled. The education level of the household head, according to NBR results, is significant and positively influences the frequency of travel. The results indicate that households whose heads are highly educated are likely to take more trips as compared to those with lower education levels. The change in the likelihood of travel increases with education level. However, OLS results indicate that households with highly educated heads travel shorter distances as compared to the less educated. While NBR results indicate that compared to households whose heads work in the public sector, those whose heads are in private sector employment take fewer trips, OLS results indicate that they actually travel longer distances to the city centre.

There is notably a significant difference in the two model results especially with the effect of social factors on demand for travel. The contrast between the two models may be attributed to the proxy measure used for the daily distance travelled by a household. This distance reflects the location of the household from the city centre, and thus the effect of social factors highly reflect the characteristics of these households. Therefore the results are interpreted with caution.

3.4.4 Simulations

Simulation analysis is an approach employed by researchers and policy analysts to aid in understanding of the link between a specific shock on a given explanatory variable and the explained. This process gives the effect of a shock introduced to an explanatory variable, on the explained variable, holding other covariates constant. The results that accrue from simulations can be used for policy guidance. Simulations have been vastly employed in modeling transport issues mainly for policy direction. These range from basic simulations using STATA programming, Monte Carlo simulation approach to model toolkits like MATSim-T. Balmer *et al.* (2008) employed a MATSim-T model toolkit that provides a variety of tools and resulting approaches to model travel demand and traffic flow as well as their interactions.

Kitamura *et al.* (2000) investigated the application of a Monte Carlo simulation method on the estimation of the urban travel demand. Basing on this method, a model was established. Individual daily travel activities of various groups were simulated from which urban travel demand for the entire city was estimated. Groups were formed using the socio-economic characteristics of individuals. The estimations were based on the probability distribution of the individual activity characteristics, including typical activity chain patterns, activity time, activity location and travel mode.

In this study, two simulations were carried out. First to ascertain if the model used can give similar results for larger samples. A simulation is carried out to assess the adherence of the behavior of the covariates to economic theory using hypothetical data and the NBR model. Since the data that is in logarithmic form behave better than the data in levels, the log-transformed variables are used. The assumption of a uniform normal distribution for the variables is considered, as the variables appear normal after log transformation. The results of the coefficients of the simulated trip volumes are shown in Table 3.8.

The results in Table 3.8 indicate that despite the increased number of observations, implying larger samples of 3000 and 5000 households, the causal effect of the covariates is not significantly different in the two samples. This is in both the magnitude and direction. When compared to results from using the observed original data set, simulation coefficients are similar and maintain the same causal direction. Trip volumes are inversely related to trip cost and positively related to household monthly income, household size, and age of the household head. Therefore, the estimated NBR model results give the true picture of the given determinants of urban household travel demand.

Table 3.8: Simulation Results Showing the Average Beta coefficients for Selected Variables from the Negative Binomial Regression

Variable N=3000	Average Beta coefficient	Standard deviation	Minimum	Maximum
Log(trip cost)	-0.042	0.001	-0.044	-0.039
Log(income)	0.024	0.001	0.020	0.027
Log(distance to the city centre)	-0.018	0.001	-0.023	-0.013
Household size	0.040	0.000	0.038	0.041
Age	0.001	0.000	0.001	0.001
Gender	0.007	0.002	0.002	0.013
Vehicle ownership	0.014	0.002	0.007	0.020
Primary education	0.147	0.000	0.146	0.148
Secondary education	0.006	0.005	-0.012	0.022
Tertiary education	0.009	0.005	-0.008	0.024
Private sector	-0.020	0.002	-0.026	-0.015
Other sectors	-0.026	0.002	-0.032	-0.019
Variable N=5000	**Average Beta coefficient**	**Standard deviation**	**Minimum**	**Maximum**
Log(trip cost)	-0.042	0.001	-0.044	-0.040
Log(income)	0.024	0.001	0.020	0.027
Log(distance to the city centre)	-0.018	0.001	-0.022	-0.013
Household size	0.040	0.000	0.038	0.041
Age	0.001	0.000	0.001	0.001
Gender	0.007	0.002	0.001	0.014
Vehicle ownership	0.014	0.002	0.007	0.020
Primary education	0.017	0.005	-0.001	0.033
Secondary education	0.006	0.005	-0.012	0.021
Tertiary education	0.009	0.005	-0.008	0.025
Private sector	-0.020	0.002	-0.026	-0.015
Other sectors	-0.026	0.002	-0.033	-0.019

Source: Author's computation using KCCA 2011 survey data.

Secondly, an experimental simulation is carried out by shocking the variable of trip cost to ascertain the effect of this shock on the travel behavior of households. This kind of simulation is important for policy direction. This was done in such a way that a hypothetical number of households is generated and added to the existing sample. These households assume values for the shocked variable and the original sample of households maintain the original values of the variables. A shock in terms of a percentage increase in the trip cost is exerted on the average travel cost holding other covariates at their mean.

The values of trip cost after the shock are assigned to the added households. Mean values are assigned to the remaining covariates for the new households introduced to the sample. Trip cost is selected since both NBR and OLS estimations identified it as a crucial impedance factor to travel demand. The NBR model is used to determine the effect of a percentage increase in trip costs on household travel demand. Table 3.9 shows the percentage change in trip cost and the associated change of its effects on trip volume as well as the change in the predicted number of trips. In this estimation, a percentage increase in the trip cost was applied to some households holding other factors constant (at the mean). An additional number of households were considered in order to create a sample on which a policy change would be applied. Then an NBR model was estimated for each percentage change in the trip cost and the average predicted trip volume recorded for each change. The simulated results in Table 3.9 indicate an increase in the effect of a percentage change in the trip cost on the average number of trips taken by a household per day.

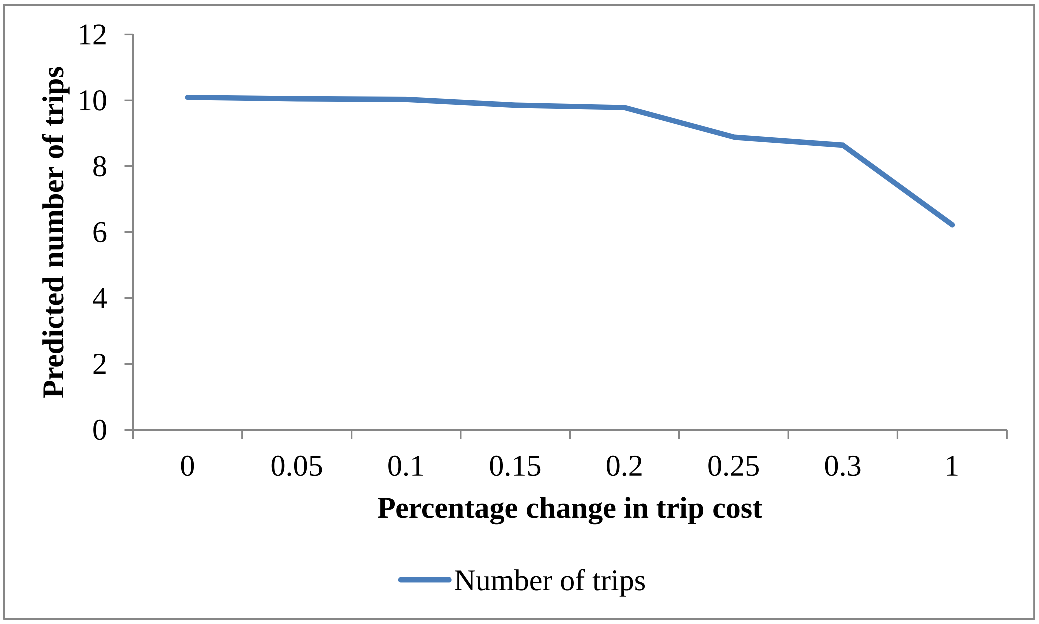
Table 3.9: Simulation Results Showing the Effect of the Change in Trip Cost on Trip Volumes

Percentage change in trip cost	Predicted household trips	Coefficient change
At mean	10.09	-0.098
0.05	10.05	-0.103
0.10	10.03	-0.109
0.15	9.86	-0.115
0.20	9.78	-0.118
0.25	8.89	-0.122
0.30	8.64	-0.125
1.00	6.22	-0.543

Source: Author's computation using KCCA 2011 survey data.

Although the change in the number of daily trips is small, it is still downward sloping as shown in Figure 3.1. The marginal changes in the average number of daily trips per household are small between 5 percent and 30 percent price changes. However, a 100 percent change in trip cost keeping other factors constant, leads to a bigger change in trip volumes. The Average number of daily trips falls drastically with the price change of 100 percent.

Figure 3.1: Predicted Number of Trips given a Percentage Change in Trip Cost



Source: Author's compilation from KCCA 2011 survey data.

3.5 Limitations in the Estimation of the Determinants of Urban Household Road Travel Demand

The key limitation in this study is to do with the data set used in model estimation. Although the data set provides the daily number of trips taken by a household, it lacks detailed information on the purpose of all these trips. Only the purpose for the first trip taken by the household head in a day is provided. Travel demand is derived demand and thus trip purpose would give a better idea on the travel behaviour of Kampala city residents, and can provide better policy guidance.

The reduction in the reported sample from 3000 to 1906 households on the basis of being in the same income group is not ignorable since these households could be having significantly different social characteristics that are important in influencing their travel behaviour. Lack of data on the average daily distances travelled by every household member in order to have the total distance by a household also limits us in making precise conclusions about the study variables. Another limitation is that there are no weights provided by KCCA in order to have precise estimates. Therefore, results are interpreted with caution.

3.6 Conclusion

Using both measures of urban household travel demand that is, daily average trip volume and distance travelled, the effect of economic factors is consistent in both models and with theory, implying strong emphasis on them for policy making. In conclusion, most of the coefficients obtained have economically and intuitively correct signs. The results from both the NBR and OLS regression consistently show that daily demand for travel by households in Kampala is inversely related to the cost of travel and positively related to household income. Further investigations indicate demand for urban travel being more elastic to higher prices; that is to say above Ushs.1000 per trip and Ushs.500 per km of distance traveled (see Appendix 10). Simulated results further show a drastic fall in the volume of daily trips taken by a household if the trip cost doubles or increases by 100 percent. Therefore, change in costs of travel can greatly reduce the household amount of urban travel.

The influence of social factors is also pronounced in both model estimations. Trip volumes increase with household size, age, and education level of the household head, and decreases with car ownership and private sector employment of the household head. Whereas distance traveled decreases with household size, age, and attainment of education, it increases with car ownership.

CHAPTER FOUR

DETERMINANTS OF URBAN HOUSEHOLD ROAD TRANSPORT MODE CHOICE: EVIDENCE FROM KAMPALA

4.1 Introduction

Kampala, being the capital city and therefore the major business centre in Uganda coupled with increased development, has drawn people to frequently travel to the city. Over a period of time, Kampala has experienced immense congestion on the city roads that has worsened by stretching into late hours in the night and almost for all days of the week. There has been an observed increase of traffic flow on the major corridors or arterials to and from Kampala since 1997.

Table 4.1 shows the average daily traffic for 1997 and 2010, average hourly traffic flow and the computed annual traffic growth rates for the major arterials. The major arterials include Jinja road, Entebbe road, Masaka Road, Hoima road, Bombo road, Gayaza road and Ggaba road. The annual growth rate on all the major arterials is above 5 percent with the lowest being 6.67 percent and the highest being 13.91 percent (see Table 4.2). Table 4.1 and Table 4.2 show that the average daily and hourly traffic flow on almost all the major transport arterials or corridors in Kampala tripled in 2010 from 1997. Though the hourly traffic flow for some of the major corridors was still less than 1000 vehicles by 2010, these figures are expected to change more than two-fold by 2016. Some of the roads are already operating beyond capacity of a two-way urban road given their width of 6.1 meters.

Table 4.1: Average Daily Traffic Flow (ADT)

Main transport arterials	ADT 1997	ADT 2010	Projected ADT 2016
Jinja road	18,260	42,296	62,309
Entebbe road	8,617	44,596	95,187
Masaka road	8,027	43,610	95,270
Hoima road	3,728	19,179	40,828
Bombo road	7,178	31,558	62,624
Gayaza road	7,329	24,831	43,607
Ggaba road	9,226	26,127	42,249

Source: KCCA and MoWT (2011).

Table 4.2: Average Hourly Traffic Flow and Annual Growth Rate

Main transport arterials	Average hourly flow 2010	Projected average hourly flow 2016	Estimated annual growth rate
	Vehicles per hour	Vehicles per hour	
Jinja road	1,057	1,558	6.67
Entebbe road	1,115	2,380	13.47
Masaka road	1,090	2,382	13.91
Hoima road	479	1,021	13.42
Bombo road	789	1,565	12.1
Gayaza road	621	1,090	9.84
Ggaba road	653	1,056	8.34

Source: KCCA and MoWT (2011).

Traffic flow on Kampala roads is expected to further increase given the predictions for 2016. An over two-fold increase in daily traffic flow from 2010 to 2016 is expected on all the major arterials leading to and from Kampala. The average hourly traffic flow is also expected to be higher in 2016. Traffic flow predictions of 2016 clearly indicate that most of the roads will be operating beyond capacity for a two-way urban road and others will actually exceed the capacity of a dual two-lane road with carriageway width of 13.5 meters. Besides, not all the mentioned major arterials are dual carriageways.

According to the Institution of Highways and Transportation (1987), traffic flow on two-way urban roads of carriageway width of 6.1 meters can only accommodate up to a maximum of 1100 vehicles per hour while dual two-lane roads with carriageway width of 13.5 meters can only accommodate up to 2950 vehicles per hour. These thresholds are only expected to apply if the roads have less of other activities like parking and cross traffics among others. Furthermore, Table 4.2 indicates that the annual traffic growth rate for all the major arterials is above 5 percent. The growth rates may seem small but they can only hold if the traffic patterns do not significantly change. However, given the rate of development of Kampala, this assumption is not likely to hold.

Automobile congestion on urban roads is sometimes related to the different automobiles used on these roads. In Kampala, Uganda's capital city, it can be observed that a number of automobiles are used for transport on the city roads. These range from "*boda-boda*" (motorcycles), "taxis"(14 seater mini-buses), private cars and buses (both public and private). Among the public transport modes are: taxis that constitute 21 percent of all the transport modes on the road and transport 82.6 percent of the passengers; *boda-bodas* constitute 42.2 percent and transport 8.5 percent of the passengers; private cars constitute 36.6 percent and transport 8.8 percent of passengers, (KCCA, 2011). Buses constitute a very minimal percentage since during the time of the survey, only few buses were available and were plying a few routes.

The above statistics indicate that the taxi mode takes the highest share of transit and yet they transport only 14 passengers at a time, implying that they are numerous on the road. This has led to a lot of disorganization in the city and they evidently contribute to traffic congestion given their disorderly way of operation. It has also been noted that car ownership and therefore use has increased in Kampala, which might have also worsened the congestion problem. The numerous number of *boda-boda* also contributes to impediments towards traffic flow given the many accidents caused by *boda-boda* riders. This therefore calls for provision of an efficient mode of transport as one of the necessary solutions towards solving traffic congestion in urban centers.

To this effect, and the assumption that the kind of public transport available is insufficient, KCCA is encouraging the improvement of the railway line joining some city zones and hence use of rail transit. Furthermore, another bus company whose operation was halted in its early stages of implementation has been allowed to begin operations to increase the number of buses plying the main corridors. KCCA of recent has been running an advert on its website promising more buses as part of continued efforts towards improving public transport. All these efforts are meant to provide an efficient mode of transport with the main objective of reducing the congestion problem to manageable levels.

However, having both buses and taxis operating on the same routes may not actually reduce congestion because they will both use the same available road space. Besides, taxis may have an advantage over buses due to their way of operation. The fact that they take few people implies getting occupied quickly and thus moving faster. They also are able to avoid congested routes by using small access roads. Buses take quite a bigger number of passengers, and thus may take longer to get full especially during off-peak hours. Further, buses cannot manage taking smaller access roads given their size.

In an attempt to achieve the objective of reducing congestion to manageable levels, there must be controls on other available transport modes; otherwise reducing congestion in Kampala city might remain a dream. Besides, all the solutions so far provided are from the supply side and not demand side which might be a short-term solution given the fact that it may instead induce congestion. The fact that congestion is excess demand for road space raises the need to also find ways of managing and/ or reducing this excess demand. Thus, studying the important factors affecting transport mode choices is very crucial. However, studies towards investigating the demand side of urban travel in Kampala are hardly found. Therefore, this study analyses the determinants of transport mode choice in order to find ways of managing excess demand for road space. Such results can act as guidelines for the type of travellers to be targeted and the kind of solutions that can be used in managing traffic flow on the city roads.

4.2 Objectives of the Study

This chapter answers the second objective that assesses the determinants of urban household road transport mode choice. The specific objectives are mainly focusing on the theoretically suggested factors and the socio-economic factors that influence transport mode choice decision-making. These factors include: travel time, travel cost, income, trip length, household size, trip volume, trip purpose as well as age, gender, and education level of the household head, on urban household road transport mode choice.

4.4 Methodology and Data

In this section, the theory adopted, empirical methodology, and data sources are presented as per the objectives of the study. The variables used are identified from the literature and are also based on the availability of data for Kampala.

4.3.1 Theoretical Framework

This study borrows ideas from the theory of consumer choice and specifically utility maximization (McFadden, 1974; Domencich and McFadden, 1975; Hausman and Wise, 1978; Davidson, 1996). The theory and model framework is based on the random utility model. Based on the axiom of classical economic choice theory, where an individual is the basic decision-making unit and is able to rank alternatives given the utility he derives, an individual's travel demand utility is a function of a number of attributes. This theory states that an individual chooses a transport mode given that the utility (*U*) he derives from using this mode is greater than what is derived from using any other mode. Thus, given a road transport mode *i* and a vector of other transport modes *k*, an individual will only choose *i* if and only if, $U_i > U_k$.

Borrowing from Hausman and Wise (1978), a separable utility function of the Cobb-Douglas type is used. A consumer derives total utility from a given transport mode choice as well as other commodities consumed. The utility derived from using a given transport mode *i* is given as;

$$U_i = W_i T^{\sim} \text{ --- } (1)$$

Where;

W_i is the sub-utility function representing the utility derived from choice *i*.

T is the utility derived from consuming all the other commodities.

After taking logs and expressing T in the indirect utility form as a function of prices and income remaining after expenditure on alternative *i*,

$$\log U_i = \log W_i + \sim \log V(m - \circ_i, p) \text{ -- } (2)$$

Where;

m is income, $\circ_i$ is the cost of alternative *i*, p is a vector of commodity prices, V is the indirect utility function and it is assumed to be homothetic.

Approximating $\log m - \circ_i$ to first order by its ratio leads to

$$\log U_i = \log W_i + \sim \frac{m}{\circ_i} + \sim \log f(p) \text{ -- } (3)$$

Normalising by assuming the mean of $f(p) = 1$ in the population leads to;

$$\log U_i = \log W_i + \sim \frac{m}{\circ_i} + ¥ \text{ ---} (4)$$

Where;

$\log W_i$ is the function of the attributes of the transport mode choice, $\sim \frac{m}{\circ_i}$ and the random term ¥ follow from the indirect utility function representing utility of other goods, ~ and ¥ are parameters permitted to vary in the population.

4.3.2 Model Specification

Logit models have been used in analysing choice problems. McFadden (1974) and Hensher (1986) analyze the travel mode of urban commuters using a logit model. A logit model gives the probability of choosing a particular mode for a given trip based on the relative values of cost, level of service, and travel time. The logit model is considered as the best approach since travel is a result of choice made depending on the activities to do and whether to do them or not, and where to perform these activities and which routes to take by choosing from a set of mutually exclusive and collectively exhaustive alternatives.

The Theoretical Logit Model

Greene (2006) hypothesises that an individual's utility for two choices, Y_l and $Y_{k,}$ are denoted by U_l and $U_{k,}$ respectively. The linear random utility model could then be specified as:

$U_l = \;{}'_l X_i + \pounds_l$ and,

$U_k = \;{}'_k X_i + \pounds_k$ --- (5)

Where U_l and U_k are perceived utilities derived from using road transport mode l and k, respectively.

X_i is the vector of explanatory variables that influence the perceived desirability of using a given mode of road transport, $\;_l$ and $\;_k$ are parameters to be estimated explaining the influence of the explanatory variables on the perceived utility derived from using a given road transport mode, $\pounds_l$ and $\pounds_k$ are error terms assumed to be independently and identically distributed.

Relating it to choice of mode of road transport, if an individual uses road transport mode l, it implies that the perceived utility derived from using this mode is greater than that derived from using any other mode of road transport.

Thus;

$U_{il}(\;{}'_l X_i + \pounds_l) > U_{ik}(\;{}'_k X_i + \pounds_k)$ for $l \neq k$ --- (6)

Therefore, the probability (P) that an individual will use road travel mode l among the set of alternatives of road travel modes can be defined as;

$P(Y = 1/X) = P(U_{il} > U_{ik})$

$$= P(\ {}_l^{'}X_i + £_l - \ {}_k^{'}X_i - £_k > 0 / X)$$

$$= P(\ {}_l^{'}X_i - \ {}_k^{'}X_i + £_l - £_k > 0 / X))$$

$$= P((\ {}_l^{'} - \ {}_k^{'})X_i + £_l - £_k > 0 / X)$$

$$= P(\ {}^{*}X_i + £* > 0 / X) = F(\ {}^{*}X_i) \quad \text{---} \ (7)$$

Where *P(.)* is a probability function, $£^* = £_l - £_k$ is a random disturbance term, ${}^* = \ {}_l - \ {}_k$ is a vector of unknown parameters that can be interpreted as a net influence of the vector of independent variables influencing road travel mode choice, and $F(\ {}^*X_i)$ is a cumulative distribution function of $£^*$ evaluated at ${}^*X_i$. The exact distribution of *F* depends on the distribution of the random disturbance term $£^*$.

Depending on the assumed distribution that the random disturbance term follows, several qualitative choice models can be estimated (Greene, 2006). Recall from equation (5) that an individual chooses a given road transport mode given the utility he derives from using this mode. McFadden (1973) developed a logit model based on the axiom of independence of irrelevant alternatives (IIA). Given situations with three or more choices, a multinomial logit (MNL) model would be used. To describe the MNL model, let y denote a random variable taking on the values $\{1,2,---j\}$ for *j*, as a positive integer, and let *x* denote a set of conditioning variables. In this study, *y* denotes road transport modes or choices available from which an individual is expected to choose and *x* contains individual characteristics like age, income levels, gender, education among others.

More broadly, the MNL pair of classes (y_1,y_2) can be described by the ratio:

$$\log\left(\frac{P(y=j/x)}{P(y=1/x)}\right)=\sim_j + \ {}_j^{'}x \text{ -- (8)}$$

However, given J alternatives, equation (8) can be rewritten as;

$$\log\left(\frac{P(y=j/x)}{P(y=J/x)}\right)=\sim_j + \ {}_j^{'}x \text{ --- (8a)}$$

Where x is the vector containing the predictor variables, $\sim_j$ is the intercept parameter for the j^{th} level and the vector of regression coefficients. Although the model is analogous to a logistic regression model, the probability distribution of the response variable is a multinomial and with *J-1* equations. These equations contrast each of the categories *1,2,---- J-1* with category *J*. On the basis of these *J-1* regression equations, it is possible to compute the probability of an individual choosing mode *j* on the basis of its features contained in the vector *x*.

Exponentiating equation (8a) gives;

$$P(y=j/x)=P(y-J/x)\exp^{\left(\sim_j + \ {}_j^{'}x\right)} \text{ -- (8b)}$$

Summing equation (8b) over *j* gives;

$$\sum_j P(y=j/x)=P(y-J/x)\sum_j \exp^{(\sim_j + \ {}_j^{'}x)} \text{ -- (8c)}$$

Taking into consideration the fact that $\sum_j P(y = j/x) = 1$, equation (8b) becomes

$$P(y-J/x)=\left(\sum_j \exp^{(\sim_j + \ {}_j^{'}x)}\right)^{-1} \text{ -- (8d)}$$

Substituting equation (8d) in equation (8b) gives;

$$P(y = j / x) = \frac{\exp^{(\sim_j + \;'_j x)}}{\sum_{k=1}^{J} \exp^{(\sim_j + \;'_j)}} \text{--} \quad (8e)$$

Letting *x* be a *1*x* vector with the first element equal to unity gives the MNL model with response probabilities given as;

$$P(y = j \mid x) = \frac{\exp(\sim_j + \;'_j x)}{1 + \sum_{h=2}^{J} \exp(\sim_h + \;'_j x)}, \; j = 1, \ldots, J \quad \text{--} \; (9)$$

Where $\;_j$ is a *kx1* vector. In this case the baseline category *j=1* with $\sim_1$=0 and $\;_1$=0.

However, Greene (2008) suggests that for data sets that have alternative-specific variables that measure for all alternatives not just the chosen alternative, a conditional logit model is more appropriate. But the conditional logit command (clogit) does not have an option of case-specific variables because here a case-specific variable is interacted with dummies for *m-1* alternatives, and the *m-1* variables are entered as regressors (Cameron and Trivedi, 2010).

For this reason the alternative specific conditional logit (ASCLOGIT) model is recommended (McFadden, 1974). The ASCLOGIT fits McFadden's choice model, which is a specific case of the more general conditional logistic regression model is estimated. This model allows both alternative-specific and case-specific variables. In estimation of the ASCLOGIT model, data is set in a long form and not the usual wide form.

Given z_{ij} as the regressors for the given transport choices and assuming a Gumbel distribution that takes into consideration type 1 extreme values, $F(£_{ij}) = \exp(-e^{-£_{ij}})$, then, the conditional logit model specifies that;

$$\Pr(Y_i = j \mid z_{i1}, z_{i2}, \ldots\ldots\ldots\ldots\ldots, z_{im}) = \frac{e^{z'_{ij}}}{\sum_{j=1}^{m} e^{z_{ij}'}} \text{ -------------------------------------- (10)}$$

But the utility derived from choosing a given mode depends on z_{ij} that includes aspects to the individual as well as to the choices. Therefore, there is a need to distinguish them (Cameron and Trivedi, 2010).

Let $z_{ij} = [x_{ij}, w_i]$ with x_{ij} varying across the alternatives and or individuals as well, and w_i contains characteristics of individuals and is therefore the same for all the choices. Incorporating all these facts therefore,

$$P(Y_i = j) = \frac{\exp(\;' x_{ij} + \sim_i' w_i)}{\sum_{j=1}^{m} \exp(\;' x_{ij} + \sim_i' w_i)} \quad j = 1,2,\ldots\ldots\ldots\ldots\ldots m \text{ ....(11)}$$

Where,

m is the total of alternatives

x_{ij} are alternative-specific regressors and w_i are case-specific regressors, are the coefficients of alternative specific regressors which in this study is travel time by mode, and $\sim_i$ are coefficients of case-specific regressors.

The parameter estimates in this case provide only the direction of the effect of the independent variables on the dependent variable; they do not represent either the actual magnitude of change nor probabilities. The odds ratios for a given alternative are expected to be independent of the other alternatives. This follows from the assumption that the disturbances are independent and homoscedastic, which is known as the assumption of independence from irrelevant alternatives (IIA). The assumption of independence of irrelevant alternatives (IIA) must hold to have unbiased consistent estimators. This assumption requires that the probability of an individual choosing a certain mode of road transport is independent from the probability of choosing another mode. Thus P_j/P_k should be independent of the other remaining probabilities.

Therefore, marginal effects are reported as the measure of the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Greene, 2006). Thus, differentiating equation (9) with respect to the explanatory variables gives;

$$\frac{\partial P_{ij}}{\partial x_{rik}} = P_{ij}(\ {}_r - \sum_{j=1}^{m} P_{ik} \ {}_r) \text{ --- } (12)$$

It is expected that the own-effects are positive and cross-effects negative using the marginal effects after model estimation. Thus,

$$\frac{\partial p_{ij}}{\partial x_{rik}} = \begin{matrix} p_{ij}(1 - p_{ij}) \ {}_r & j = k \\ - p_{ij} p_{ik} \ {}_r & j \neq k \end{matrix} \text{ --- } (13)$$

If $\ {}_r > 0$, then the own-effect is positive because $p_{ij}(1 - p_{ij}) \ {}_r > 0$ and the cross-effect is negative because $- p_{ij} p_{ik} \ {}_r < 0$. Thus, a positive coefficient means that if the regressor increases for one category, then that category is chosen more and other categories are chosen less, and vice versa for a negative coefficient.

Although the conditional logit choice model has been criticized for its IIA assumption, Hausman and Wise (1978) point out that the model is adequate for many problems despite it being restrictive especially for choices that are close substitutes for each other. In contrast, in this study, the transport mode choices cannot be referred to as close substitutes since they are different by their nature and operation. For example, a private car is private in nature and operation, and only a small percentage of households own a car whereas taxi and *boda-boda* are purely public and cannot be referred to as close substitutes given their nature and way of operation. The mode choices in this study are very distinct and cannot be related to the example of the red-bus and blue-bus problem in McFadden (1974).

4.3.3 Hypotheses

Based on the reviewed theories and empirical literature, the following hypotheses are derived and tested.

1. Urban road transport mode choice is inversely related to travel time. It is expected that an increase in the time taken by using a specific transport mode would negatively affect the probability of frequently choosing that mode and increase the chances of choosing the other available modes.

2. Urban road transport mode choice is inversely related to travel cost. It is expected that an increase in the cost of travel by using a specific transport mode would

negatively affect the probability of frequently choosing that mode and increase the chances of choosing the other available modes.

3. Household monthly income has a significant influence on urban road transport mode choice. It is expected that as household incomes increase, people's tastes and preferences shift and therefore the choice of the frequently used transport mode might also change accordingly. Individuals are expected to own cars given higher income levels and thus shift from public transport to private car use. However, an increase in income may also imply more responsibilities increasing the value of time, hence households may choose inferior modes to evade congestion.

4. Urban road transport mode choice is significantly related to trip length. It is expected that the longer the frequently taken trips, the less the chances of frequently choosing a specific transport mode especially in the urban setting where road traffic congestion is a problem.

5. Urban road transport mode choice is significantly influenced by household size. It is expected that the size of a household may influence the frequently used mode of transport. Household size may increase or reduce the chances of frequently choosing a specific mode of urban road transport.

6. The daily trip volumes taken by a household significantly influence urban road transport mode choice. It is expected that the probability of frequently using a specific mode of urban road transport may increase or fall with an increase in daily trip volume.

7. Urban road transport mode choice is significantly influenced by the age of the household head. It is expected that as household heads grow older, the probability of

frequently choosing certain modes of transport decreases while increasing the chances of frequently using other modes.

8. Urban road transport mode choice is significantly influenced by the gender of the household head. Male-headed households are expected to have higher chances of frequently using a private car as compared to female-headed households.

9. Urban road transport mode choice is significantly influenced by the purpose of travel. It is expected that the probability of frequently choosing a specific mode of transport may increase or fall depending on the travel purpose. The frequently used mode of transport may differ for work trips and non-work trips.

10. The education level of the household head significantly influence urban road transport mode choice. It is expected that households who have attained higher education levels have higher incomes and are more enlightened on urban transport issues, and therefore may increase or reduce the chances of frequently using a specific road transport mode as compared to others.

4.3.4 Data Source and Description of Study Variables

This section presents the type of data used and its source as well as the description of the study variables.

Data Source

The KCCA (2011) data set used in the first empirical chapter is lacking in terms of detailed and consistent information about mode choice selection at household level. Therefore, for this objective, the researcher carried out a new survey in 2013, consisting of 245 households in Kampala capital city. The survey captured specific issues in relation to mode choice selection for frequently taken trips with the main focus on frequently used modes for these trips. The sample of households was proportionally picked across all divisions in the city centre. Kampala is divided into five geographical zones from which proportional samples were selected. Based on Cochran (1977) and Bartlett *et al.* (2001), the total sample size for the household survey was determined proportionally by the ratio of the zonal number of households to the total number of households in Kampala for better representation of each zone.

Households were selected purposively by considering those that have frequent travels to the city centre. This would give meaning to the study since the main objective is to find ways of managing traffic congestion in Kampala city through ascertaining probable solutions to managing and controlling travel to the city centre from the demand side. The selected households were mainly those in the vicinity of the road. These were selected to avoid variability that may arise due to an unequal accessibility to the road net work and public transport. The selected households were mainly those along the main transport corridors/arterials. The corridors are Ggaba road, Jinja road, Bombo road, Gayaza road, Masaka road, Hoima road and Entebbe road. The focal person in the household was the household head whose characteristics and decisions were taken as a representation of a given household. The main focus was on frequently taken trips and the unit of analysis was a household.

Using self-administered questionnaires, data was obtained for household characteristics, travel behaviors including travel frequency or trip volumes, purpose of the frequently taken trips from home and the destination, as well as the choice of transport mode used; the cost and the travel time for each mode and specific trip taken. The study was carried out over the weekend with the expectation of getting the household heads at home. Because of the timing, the study responses might have suffered from memory lapse.

Description of Study Variables

In this section, the variables used in the analysis and model estimation are defined and described. The variables are grouped into dependent and independent variables.

Dependent Variable

In this study, the dependent variable is the choice of urban road transport mode. This study mainly focuses on urban road transport in Kampala city. The commonly used mode for the frequently taken trips is captured. There are currently four modes of transport that include commuter bus, taxi, *boda-boda* and private cars. However, by the time of the survey, bus transport had not gained ground on most routes. Until today, only a few routes have commuter buses that are still very few to be a regular transport mode. Therefore, three choices of commonly used urban road transport are used to represent the dependent variable. These are; taxi which is purely public transit, *boda-boda* that can be both public and private transport but it is mainly public transport in Kampala, and a private car for personal use. These variables are categorical with taxi = 1, private car = 2, and *boda-boda* = 3. In the estimations, the taxi mode is used as a base alternative.

Independent Variable

Travel Cost

This is one important variable that influences transport mode choice decision-making. Travel cost is the amount of money spent on each trip taken. The average transport cost is captured since the study focuses on the commonly taken trips in the city. The average travel cost is the measure of the transport cost incurred per trip taken. Travel cost is recorded in Uganda shillings. Respondents were asked to give the average travel cost incurred per trip focusing on the frequently taken trips. Travel cost is used as a continuous logarithmic transformed variable.

Travel Time

Travel time is a vital variable that influences transport mode choice decision-making. Travel time is the time used to travel from home to a given destination. As mentioned earlier, in this study home is the origin/point of reference. Since we are focusing on the frequently taken trips to any part of the city, the average travel time per trip using the commonly used transport mode is what is recorded for estimations. This variable can be used as a case-specific variable that varies across households. However, in this study, to explore the importance of travel time in transport mode choice decision-making, travel time per trip for the frequently taken trips is captured for the three urban road transport modes.

Thus, respondents were asked to give average estimates of the time they spend to their frequent destinations using the frequently used mode as well as the other two urban road transport modes. This variable is then used as a choice-specific variable that allows for selection of more than one choice, and thus be able to compare the effects across choices. Therefore, travel time is used as an alternative specific variable in the model estimations. Travel time is recorded in terms of minutes, but is used in model estimation as a continuous logarithmic transformed variable.

Trip Length

Trip length is another important variable that influences transport mode choice decision-making. Trip length is the distance travelled from the origin to the destination of a trip. In this study, the trip length for the frequently taken trip from home, as the origin, to the destination is used. Trip length is recorded in kilometers (km) but it is used in model estimation after logarithmic transformation. Since mode choice is expected to change with distance travelled, trip length was first used as a continuous logarithmic variable and later as a categorical variable. The categories are; shorter trips are less than 4kms, average trip length are 4-5km and longer trips are above 5kms. The shorter trips category is the base.

Income

This is one of the key economic factors used in assessing urban transport mode choice decision-making. Income of a given household is associated with the daily amount of travel taken as well as the choice of mode of transport to use. The monthly income per household was collected. However, due to problems with individual's willingness to divulge the right information about their incomes, monthly expenditure was instead used. Income is recorded in Uganda shillings. In the estimation income is used as a continuous logarithmic transformed variable. Income is also used in the model as a categorical variable to capture the expected change in mode choice at different income levels. The categories are: low income (less than 410,000); average income (410,000-1,000,000); and high income (above 1,000,000). The low income group is the base category. These categories are based on the taxable base for pay as you earn in Uganda.

Household Size (hhsize)

Household size is one of the essential variables in assessing urban transport mode choice by households. Being a discrete variable, it is first used in its original form as a count variable.

Age

Age is another important variable in assessing urban transport mode choice by households. Since the unit of analysis is a household, for such individual characteristics, age of the household head is considered. Therefore, the age of the household head is used in this study. This variable has been used as a squared variable to capture the lifecycle characteristics and later categorized into five age groups. The age groups used are: 15-25; 25-35; 35-45; and above 45. The age group with 15-25 years is the base category.

Gender

This is another variable that cannot be ignored in assessing urban transport mode choice decision-making. Just like age, the gender of the household head is used in this study. The gender of the household head is associated with the frequently used mode of transport by a household. This variable has been used in its original form and defined as 0 for female and 1 for male. Female is used as a base category. Therefore in the discussion of results, the terms used are female-headed and male-headed households.

Trip Volume

This is another critical factor in transport mode choice decision-making for urban travel. Trip volume indicates the frequency of travel by a household. It is a discrete count variable. In this study, the average daily number of trips taken by a household is considered. Households were requested to report the daily average number of trips taken.

Education Level

Education level is another variable that cannot be ignored in assessing urban transport mode choice decision-making. Just like age and gender, the education level of the household head is used. The education level of the household head is associated with the frequently used transport mode by a household. This variable is categorized into three levels. They include; primary; secondary; and post-secondary education. Primary education level is used as the base category.

Trip Purpose

This is another essential variable in assessing urban transport mode choice decision-making. Since we are assessing the commonly used mode given the frequently taken trips, the purpose for these trips is captured for analysis. These trips are categorized as work (0) and non-work (1), with work trips being the base.

4.3.5 The Empirical Model

Borrowing from Jin and Horowitz (2008), a number of regressors have been considered. These include, in-bound time taken by mode as choice-specific, age, gender, education, household income, cost of travel, household size, distance to destination, trip volume, and trip purpose. There are three transport mode choices that include taxi, private car and *boda-boda*.

$$U_{ij} = {}_{taxi}T_{i.taxi} + {}_{car}T_{i.car} + {}_{boda-boda}T_{i.boda-boda} + \sim_C TC_{ij} + \sim_L TL_{ij} + \sim_I income_{ij} + \sim_A age_{ij}$$
$$+ \sim_G gender_{ij} + \sim_V TV_{ij} + \sim_S hhsize_{ij} + \sim_P TP_{ij} + \sim_E edlevel_{ij} + £_{ij} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

Where,

T is the travel time per household i for each transport mode j as an alternative specific variable; The rest of the variables are case specific taking a household as a case. These are; TC is the average transport cost per trip taken; TL is the distance to trip destination/ trip length; *TV* is the trip volume/frequency of travel; *TP* is the trip purpose; hhsize is the household size and edlevel is the education level of the household head.

For each $j, £_{ij}$ has the same independent, type 1 extreme value distribution,

$$F_{£}(£_{ij}) = \exp(-\exp(-£_{ij}))$$

4.3.6 Descriptive and Summary Statistics

Table 4.3 give the summary statistics of the presumed determinants of transport mode choice in levels, including the skewness and kurtosis. According to the results, the average household income is Ushs.588,582 per month (approximately US$ 235)[19]. Most of the respondent households stay within a radius of 4.39 kms from the city centre as indicated by the proximity to the city centre variable. This is expected of a small city like Kampala with a surface area of only 195 square kms; most of her residents live within the maximum distance of 9 kms following distance along the major transport corridors. Results further indicate that on average, residents in Kampala spend an average of Ushs.2,591 (approximately US$1) for every single trip taken around the city with the highest trip cost of Ushs.25,000 (approximately US$10).

In this survey, the average age of the household heads is 34, with the youngest being 17 years and the oldest being 78 years old. Majority (43 percent) of the respondents

[19] The average nominal exchange rate in 2013 was 1US$=Ushs.2500.

are aged 25-35 years followed by those aged between 12-25 years and 35-45 years. These are all active age groups that are expected to be in the urban centers for work and thus can increase mobility. The average household size is approximately 4 members per household as expected for urban areas in Uganda. These households have an average of 3 adults and 1 child below 15 years. The highest number of children below 15 years is 4.

Most of these households take an average of 4 trips within Kampala per day with the average length of a trip being 4.5 kms and the maximum length per trip of 12 kms. The maximum trip length of 12 kms is expected since the survey covered only travels within Kampala city. The average travel time per trip is approximately 44 minutes, with the maximum being 180 minutes (3hours). This implies on average a minimum speed of 6.2 km per hour and maximum speed of 4 km per hour, which is on the lower side but can be attributed to the congestion in the city.

Table 4.3 also shows the skewness and kurtosis of the study variables[20].. All the variables have distributions skewed to the right with heavy tails, implying that they are not normally distributed in their current form. Therefore, the data cannot be analyzed in its current form. There is need to transform the data in order to achieve normality of the distribution of the continuous variables such that robust model estimates are attained. Logarithmic transformation of continuous variables gives normal distributions of these variables as shown by results in Appendix 12.

[20] Skewness can also be used to assess the degree and direction of asymmetry, while kurtosis measures the heaviness of the tails of the distribution of the data set. Based on the symmetry of the distribution, one can ascertain if the data is normally distributed (Greene, 2006).

Table 4.3: Summary Statistics of the Selected Variables (in Levels)

Variable	N	Mean	Standard deviations	Minimum	Maximum	Skewness	Kurtosis
Monthly income	243	588582.30	461721.40	50000.00	3000000.00	4.68	36.70
Distance from home to city centre	245	4.39	1.61	1.50	9.00	0.62	3.10
Trip cost	245	2590.61	2565.72	500.00	25000.00	3.97	28.09
Age	245	34.20	10.93	17.00	78.00	1.13	4.29
Household size	245	3.61	1.64	1.00	8.00	0.51	2.51
Number of adults	245	2.53	1.18	1.00	6.00	0.82	3.22
Number of children below 15years	245	1.08	1.04	0.00	4.00	1.34	4.11
Trip length	245	4.52	2.24	0.00	12.00	0.58	3.23
Average daily trips/ trip volume	245	4.0	2.3	2	16	1.48	5.89
Trip travel time	244	44.1	39.8	4	180	3.39	20.75

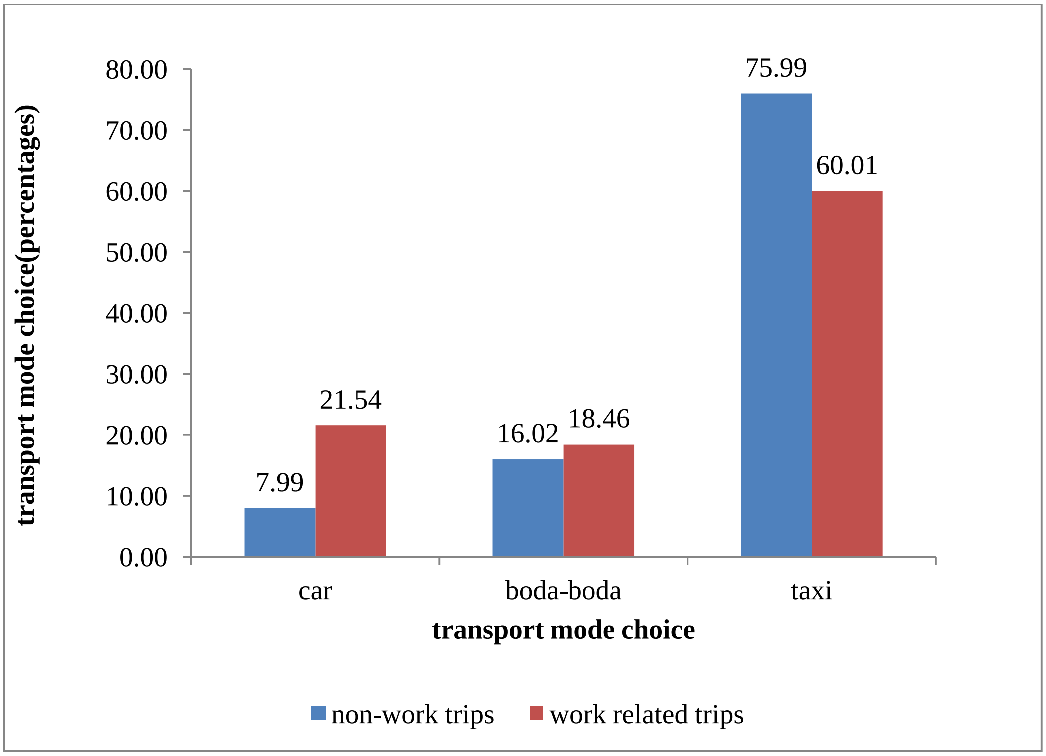
Average monthly income excludes two (2) households whose income is greater than ushs3000000; travel time >180 minutes to avoid the outlier effect.

Source: Author's computation from own survey data.

The most commonly used mode of transport is taxi, taking up to 63.27 percent. The share of private car and *boda-boda* is almost the same, standing at 18.78 percent and 17.96 percent respectively. This implies that public transport takes the highest share of transport modes. However, most of the trips frequently taken are mainly work-related (79.79 percent), and the remaining percentage is distributed to social activities, shopping, going to school, and seeking health services. This implies that most people in Kampala travel mainly for the purpose of work. Thus, in this study, trip purpose will be broadly categorized as work and non-work trips.

According to Figure 4.1, taxi is the most commonly used mode irrespective of the trip purpose with usage for work-related trips being 60.01 percent and for non-work related trips being 76 percent. Private cars are the least used mode (7.99 percent) for non-work related trips while *boda-boda* is the least used mode (18.46 percent) for work related trips. This is intuitively understandable since an individual going to work must already have a routine and the time to leave for work unless otherwise. They also need to be tidy and may feel uncomfortable sitting on a *boda-boda* while smartly dressed for work if they do not own or drive a private car. Besides, *boda-boda* is mainly used if one is in a rush and trying to catch up with time. This is evident in Figure 4.1, where the usage of *boda-boda* as compared to private car is highest among non-work-related trips.

Figure 4.1: Distribution of Transport Mode Choice by Trip Purpose

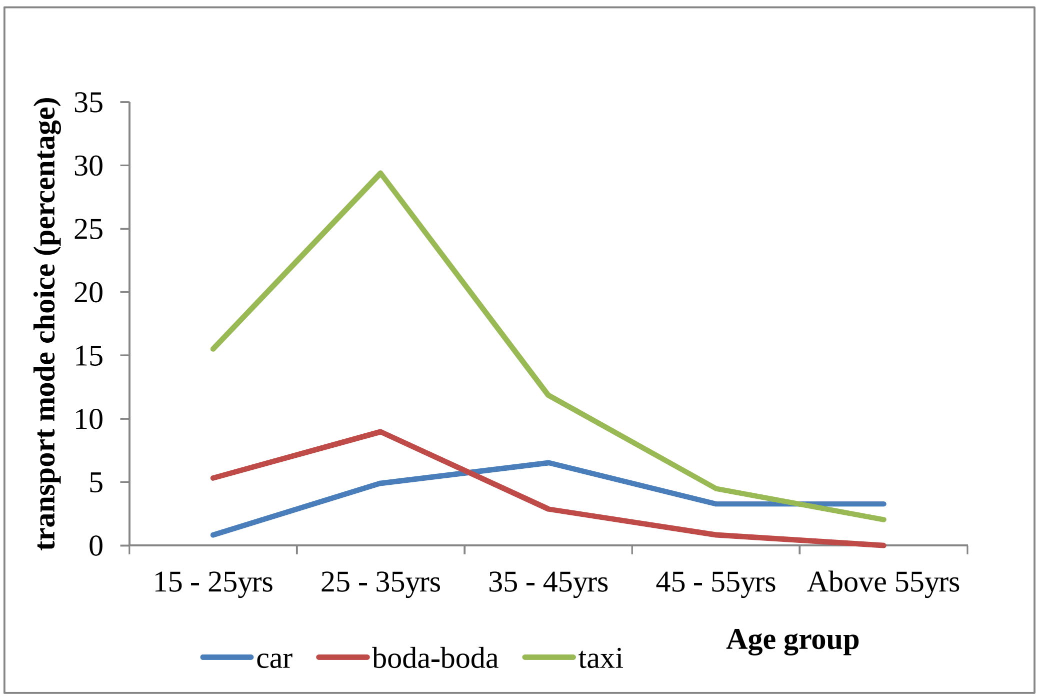


Source: Author's computation from own survey data.

Figure 4.2 indicates the usage of the different modes of transport by age. The figure clearly shows that the mode of transport differs among the age groups. The highest usage of taxi and *boda-boda* is among the age group of 25-35 years while the use of private cars is highest amongst the age group of 35-45 years. This also signifies the importance of public transport in urban centers since both taxi and *boda-boda* are public modes and command the highest share in transit. Generally, the use of each mode improves with increase in age of the household head and is highest at the age group of 25-35 years for taxi and *boda-boda* while for private car, it is at the age group of 35-45 years but then drops thereafter. This may imply less travels taken by the old. Public transit (taxi) drops sharply after 35-45 years, at which private car usage attains its maximum.

However, the fall in private car usage is gradual and is maintained at the same level as household heads grow older. But use of *boda-boda* wanes away as household heads become older. At old age, private car usage is higher as compared to other modes. Figure 4.2 seems to depict a concave relationship between age and choice of mode of transport. Therefore, age enters into the model as squared because of this suggestive relationship with mode of transport.

Figure 4.2: Distribution of Transport Mode Choice by Age of Household Head

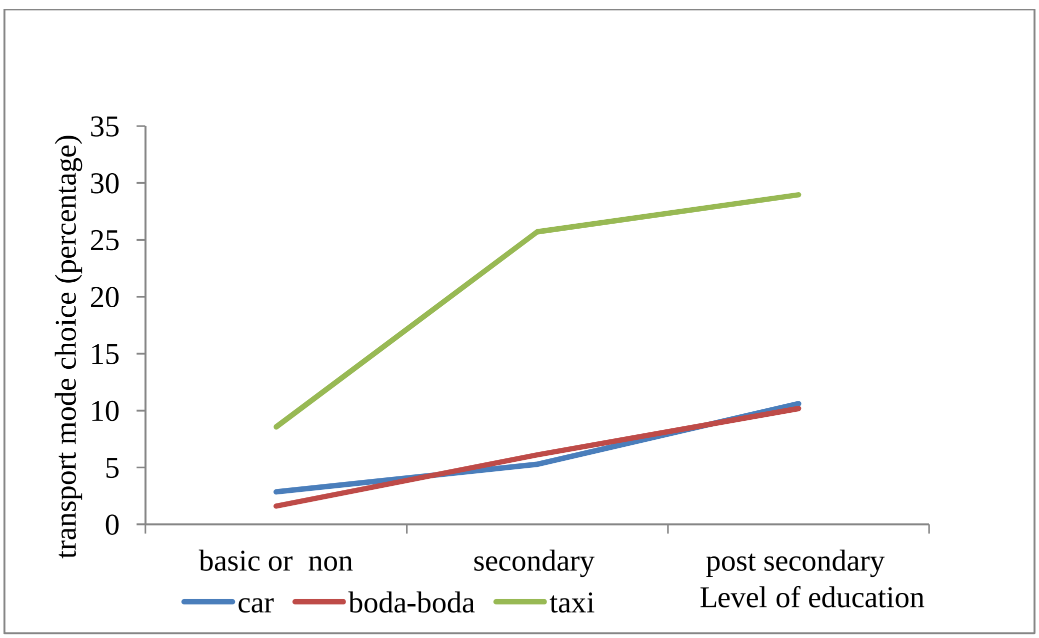


Source: Author's computation from own survey data.

The choice of mode of transport also differs according to education level. However, the direction of change is similar at all levels as shown in Figure 4.3. Although taxi use is increasing at a lower rate after secondary education, usage of each mode increases with education level with higher usage at post-secondary education. This might be true since in practice people with higher education levels are expected to get jobs and work, and thus travel more. Educated people are also expected to have higher incomes that enable them to acquire private cars. Thus, it would not be surprising that car usage increases with education level.

However, surprisingly the use of *boda-boda* also increases with education level and the relationship seems linear! This might be explained by the circumstances under which people decide to use *boda-boda*. In relation to Figure 4.1, *boda-boda* usage is high among non-work-related trips and thus it would not matter what the education level of the users is. This implies that if more educated people have more non-work trips, then they are bound to use more of *boda-boda* compared to other modes.

Figure 4.3: Distribution of Transport Mode Choice by Level of Education of the Household Head



Source: Author's computation from own survey data.

From Table 4.4, the choice of mode of transport is also varying with household size. While private car use increases with increase in household size, the use of *boda-boda* and taxi decreases with an increase in household size. Households that have more than 4 members use more of private cars compared to other modes. This may be related to the fact that car ownership also increases with household size. The data shows that most households with more members own a car (see Appendix 11E). Sometimes income increases depending on the number of working adults in a household, which makes it easier to own a private car. Besides, if one owns a car and has more members that travel in the same direction, it is understandably cheaper and convenient than using a taxi or *boda-boda*.

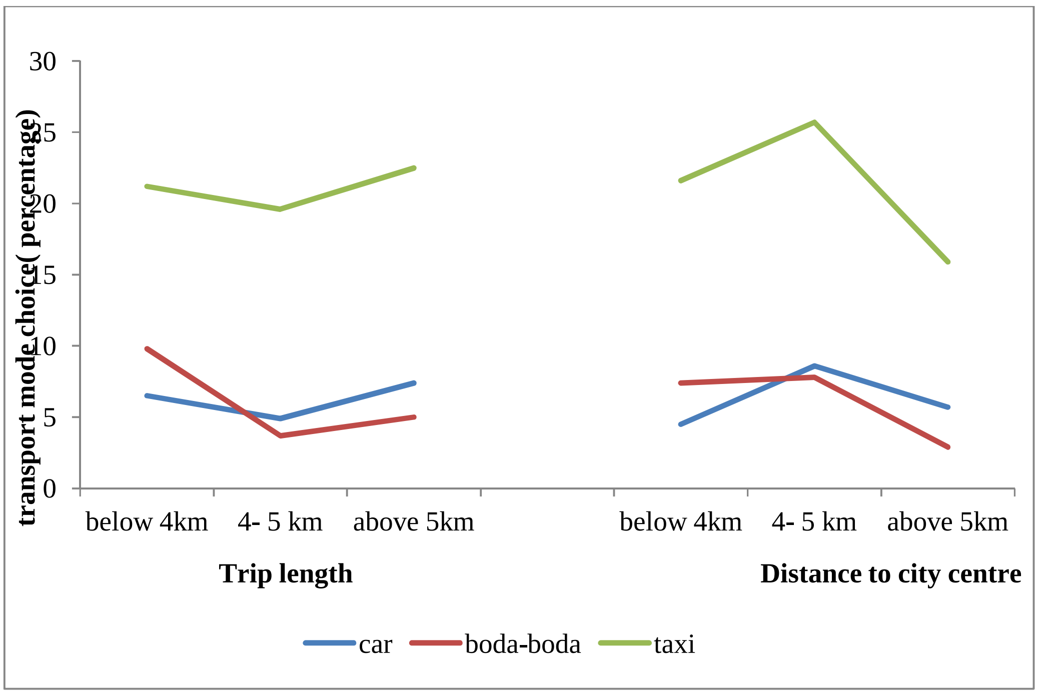
Table 4.4: Distribution of Transport Mode Choice by Household Size

	Transport mode Share (Percentages)			
Household size	Private car	*Boda-boda*	Taxi	Total
1 - 2'	1.22	10.61	30.62	42.45
3 - 4'	7.76	5.71	24.49	37.96
Above 4	9.8	1.63	8.16	19.59
Total	18.78	17.95	63.27	100

Source: Author's computation from own survey data.

The choice of transport mode also varies with trip length. According to Figure 4.4, mode usage is highly concentrated for households that stay closer to the city centre, implying shorter trip lengths of less than 4 km and for longer trip lengths of more than 5 km. However, around the average trip length of 4-5 km, mode usage is lower for all choices. This might be attributed to majority (37.5 percent) of trips being less than 4 kms and others being above 5 kms (34.3 percent). Fewer trips taken are for 4 to 5 kms (28.2 percent). This implies that the choice of transport mode may not be dependent on the trip length. In contrast, looking at the proximity of the household to the city centre, the usage of different transport modes increases with distance and is highest at an average distance of 4-5 kms but drops thereafter. This might be attributed to most households staying within the distance of 4-5 kms.

Figure 4.4: Distribution of Transport Mode Choice by Trip Length and Proximity to the City Centre



Source: Author's computation from own survey data.

Comparing mode choice with transport cost as indicated in Table 4.5, taxi seems to be the cheapest compared to other modes, followed by *boda-boda* and private car is the most expensive having the highest percentage of costs above Ushs.5000 (US$2) per trip. Most taxi and *boda-boda* trips costs lie within the lowest cost range of less or equal to Ushs.2500 (US$1). There are very few private car trips that cost within this range.

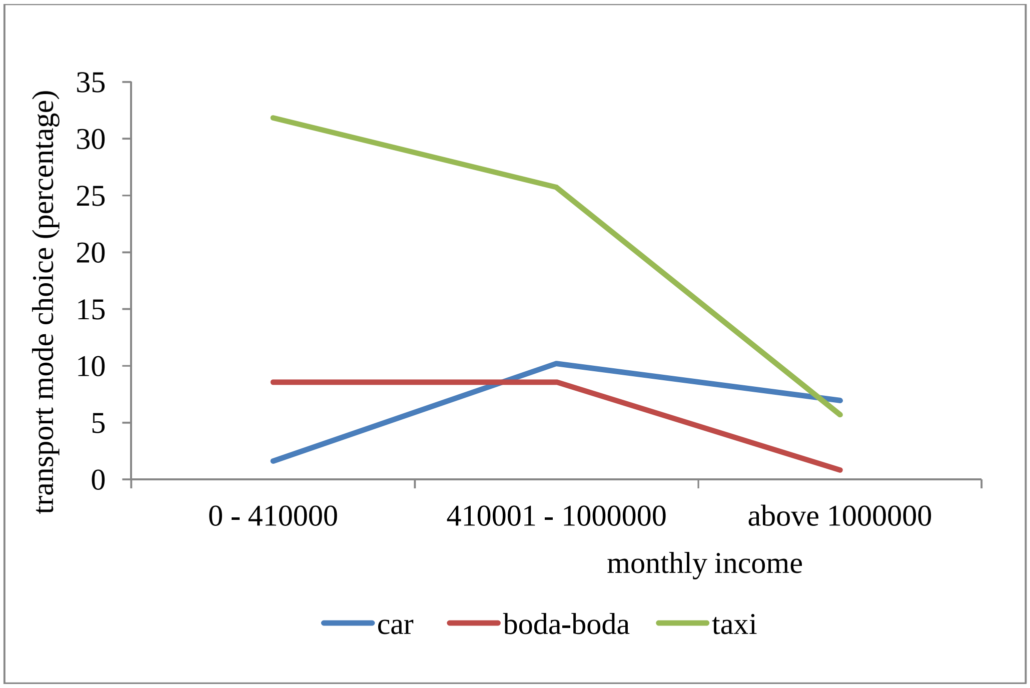
Table 4.5: Distribution of Transport Mode Choice by Cost per Trip

Cost per trip	Cell values	Transport mode			Total
		Private car	*Boda-boda*	Taxi	
0 – 2500	frequency	9	27	144	180
2501 – 5000	frequency	20	16	9	45
above 5000	frequency	17	1	2	20
Total	frequency	46	44	155	245

Source: Author's computation from own survey data.

From Appendix 11H, it is clear that most of the respondents earn a monthly income of less or equal to one million shillings with 42 percent earning less than Ushs.410001. According to Figure 4.5, majority of them use taxi and *boda-boda* and the use of these two modes dwindles as income increases, while the use of private car increases as income increases. Individuals in the average income group of Ushs. 41000-1000000 use private cars more than any other transport mode. This might be attributed to the fact that most private car owners on average earn an income of over Ushs.410000. The rate of use of private cars seems to increase with income though it seems to drop at higher incomes. This might be attributed to the sample having fewer households with such higher incomes.

Figure 4.5: Distribution of Transport Mode Choice by Income Group



Source: Author's computation from own survey data.

Results in Table 4.6 indicate the pair-wise correlation analysis of the selected study variables. This is necessary as an indicator of the relationship between variables though if very strong may imply multi-collinearity of the error term. However, the results may still act as an indication of the expected direction of the relationship between the study variables. Results show variations in most of the variables being significantly associated. None of the variables are highly correlated especially with the dependent variable, mode choice. Therefore, there is no alarm for expecting multi-collinearity of the error term.

As expected, mode choice is significantly and negatively associated with travel time and trip length. It is also positively and significantly associated with gender of the household head at 5 percent level of significance. Mode choice is also significantly associated with trip cost. Results further indicate a 50 percent significant positive association between household size and the age of the household head. This kind of association is not surprising since it is expected that as the household head grows older, the household size increases, as a sign of increased responsibility.

There is also a significant positive relationship between the average daily trips taken and household size. This is also expected since daily trips taken by a household are expected to increase with an increase in household size, especially the number of adults or working adults as well as school-going children. Likewise, distance from home to the city centre is also significantly associated with trip length. This might imply that most trips taken by households are towards the city centre, especially for those households staying within Kampala. Since individuals tend to stay closer to their work places, this association may imply that most people staying in Kampala work within the city.

Table 4.6: Pair-wise Correlation Results for Selected Study Variables*

Variable	Mode choice	Age	Household size	Income	Travel time	Gender	Education level	Trip purpose	Distance to city centre	Trip cost	Trip length
Mode choice											
Age	0.04										
Household size	0.03	0.50*									
Income	0.03	0.21*	0.21*								
Travel time	-0.21*	0.06	0.1	0.04							
Gender	0.14*	0.08	0.09	0.09	0.11						
Education level	0.10*	-0.07	-0.01	-0.01	0	0.11					
Trip purpose	0.10	0.18*	0.09	0.21*	-0.08	0.02	0.02				
Distance to city centre	-0.11*	0.02	0.02	0.05	0.06	0.07	0.04	0.11			
Trip cost	0.33*	0.27*	0.30*	0.15*	0.17*	0.1	-0.04	0.12	0.06		
Trip length	-0.11	0.06	0.03	-0.02	0.3*	0.11	0.09	0.05	0.42*	0.29*	
Daily trip volume	0.03	0.37*	0.44*	0.33*	0.02	0.06	0.08	0.13*	-0.07	0.25*	-0.04

** Values with * refer to significance (P < 0.05)*

Source: Author's computation from own survey data.

4.4 Model Estimation and Discussion of Findings

This section presents the specification test of the logit model as well as the model estimations of the determinants of road transport mode choice.

4.4.1 Testing for Independence of Irrelevant Alternatives (IIA)

The most worrying methodological issue that comes with logit choice models and specifically the conditional logit model is the problem of independence of irrelevant alternatives (IIA). While other researchers suggest the use of other models that do not exhibit such problems (Greene, 2008), Hausman and McFadden (1984) suggest and empirically test for the IIA assumption. The Hausman test results in Table 4.7 validate the IIA assumption, and thus the conditional logit model fits the data well.

Table 4.7: Result of the Hausman-McFadden Test of Independence of Irrelevant Alternatives (IIA)

Omitted variable	Chi2	P> Chi2	Degrees of Freedom	Conclusion
Boda-boda	6.18	0.8613	11	Fail to reject Ho
Private Car	6.16	0.8625	11	Fail to reject Ho

Source: Author's computation from own survey data.

4.4.2 Determinants of Urban Household Road Transport Mode Choice

As pointed out earlier, in assessing factors that affect road transport mode choice in Kampala, an ASCLOGIT model is estimated. However, only marginal effects are discussed. Preliminary estimates including the odds ratios, are reported in Appendix 13, and the marginal effects are presented in Table 4.8 and Table 4.9.

Table 4.8: Alternative Specific Conditional Logit Marginal Effects for the Determinants of Urban Household Transport Mode Choice

	Dependent Variable : Choice of mode of transport Base(taxi)		
Variable	Taxi	Private car	*Boda-boda*
Choice specific variable			
Log of time taken by mode			
Taxi	-0.165*(0.095)	0.027(0.020)	0.138*(0.081)
Private car	0.027(0.020)	-0.033(0.024)	0.006(0.005)
Boda-boda	0.138*(0.081)	0.006(0.005)	-0.145*(0.084)
Case specific variables			
Log of travel cost	-0.372***(0.095)	0.127**(0.052)	0.247***(0.081)
Log of trip length	0.242***(0.094)	-0.073**(0.036)	-0.169**(0.084)
Log of household monthly income	-0.064(0.054)	0.094***(0.034)	-0.030(0.047)
Age2	0.0001*(0.00006)	-0.000002(0.00001)	-0.0001*(0.00006)
Gender	-0.137**(0.070)	-0.001(0.037)	0.139**(0.058)
Trip volume	0.016(0.018)	-0.009*(0.005)	-0.007(0.018)
Household size	-0.009(0.026)	0.031**(0.013)	-0.021(0.024)
Trip purpose*	-0.069(0.074)	-0.026(0.046)	0.096(0.061)
Secondary education*	-0.076(0.116)	0.053(0.056)	0.023(0.103)
Post secondary education*	-0.124(0.108)	0.053(0.047)	0.071(0.098)
Probability	0.780	0.036	0.184
Wald chi2 (23) = 69.44 Prob > chi2 = 0.0000			
Log likelihood = -117.06			
Observations (number of cases) = 720 (240)			
(*) dp/dx is for discrete change of indicator variable from 0 to 1			

*Standard errors in parentheses: * p < 0.10, ** p < 0.05, *** p < 0.01*
Marginal effects after Alternative Specific Conditional Logit estimation
Source: Author's computation from own survey data.

The results in Table 4.8 show the marginal effects of the determinants of transport mode choice obtained after estimating the alternative specific conditional logit model based on McFadden (1974). These results indicate the marginal effects of the determinants of transport mode choice. Both own and cross-effects are reported. The Prob > chi2 =0.000 implies that the alternative specific conditional logit model fits the data well. As pointed out earlier, this model has been used in the study to capture the alternative specific covariate in the model and this is time taken by each mode for a specific trip. Results further show that the sample probabilities of choosing a taxi, private car and *boda-boda* are 0.780, 0.036 and 0.184 respectively. Results show that factors that significantly affect transport mode choice include time taken by a given mode as compared to other modes, travel cost, trip length, income, age, household size, trip purpose, gender, and the daily trip volume. The results have been presented according to specific mode choices.

It is expected that an increase in the time taken by using a specific transport mode would negatively affect the probability of choosing that mode and increase the chances of choosing the other available modes. Based on the results of the log of travel time taken for a specific trip using a given mode, a 1 percent increase in the time taken using a taxi significantly reduces the probability of using a taxi by 16.5 percent at 10 percent level of significance. This implies that an increase in the travel time when one uses a taxi reduces the chances of using a taxi. This change in turn increases the probability of using a private car or *boda-boda*. The increase in the probability of using a *boda-boda* is 13.8 percent and it is significant at 10 percent. These results are in line with the theory that suggests that the probability of choosing a given mode reduces with an increase in time taken for travel using that model which in turn increases the probability of choosing the other available modes (McFadden, 1974; Lindsey *et al*., 2011).

Although the increase in the chances of using a private car is insignificant, it is still in the right direction. Looking at the effect of time on the choice of a private car, all the results are insignificant but have the expected sign. However, with use of a *boda-boda*, a 1 percent increase in the time taken for a given trip while using a *boda-boda* reduces the probability of using it by 14.5 percent at 10 percent level of significance, which leads to an increase in the chances of using a taxi by 13.8 percent at 10 percent significance level. The results are in line with the notion of own elasticity being negative and cross elasticity being positive, given that time is an impedance factor in transport mode choice (Litman, 2013). The effect of time taken on private car use is insignificant.

Travel cost is another factor that significantly affects the choice of transport mode to be used for a given trip. It is expected that an increase in the cost of using one mode reduces the chances of using that particular mode while increasing the chances of using the alternative modes. The results in Table 4.8 indicate that relative to the probability of choosing a taxi, an increase in the cost of transport for a given trip while using a taxi, increases the chances of using a private car and/or *boda-boda*, hence reducing the chances of using a taxi for that particular trip. A 1 percent increase in travel cost by using a taxi significantly increases the chances of choosing a private car and *boda-boda* by 12.7 percent and 24.7 percent respectively at 5 percent and 1 percent significance levels respectively. The chances of using a taxi significantly fall by 37.2 percent at 1 percent significance level. This result can be explained by the fact that an increase in transport cost of using a taxi may not be cost saving especially for those who have their own car, leaving other factors constant. The fact that consumers are rational means that they would choose a mode of transport that maximizes their utility while minimizing costs, which is in line with theory (Davidson, 1996).

Another significant factor that influences the choice of mode of transport for households according to results in Table 4.8 is the trip length. It is expected that for longer trips, a cheaper and/or faster mode would be chosen. But this decision is entirely subjective and depends on the individual consumer's decision of what he wants to minimize. If one is to minimize the cost of travel in monetary terms, then he is bound to choose a cheaper mode but if he wants to minimize the time of travel, then the choice will be for a quicker mode. But results in Table 4.8 show that relative to the probability of choosing a taxi, an increase in the trip length significantly reduces the chances of using a private car and *boda-boda*. The results imply that travelers prefer using taxis for longer trips. The results in Table 4.9 still conform to this conclusion when trip length is grouped into shorter, average and longer trips. Relative to the probability of choosing a taxi, the chances of using a private car and *boda-boda* falls with average, and longer trips as compared to shorter trips.

Thus, the further the trip destination, the lower the expectations of using a private car, and a *boda-boda*. The results in Table 4.8 indicate that a 1 percent increase in the trip length leads to a decrease in the chances of using a private car by 7.3 percent at 5 percent significance level, while the reduction in the probability of using *boda-boda* is 16.9 percent at 5 percent level of significance. This significantly increases the chances of using a taxi by 24.2 percent at 1 percent level of significance. It implies, therefore, that households would prefer using taxis for longer distances as compared to private cars and *boda-boda*.

The results therefore suggest that being rational consumers, households would prefer using a monetarily cheaper mode for longer distances. The same pattern of results is exhibited when trip length is grouped into shorter, average and longer trips as shown by the results in Table 4.9. Although the results in Table 4.9 indicate an insignificant effect of trip length on private car use for average trip length as compared to shorter trips, the results are still negative.

Household monthly income has also been identified as another significant factor that influences the decision of the transport mode to be used. The results show that relative to the probability of choosing a taxi, an increase in household monthly income increases the chances of choosing a private car and reduces the chances of using a *boda-boda*. A 1 percent increase in the household monthly income significantly increases the chances of using a private car by 9.4 percent at 1 percent significance level. This result can be explained by the descriptive statistics that indicate car ownership being higher at higher income levels especially in the average income group (see Figure 4.5). In Uganda, car ownership is seen as a sign of being rich, living a high standard life, and increases self esteem.

Table 4.9: ASCLOGIT Results of Urban Household Transport Mode Choice with Grouped Data on Household Income, Trip Length, and Age of Household Head

Variable	Dependent Variable : Choice of mode of transport ; Base(taxi)		
	Taxi	Private car	*Boda-boda*
Choice specific variable			
Log of time taken by mode			
Taxi	-0.172*(0.092)	0.0034(0.023)	0.138*(0.076)
Private car	0.034(0.023)	-0.042(0.028)	0.008(0.005)
Boda-boda	0.138*(0.076)	0.008(0.005)	-0.145*(0.080)
Case specific variables			
Log of travel cost	-0.368***(0.091)	0.147***(0.057)	0.221***(0.075)
Trip length group	Base = shorter		
Average trip length	0.226***(0.072)	-0.043(0.031)	-0.183***(0.064)
Longer trips	0.238***(0.071)	-0.061*(0.032)	-0.178***(0.064)
Income group	Base = low income		
Average income group	-0.210**(0.085)	0.174***(0.065)	0.036(0.065)
Higher income	-0.543***(0.167)	0.662***(0.193)	-0.120*(0.066)
Age group	Base=15-25years		
25-35	0.153*(0.086)	-0.017(0.043)	-0.136*(0.075)
35- 45	0.176**(0.80)	-0.025(0.036)	-0.151**(0.068)
Above 45	0.170**(0.082)	-0.012(0.041)	-0.158**(0.066)
Gender	-0.145*(0.071)	0.014(0.036)	0.131**(0.060)
Trip volume	0.019(0.018)	-0.006*(0.005)	-0.013(0.017)
Household size	-0.014(0.027)	0.031**(0.013)	-0.017(0.025)
Trip purpose*	-0.098(0.076)	-0.018(0.047)	0.116**(0.06)
Secondary education*	-0.044(0.115)	0.006 (0.041)	0.038(0.107)
Post secondary education*	_0.140(0.108)	0.029(0.040)	0.111 (0.101)
Probability (Choice/1 selected)	0.776	0.045	0.179
Wald chi2 (27) = 73.03			
Prob > chi2 = 0.0000			
log likelihood = -118.976			
Observations (number of cases) = 720(240)			
(*) dp/dx is for discrete change of indicator variable from 0 to 1			

*Standard errors in parentheses: * p < 0.10, ** p < 0.05, *** p < 0.01*
Marginal effects after Alternative Specific Conditional Logit estimation

Source: Author's computation from own survey data.

Therefore, it becomes inevitable for people with an average income to own private cars especially in urban centres like Kampala, and to use them for personal travel. Furthermore, it would be expected that income elasticity at higher income levels is higher for private car use and lower for public transport. This is due to the expectation that car ownership and use is associated with higher income levels. This is true as per the results in Table 4.9. The income elasticity of private car use significantly increases at higher levels of income (0.662), and is lower at average levels of income (0.174) as compared to lower income levels. Therefore, the rich households prefer using private car transport as compared to the poor. The same pattern is also depicted for average income earners as compared to low-income earners. Thus, this confirms the assumption that as household income increases, private car use as a means of transport is more preferred as compared to other modes.

Although the results in Table 4.8 show that an increase in household monthly income does not significantly affect the chances of using a *boda-boda* as compared to those of using a taxi, the inverse relationship still exists. These results, though not significant, imply that an increase in income reduces the chances of using *boda-boda* and taxi as well. The same pattern of results is exhibited even in Table 4.9, when households are separated by income groups.

The age of the household head is another significant factor affecting transport mode choice. Age-squared was used instead of age taking into consideration the lifecycle assumption and thus assuming concavity since the use of each mode of transport increases with age until up to a certain age, then it starts falling (see Figure 4.2). Compared to the probability of choosing a taxi, as household heads grow older, the chances of using a *boda-boda* significantly decrease at 10 percent significance level, while the chances of using private cars increase. This implies that the older the household heads, the higher the preference for private cars or taxi. Such a result might be attributed to the nature of transport mode, where *boda-boda* may not be convenient or even comfortable for older people. As seen from Appendix 11A, the choice of *boda-boda* is highly concentrated in the ages of 15-35 years, and it decreases thereafter.

The effect of age can further be well explained by the results in Table 4.9, with age as a categorical variable. Results in Table 4.9 indicate that the elasticity of change in the probability of choice of transport mode as household heads grow older increases. As household heads grow older, the chances of choosing a taxi significantly increase as compared to young household heads, and it becomes higher with old age. However, the chances of choosing *boda-boda* significantly reduce. Results in Table 4.9 further show that the effect of age on private car use is insignificant.

Trip volume is another factor that significantly affects the choice of transport mode, thus the frequency of expected daily travels in a household influences mode choice. The results show that relative to the probability of choosing taxi, the higher the number of daily trips to be taken by a household, the lower the chances of using a private car. Relative to the probability of choosing a taxi, a unit increase in the daily trip volume leads to a significant decrease in the probability of choosing a private car by 0.009 at 10 percent level of significance. This result might be explained from the cost minimization point of view, whereby any rational consumer would choose an alternative that minimizes his expenditure while maximizing his utility. Therefore, the choice of transport mode shifts to taxi, which is regarded as the cheapest mode as compared to a *boda-boda* and a private car. Though the coefficient for taxi and *boda-boda* is insignificant, they have the expected sign.

The results further show that the gender of the household head also significantly affects the choice of mode of transport used. The results show that as compared to female-headed households, male-headed ones are more likely to frequentlyuse a *boda-boda* instead of a private car. Relative to the probability of choosing a taxi, the chances of male-headed households using a *boda-boda* significantly increase by 0.139 times as compared to female-headed ones. Thus, male-headed households are 0.139 times more likely to use a *boda-boda* as compared to female-headed ones The increase in the chances of male-headed households using a *boda-boda* instead of a private car as compared to female-headed one implies the reduction in the chances of using a taxi by male-headed households. The result also implies that female-headed households are more likely to choose a private car for travel as compared to their male counterparts. The results in one way concur with the argument that women tend to be more reliant on public transport. But on the other hand, the results contradict earlier arguments that women have no access to private cars despite living with households that own cars (Pickup, 1984). However, the descriptive statistics indicate that 18 percent out of 20 percent of households owning private cars are male-headed.

Following earlier studies, it could be argued that female heads are now more involved in employment and thus can own private cars with increased income (Pickup, 1984). However, looking at the distribution of income among these households, approximately 59 percent of male-headed households (51 out of 86 in percentages) earn an income of above Ushs. 410,000 as compared to only 36 percent (5 out of 14 in percentages) of female-headed households. This means that male heads on average earn more than female heads.

If this allegation is true, then the highest probability of female-headed households choosing a private car instead of *boda-boda* as compared to a taxi may not entirely depend on their income or car ownership. This is purely subjective and may be explained by the nature of the two genders. Many times, African societies attribute women access to such travel means as being provided by their male counterparts irrespective of whether they live in the same household or not. Therefore, explanation of this result can highly be subjective. One may also point out that women tend to fear travelling in the open and may not be comfortable given the nature of *boda-boda*. Thus they tend to move early and avoid rushing while men may not care about being seen on a *boda-boda* as long as it meets their need at that time.

The other factor that significantly influences mode choice decision in a household is household size. The results show that relative to the probability of choosing a taxi, an extra member in a household will significantly increase the chances of using a private car by 0.031 at 5 percent significance level, while the chances of using a taxi and a *boda-boda* will decrease. It would be expected that larger households could be having more income and thus have a higher probability of owning a private car. However, as shown by the descriptive results in Appendix 11J, quite a small percentage of households with a size of more than three people earn an income beyond one million Uganda shillings.

Actually, approximately 24 percent of households with more than 3 members earn an income beyond Ushs.410,000, an equivalent of US$160 per month as compared to households with less than 4 members, that gives approximately 32 percent earning beyond this value. The income distribution does not change even if all members considered in a household were adults (see Appendix 11K). Despite the unexpected income disparities given the household size, 14 percent of larger households own private cars as compared to only 5 percent of smaller households (see Appendix 11I). Therefore, the choice of private car by larger households can be explained by the fact that the higher the number of members in a household, the higher the overall transport cost, and thus it is intuitively expected that owning and using a private car may suffice as a form of cost reduction, *ceteris paribus*. Although, the coefficients for taxi and *boda-boda* being insignificant, they still have the expected negative sign.

According to the results in Table 4.8, trip purpose and education level of the household head have no significant effect on transport mode choice selection. Trip purpose may not be significant because most of the trips reported as frequently taken are work-related. A small percentage of travels are reported to be non-work related (see Figure 4.1). The results further contradict the expectation that more educated people have higher incomes since they are bound to be employed and thus can afford private cars. This contradiction might be explained by the distribution of mode choices among different education levels (see Figure 4.3); the use of all modes increases with education level. The kind of distribution pattern exhibited may imply less variability in mode choice selection among households given the education level of their household heads.

4.4.3 Predicted Probabilities

Table 4.10 shows results for the average sample probabilities as well as the ASCLOGIT model average predicted probabilities for mode choices. Predicted probabilities indicate on average a general increase in the probability of using taxi (public transport), while that of private car use seems to be constant. The predicted probability of using a *boda-boda* is expected to fall over time. These results imply that households are more likely to choose public transport (taxi) in future as compared to a *boda-boda* and a private car.

Table 4.10: Predicted Average Probabilities of Urban Household Transport Mode Choice

Transport Mode	Sample Probabilities	Predicted Probabilities	Standard Deviation
Taxi	0.63	0.64	0.33
Private Car	0.19	0.19	0.33
Boda-boda	0.18	0.17	0.18

Source: Author's computation from own survey data.

4.4.4 Limitations in the Estimation of Urban Household Transport Mode Choice Determinants.

This study has data set limitations. Data is provided at a household level, meaning aggregation of the variables. For this reason, this study focuses mainly on the frequently taken trips and the main purpose of these trips, as well as the commonly used mode. This implies aggregation of these important variables in analyzing travel and mode choice selection behaviour of households. Thus, there is no comprehensive capturing of the activities that the household is engaged in. The other drawback is that focusing on the employment sector of the household head ignores the other sectors and activities other adult members may be engaged in that could be significantly different and may influence the transport mode choice decision-making.

4.4.5 Conclusion

The results on determinants of urban household transport mode choice in Kampala indicate that an increase in the time taken and travel cost by using a given mode of transport reduces the probability of choosing that mode while increasing the chances of choosing the other available modes. There is also an inverse relationship between trip length/distance travelled and the probability of choosing a private car or a *boda-boda* as compared to a taxi. Households prefer using taxis as compared to using private cars and *boda-boda* for longer distances in contrast to shorter distances. Furthermore, rich households as compared to the poor prefer using private car transport as compared to a taxi and a *boda-boda*.

Larger households tend to choose a private car instead of a *boda-boda* as compared to a taxi. Households with older heads prefer less of a private car compared to a taxi. Unlike female-headed households, male-headed households are more likely to choose *boda-boda* relative to taxi, while female-headed ones are more likely to choose a private car. Households that have higher daily frequency of travel prefer using a taxi as compared to a private car and *boda-boda*

CHAPTER FIVE

SUMMARY, CONCLUSION, POLICY IMPLICATIONS AND RECOMMENDATIONS

5.1 Summary of Findings

5.1.1 Determinants of Urban Household Road Travel Demand

Two different measures of demand for travel have been used and thus two distinct estimations made. Using the average daily number of trips taken by a household as a measure of demand for travel, an NBR was estimated, while using the average daily distance traveled by a household, an OLS regression was used.

The results of both the NBR and OLS indicate that household demand for travel in Kampala is significantly affected by the travel cost and the average monthly income of a household. While travel cost has a negative influence, monthly income has a positive influence. Whereas the results of the NBR indicate that household size and age of the household head have a significant positive influence on demand for travel, OLS results show that these factors are insignificant in determining household daily demand for travel. However, OLS results indicate another factor of education (secondary) level of the household head as being significant, and it negatively affects household daily demand for travel in Kampala.

The same pattern of results is exhibited when social factors are separated from the economic factors. While household size and age have a positive effect on the volume of trips taken, they have a negative effect on distance travelled. This is intuitively true since many people in a household lead to more trips taken for shorter distances but less travel for longer distances. Likewise, older people are likely to travel for shorter distances; meaning that the older the people in a household, the shorter the distance traveled.

Car ownership has a negative effect on the volume of trips taken and a positive effect on distance traveled; implying car owners take fewer trips but travel longer distances. This may arise from the fact that car owners also tend to be owners of their dwellings (houses) and these are mainly located further from the city centre, since land ownership closer to the city centre may be near to impossible for an average income earner. Such people tend to buy land on the outskirts of the city.

Whereas education level has a significant negative effect on distance traveled, its effect on trip volume is positive. This implies that more educated people take more trips and travel shorter distances as compared to the less educated. Such a situation may arise in cases where more educated people reside closer to the city centre such that they can afford to commute more often to the city centre.

5.1.2 Determinants of Road Transport Mode Choice

The results show the inverse relationship between time taken using a given mode of transport and the probability of choosing it. This result is consistent with all modes and for both cases where we study both the own- and cross-effects. An increase in the time taken by using a private car and/or a *boda-boda* reduces the probability of choosing them relative to the chances of choosing a taxi. Therefore, the increase in time taken while using a given transport mode reduces the chances of using that mode relative to other modes.

The results further indicate an inverse relationship between the travel cost by using a given mode and the probability of choosing it relative to the base transport mode. Findings show that an increase in the travel cost per trip by using a given transport mode reduces the chances of using that mode and increases the chances of using the alternative. Thus, an increase in the travel cost by using a private car or a *boda-boda* reduces the chances of using the two modes relative to the taxi. This is an implication of preference for taxi as compared to other available alternatives in situations of increased transport cost per trip.

Trip length (distance to travel) is another factor that significantly affects choice of mode of transport. Relative to the probability of choosing a taxi, the chances of using a private car and a *boda-boda* reduces with average and longer trips as compared to shorter trips. The result therefore highlights travelers' preference for public transport (taxi) for average and longer trips as compared to other modes.

Findings further confirm, as expected, that income elasticity at higher income levels is higher for private car use and lower for public transport. Therefore, rich households as compared to the poor prefer using private cars compared to other modes. The same pattern is also depicted for average income earners as compared to low-income earners. This confirms the assumption that as household income increases, private car use as a means of transport is more preferred as compared to other modes. The other factor that has been noted as significant in determining the choice of transport is the average daily frequency of travels or trip volumes per household. Households that have higher daily frequency of travel prefer using public modes (taxi) as compared to others, which might be attributed to cost effectiveness.

Among the social factors that significantly affect mode choice decisions by households are the household size, age, and gender of the household head. Larger households tend to choose private cars instead of *boda-boda* as compared to a taxi. Likewise, relative to chances of choosing a taxi, the likelihood that households with older heads will choose a private car instead of *boda-boda* tends to increase. While unlike female household heads, male household heads are more likely to choose a *boda-boda* relative to a taxi. Households that have higher daily frequency of travel prefer choosing public modes (taxi) as compared to others.

5.2 Conclusion

Estimated results obtained by using both measures of urban household travel demand that is, daily average trip volume and distance travelled, consistently emphasize the effect of economic factors on household travel demand and results are in line with theory, implying strong emphasis on them for policy making. In conclusion, most of the coefficients obtained have economically and intuitively correct signs. The results from both the NBR and OLS regression consistently show that daily demand for travel by households in Kampala is inversely related to the cost of travel and positively related to household income. Further investigations indicate demand for urban travel being more elastic to higher prices. Simulated results further show a drastic fall in the volume of daily trips taken by a household if the trip cost doubles or increases by 100 percent. Therefore, change in costs of travel can greatly reduce the household amount of urban travel.

The influence of social factors is also pronounced in both model estimations. Trip volumes increase with household size, age, and education level of the household head, and decreases with car ownership and private sector employment of the household head. Whereas distance traveled decreases with household size, age, and attainment of education, it increases with car ownership.

The results on determinants of urban household transport mode choice in Kampala indicate that an increase in the time taken and travel cost by using a given mode of transport reduces the probability of choosing that mode while increasing the chances of choosing the other available modes. There is also an inverse relationship between trip length/distance travelled and the probability of choosing a private car or a boda-boda as compared to a taxi. These results are consistent with theory. Households prefer using taxis as compared to using private cars and boda-boda for longer distances in contrast to shorter distances. Furthermore, rich households as compared to the poor prefer using private car transport as compared to a taxi and a boda-boda.

Larger households tend to choose a private car instead of a boda-boda as compared to a taxi. Households with older heads prefer a private car compared to a taxi. Unlike female-headed households, male-headed households are more likely to choose boda-boda relative to taxi, while female-headed ones are more likely to choose a private car. Households that have higher daily frequency of travel prefer using a taxi as compared to a private car and boda-boda

5.3 Policy Implications and Recommendations

In order to reduce and manage traffic congestion or excess demand for road space, the policies arising from this study should assist in regulating travel demand behavior of households including the frequency of travel and mode choice selection. One fact to note is that there is no single policy measure that can reduce excess travel demand (traffic). There is no record of a single policy measure that can work in isolation in handling urban travel demand behavior to curb congestion. Therefore, a combination of different approaches would be advised. Whereas the supply of road infrastructure is necessary, controlling and managing urban travel demand behavior is also inevitable especially at individual and household level. Some empirical studies show that increasing supply of road infrastructure may actually induce auto traffic hence having only a short-term impact on curbing the congestion problem.

The significant inverse relationship between the cost of travel and daily demand for travel by households in Kampala implies that some travels may not arise as a matter of necessity and thus can be done without. Further investigations indicate that demand for urban travel is more elastic to higher prices, that is to say, above Ushs.1000 per trip and Ushs.500 per km. Likewise, the simulated results further show a drastic fall in the volume of daily trips taken by a household if the trip cost doubles or increases by 100 percent. Therefore, a change in costs of travel can greatly reduce the amount of travel. However, as indicated, this policy can suffice with a provision of a good and efficient transport mode. This is left to the discretion of policy makers.

From the study findings, evaluation of both the cost of travel by mode and trip length emphasize the use of a taxi that can be regarded as a monetarily cheaper transport mode since for every trip, its average cost is approximately lower as compared to that of the private car and *boda-boda*. Findings clearly show that relative to the probability of choosing a taxi, an increase in the transport cost per trip by using a private car and/or *boda-boda* significantly reduces the chances of using the two modes within the city.

Average and/or longer distance travelers within the city also prefer using a taxi as compared to a private car and a *boda-boda*. This result is therefore in favor of taxi if the associated transport costs of using this mode are controlled and kept at bay (at minimum) while for other alternative modes increases. Therefore, the main policy implication in this study arises from costs. Policy makers can increase the costs associated with private car and *boda-boda* use within the central district of Kampala city to encourage use of public transit (taxi). For example, cost of car parking and road tolls can regulate the use of private cars for travel to the city centre and thus reduce the congestion that arises from that.

The significant positive effect of income implies that as people's incomes improve, demand for travel will increase. Increase in income may lead to more travel or more activity and a rise in car ownership, an indication of an increase in future demand for travel. This calls for policies that are geared towards increasing supply of road infrastructure and provision of a more efficient public transport system. But this should be coupled with managing future private car usage.

It is expected that with high income levels, private car use increases, and thus increasing parking costs alone may not significantly reduce the use of this mode. Therefore, another policy that can be used in conjunction with car parking costs is required. For example, promoting car-pooling may also reduce the number of private cars moving towards the city centre. The intention of such a policy is to discourage driving to the city centre alone. It encourages driving with other people in one's car rather than alone for maximum mode usage. This policy can be supported by findings of the influence of household size on transport mode choice where larger households prefer using private cars as compared to other modes. Of course, private car mode may be cost-effective for such households especially if all members are moving towards the same direction. What about in situations where not all individuals are moving towards the same directions and perhaps each may have to drive to their destination? Car-pooling can still come in to control this situation.

Whereas increasing the cost of car parking may apply to all private cars that park in the city centre, to promote car-pooling, road tolls may specifically apply to auto-alone mode only. This would definitely reduce the number of private cars driving into the city. Applying road tolls to private car users who drive alone and increasing parking cost can considerably reduce private car use in the city centre (Train, 1980).

The significant positive effect of household size and age of household head implies that demand for travel is bound to grow at a much higher rate. High concentration of travels, as well as car ownership and use, is found to be among the adult youth age group who in many cases have high birth rates; implying an increase in population and future urban travels. In addition to population increase arising from rural-urban migrations tendencies whereby most of the youths view the city as their end point to achieve greener pastures, a higher population is expected and thus more travels. It could be one reason that has escalated the day population of Kampala causing heavy traffic congestion on these roads. But a need to sensitize youth on diversification of income generating activities, and distribution of development activities and investments to other regions may curb rural-urban migration especially towards Kampala city.

Besides, for better policy implementation, in order to reduce private car use and *boda-boda*, an efficient transport mode is required. This is seconded by the results of the predicted average probabilities that emphasize that households are more likely to choose public transport (taxi) in future as compared to a *boda-boda* and a private car. An efficient public transport would serve the purpose for travelers around the city irrespective of the distance travelled. Otherwise, increasing the cost of choosing other modes for travel may not fully achieve its intended objective.

Furthermore, the results indicate that the more educated travel less compared to the less educated. This calls for sensitization programs geared towards reducing unnecessary and avoidable travels to the city centre and they should encompass all travelers to Kampala.

5.4 Limitations of the Study and Recommendations for Further Research

A study extending causes of congestion beyond travel demand is necessary for a sustainable long-term solution. Given the problem of endogeneity in survey data and for certainty of the above causal relationship for policy implications, a real life policy experiment would suffice. Since policy-wise, in this study, use of public transit and thus provision of a more efficient public transport is encouraged, extensive research on willingness to pay for public transport should be carried out. This will assist in levying a right price on public transit that can be favorable as compared to the cost of other modes.

This study has mainly focused on frequently taken trips in analyzing mode choice selection, it would also be interesting to carry out an extensive study covering a chain of trips (a tour) taken by household members to have a more elaborate idea on the purpose and mode choice selection. In this way, one is able to capture the activity participation and schedules taking a whole day as a unit of analysis. A more realistic model that shows how people adapt to a changing travel environment can then be estimated. A micro-simulation of individual and household travel behaviour can then be carried out with few data limitations. Knowing how people modify their travel activities can help in managing congestion problems.

There are studies in the reviewed literature that recommend joint analysis of car ownership and use, and mode choice, in order to extend the policy of reducing the choice of private car for travel, regulating car ownership may also be useful. The descriptive statistics from this study indicate that most private car users are actually car owners, which emphasize extensive studies about private car ownership and use or mode choice.

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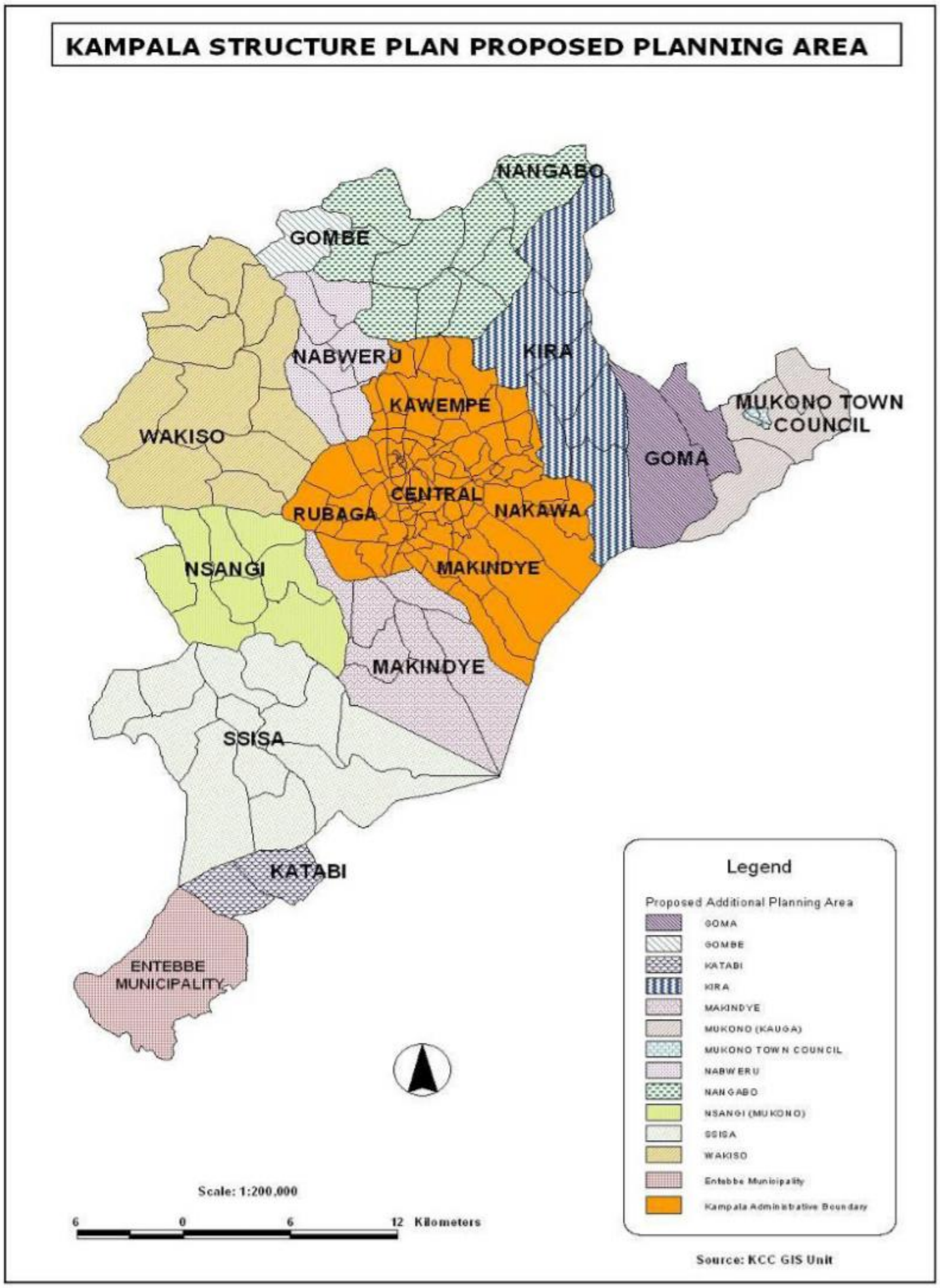
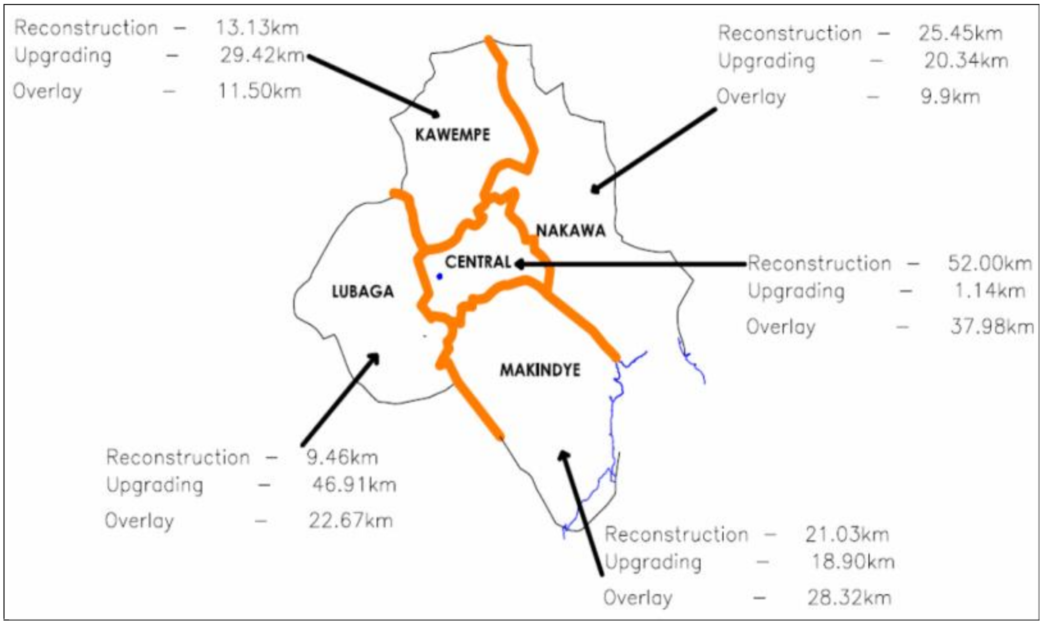
APPENDICES

Appendix 1A: Kampala Structure Plan



Source: KCCA 2012.

Appendix 1B: Proposed Plan for Reconstruction and Improvement of the Road Network



Source: KCCA 2012.

Appendix 1C: A Sample of Improved Roads

Source: KCCA 2014.

Appendix 2A: Theoretical framework of the Gravity Model by Niedercorn and Bechfdolt (1969)

Assumptions:

i. *n+1* areas and individual *k* at origin *i (i=0)* with destination area *j (j=1,2,--,n)*

ii. only one person or thing at each destination *j* with which the individual at origin *i* would like to interact per trip.

The approximate utility of trip making of an individual from *i* to *j* net of all disutilities is given as;

$$ {}_kU'_{ij} = f({}_kT_{ij}) \quad \text{--} \quad (1) $$

where,

${}_kU'_{ij}$ = net utility of individual *k* at origin *i* of interacting with persons or things at destination *j* per unit time.

${}_kT_{ij}$ = number of trips taken by individual k from origin *i* to destination *j* per unit time

Thus an individual's total net utility of interaction with all destinations is given as;

$$ {}_kU'_{i} = \sum_{j=1}^{n} f({}_kT_{ij}) \quad \text{--} \quad (2) $$

Where,

${}_kU'_{i}$ = total net utility of individual *k* at origin *i* of interacting with persons and things at all destinations per unit time.

In reality, there could be more individuals and things at each destination which an individual at origin *i* would like to interact with. Assuming that the number of persons or things at each destination is proportional to its population, an individual can make only one interaction per trip. Therefore, an individual's utility function of interaction with persons or things at all destinations is given;

$${}_kU_i = a\sum_{j=1}^{n} P_j f({}_kT_{ij}) \text{ -- (3)}$$

Where,

${}_kU_i$ = total net utility of individual *k* at origin *i* if interacting with persons or things at destination *j*

P_j = population of destination *j*

a = constant of proportionality

Assuming ${}_kU_i \succ 0$ for all ${}_kT_{ij} \succ 0$, an individual can increase his utility without limit. However, he is constrained by the total amount of money he is willing to spend on travel out of a limited income and the total amount of time he is willing to allocate for travel such that;

$${}_kM_i \geq r\sum_{j=1}^{n} d_{ij}\, {}_kT_{ij} \qquad \textit{(Income constraint)} \text{ ------------------------------------- } \textit{(4)}$$

where,

${}_kM_i$ = total amount of money individual *k* at origin *i* is willing to spend on travel per unit time.

r = cost per mile distance travelled

d_{ij} = distance between origin *i* and destination *j*

and,

$${}_kH_i \geq \tfrac{1}{s}\sum_{j=1}^{n} d_{ij}\,{}_kT_{ij} \qquad \textit{(Time constraint)} \text{ ----------------------------------- } \textit{(5)}$$

Where,

${}_kH_i$ = total amount of time individual *k* located at origin *i* is willing to allocate for travel, per unit time.

s = average speed at which people in the region travel.

The binding constraint for this individual depends on the maximum distance that can be travelled in the region ${}^{{}_kM_i}\!/_{r}$ or $s\,{}_kH_i$ such that,

if ${}^{{}_kM_i}\!/_{r} < s\,{}_kH_i$, the income constraint is binding;

if ${}^{{}_kM_i}\!/_{r} > s\,{}_kH_i$, the time constraint is binding.

To get the total net utility of an individual *k* for interaction with persons or things at all destinations when constrained by money, equation (6) is maximised with respect to number of trips to each destination per unit time.

$${}_kU_i^* = a\sum_{j=1}^{n} p_j\, f({}_kT_{ij}) - \mathsf{a}\left(r\sum_{j=1}^{n} d_{ij}\,{}_kT_{ij} - {}_kM_i \right) \text{ --- } (6)$$

Where a = Lagrangian multiplier

The first order conditions for maximising equation (13) are;

$$\frac{\partial\,{}_kU_i^*}{\partial\,{}_kT_{i1}} = aP_1\frac{\partial f({}_kT_{i1})}{\partial\,{}_kT_{i1}} - \mathsf{a}\,rd_{i1} = 0$$

$$\vdots \qquad\qquad \vdots \qquad\qquad \vdots \text{ --- } (7)$$

$$\frac{\partial\,{}_kU_i^*}{\partial\,{}_kT_n} = aP_n\frac{\partial f({}_kT_{in})}{\partial\,{}_kT_{in}} - \mathsf{a}\,rd_{in} = 0$$

$$\frac{\partial\, {}_kU_i^*}{\partial\, \text{a}} = r\sum_{j=1}^{n} d_{ij}\, {}_kT_{ij} - {}_kM_i = 0$$

When $^{\text{a}}r$ is eliminated from the first n partial derivatives in equation (7) yields the following *n-1* equations and the partial derivative with respect to a .

$$P_2\frac{\partial f({}_kT_{i2})}{\partial_k T_{i2}} - \frac{d_{i2}}{d_{i1}}P_1\frac{\partial f({}_kT_{i1})}{\partial_k T_{i1}} = 0$$

$$\vdots \qquad\qquad \vdots \qquad\qquad \vdots \text{--- (8)}$$

$$P_n\frac{\partial f({}_kT_{in})}{\partial_k T_{in}} - \frac{d_{in}}{d_{i1}}P_1\frac{\partial f({}_kT_{i1})}{\partial_k T_{i1}} = 0$$

$$r\sum_{j=1}^{n} d_{ij}\, {}_kT_{ij} - {}_kM_i = 0$$

Solving equations (8) simultaneously gives the trip maximising values of ${}_kT_{ij}$ for all j.

Assuming that each individual at origin i has the same form of utility function and using logarithmic or power function of trip making, utility maximising values of ${}_kT_{ij}$ for all j can be obtained. In this study we will highlight only the use of a logarithmic function of trip making.

Using the logarithmic utility of trip making function

If

$$f({}_kT_{ij}) = \ln {}_kT_{ij} \text{ --- (9)}$$

Substituting $\dfrac{\partial f({}_kT_{ij})}{\partial_k T_{ij}} = \dfrac{1}{{}_kT_{ij}}$

$$ {}_kT_{ij} = \left(\frac{{}_kM_i}{r}\right)\left(\frac{P_j}{\sum_{j=1}^{n} P_j}\right)\left(\frac{1}{d_{ij}}\right) \text{ -- } (10) $$

i) travel is directly proportional to total distance travelled by individual k to all destinations per unit time, ${}_kM_i/r$,

ii) directly proportional to the fraction of the region's population that is located at destination j, $P_j / \sum_{j=1}^{n} P_j$

iii) inversely proportional to the distance from origin i to destination j.

The total number of trips T_{ij} taken by all m individuals from origin i to a particular destination j is given as;

$$ T_{ij} = \sum_{k=1}^{m} {}_kT_{ij} = \frac{1}{r}\left(\frac{1}{d_{ij}}\right)\left(\frac{P_j}{\sum_{j=1}^{n} P_j}\right)\left(\sum_{k=1}^{m} {}_kM_i\right) \quad = \frac{M_i}{r}\left(\frac{P_j}{\sum_{j=1}^{n} P_j}\right)\left(\frac{1}{d_{ij}}\right) \text{ ------------------ } (11) $$

Where,

T_{ij} = total number of trips taken by all individuals from origin i to destination j per unit time.

M_i = total amount of money that all individuals at origin i are willing to spend for travel to all destinations, per unit time.

In cases where travel time is the relevant constraint other than money (income), then $\frac{M_i}{r}$ is replaced by sH_i where H_i is the total time allocated by all individuals at origin i for travel to all destinations per unit time.

Using either time or income constraints, equation (11) is similar to the gravity law version showing that the total number of trips taken by all individuals from one origin to all destinations is inversely proportional to the total distance travelled from the origin to all destinations.

Appendix 2B: Theoretical Negative Binomial

Greene, (2006); Hilbe (2007, 2011) and Zwilling (2013) parameterize the Negative Binomial as;

$$p(y) = P(Y = y) = \frac{\Gamma(y + 1/\alpha)}{\Gamma(y+1)\Gamma(1/\alpha)} \left(\frac{1}{1+\alpha\mu} \right)^{1/\alpha} \left(\frac{\alpha\mu}{1+\alpha\mu} \right)^{y} \text{ ------------------------- (10)}$$

Where;

μ > 0 is the mean of *Y* and α > 0 is the heterogeneity parameter.

This derivation is a form of a Poisson-gamma mixture or as the number of failures before the $(1/\alpha)^{th}$ success. The standard NBR model commonly referred to as NB2 is given as;

$$\ln\mu = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots\dots\dots + \beta_p x_p \text{ -- (11)}$$

where;

$x_1, x_2, \dots\dots\dots, x_p$ are the given predictor variables and $\beta_0, \beta_1, \beta_2, \dots\dots\dots, \beta_p$ are parameters to be estimated.

Given a random sample of *n* subjects, for each subject *i*, the dependent variable y_i and predictor variables $x_{1i}, x_{2i}, \dots\dots\dots, x_{pi}$ are observed.

Let $\beta = (\beta_0, \beta_1, \beta_2, \dots\dots\dots, \beta_p)^z$ such that using matrix notation, the predictor data will be given as;

$$X = \begin{pmatrix} 1 & x_{11} & x_{12} & \cdots x_{1p} \\ 1 & x_{21} & x_{22} & \cdots x_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ 1 & x_{n1} & x_{n2} & \cdots x_{np} \end{pmatrix} \text{ -- (12)}$$

Taking the i^{th} row of *X* to be x_i and exponentiating (11), the distribution (10) can be written as;

$$p(y_i) = \frac{\Gamma(y_i + 1/\sim)}{\Gamma(y_i + 1)\Gamma(1/\sim)} \left(\frac{1}{1+\sim e^{x_i \cdot}} \right)^{1/\sim} \left(\frac{\sim e^{x_i \cdot}}{1+\sim e^{x_i \cdot}} \right)^{y_i} \text{------------------------------} \quad (13)$$

i =1, 2, ... , n.

α and β are estimated using maximum likelihood estimation and the likelihood function is given as;

$$L(\sim, \quad) = \prod_{i=1}^{n} p(y_i) = \prod_{i=1}^{n} \frac{\Gamma(y_i + 1/\sim)}{\Gamma(y_i + 1)\Gamma(1/\sim)} \left(\frac{1}{1+\sim e^{x_i \cdot}} \right)^{1/\sim} \left(\frac{\sim e^{x_i \cdot}}{1+\sim e^{x_i \cdot}} \right)^{y_i} \text{------------------} \ (14)$$

and the log-likelihood function is given as;

$$\ln L(\sim, \quad) = \sum_{i=1}^{n} \left(y_i \ln \sim + y_i (x_i . \quad) - \left(y_i + \tfrac{1}{\sim} \right) \ln(1+\sim e^{x_i \cdot} \quad) + \ln \Gamma\left(y_i + \tfrac{1}{\sim} \right) - \ln \Gamma(y_i + 1) - \ln \Gamma\left(\tfrac{1}{\sim} \right) \right)$$

---(15)

Therefore, the values of α and β that maximize equation (15) are the maximum likelihood estimates.

Appendix 3: Descriptive Statistics for Urban Road Travel Demand

Appendix 3A: Distribution of Vehicle Ownership by Income

	Vehicle ownership		
Income group	No	Yes	Total
0 - 500000	813	25	838
500000 - 1000000	372	105	477
100000 - 1500000	59	95	154
150000 - 2000000	23	70	93
200000 - 2500000	8	79	87
2500000 - 3000000	10	62	72
> 3000000	83	102	185
Total	1,368	538	1906

Source: Author's computation from KCCA 2011 survey data.

Appendix 3B: Distribution of Household Size by Proximity to the City Centre

Proximity to Kampala city center	Grouped household size (number of people)				
(Kilometers)	1 - 3'	4 -6'	7 - 9'	Above 9	Total
0.00-3.0km	134	219	25	7	385
3.01-6.0km	311	492	72	8	883
6.01-9.0km	148	261	32	3	444
Above 9.0km	73	113	7	1	194
Total	666	1,085	136	19	1,906

Source: Author's computation from KCCA 2011 survey data.

Appendix 3C: Distribution of Household Size by Distance to Work

Distance to work (Kilometers)	Grouped household size (number of residents)				
	1 - 3'	4 -6'	7 - 9'	Above 9	Total
0.00-3.0km	316	436	51	8	385
3.01-6.0km	226	403	55	9	693
6.01-9.0km	75	150	19	2	246
Above 9.0km	49	96	11	0	156
Total	666	1,085	136	19	1,906

Source: Author's computation from KCCA 2011 survey data.

Appendix 3D: Distribution of Distance to Work by Proximity to the City Centre

Proximity to Kampala city center (Kilometers)	Distance to work (Kilometers)				
	0.00-3.0km	3.01-6.0km	6.01-9.0km	Above 9.0km	Total
0.00-3.0km	207	153	18	7	385
3.01-6.0km	409	329	122	23	883
6.01-9.0km	151	180	83	30	444
Above 9.0km	44	31	23	96	194
Total	811	693	246	156	1,906

Source: Author's computation from KCCA 2011 survey data.

Appendix 3E: Distribution of Age of the Household Head

Age (Grouped)	Frequency	Percentage	Cumulative percentages
15 - 24yrs	193	10.13	10.13
25 - 34yrs	771	40.45	50.58
35 - 44yrs	513	26.92	77.49
45 - 54yrs	279	14.64	92.13
Above 54yrs	150	7.87	100
Total	1906	100	

Source: Author's computation from KCCA 2011 survey data.

Appendix 3F: Distribution of the Primary Purpose of Travel

Purpose of travel	Frequency	Percent	Cumulative Frequency
Work	1,545	81	81
Social	260	14	95
Home	101	5	100
Total	1,906	100	

Source: Author's computation from KCCA 2011 survey data.

Appendix 4: Multi-Collinearity and Heteroskedasticity Test Results of the Variables before Log Transformation

Variable	VIF	1/VIF
Cost per km to city centre	7.67	0.130418
Cost per km to work	4.08	0.244884
Distance to work	1.29	0.772863
Household monthly income	6.32	0.158233
Monthly per capita income	5.81	0.172102
Daily transport cost	13.76	0.072693
Trip cost	5.35	0.187029
Household size	1.92	0.521701
Age	41.12	0.02432
Age2	40.35	0.024783
Gender	1.08	0.923869
Car ownership	1.35	0.739562
Education level		
Primary	5.76	0.173565
Secondary	13.76	0.072681
Tertiary	14.83	0.067439
Employment sector		
Public	7.8	0.128177
Private forma	10.48	0.095442
Private informal	6.49	0.15409
Others	6.72	0.148914
Mean VIF	10.31	

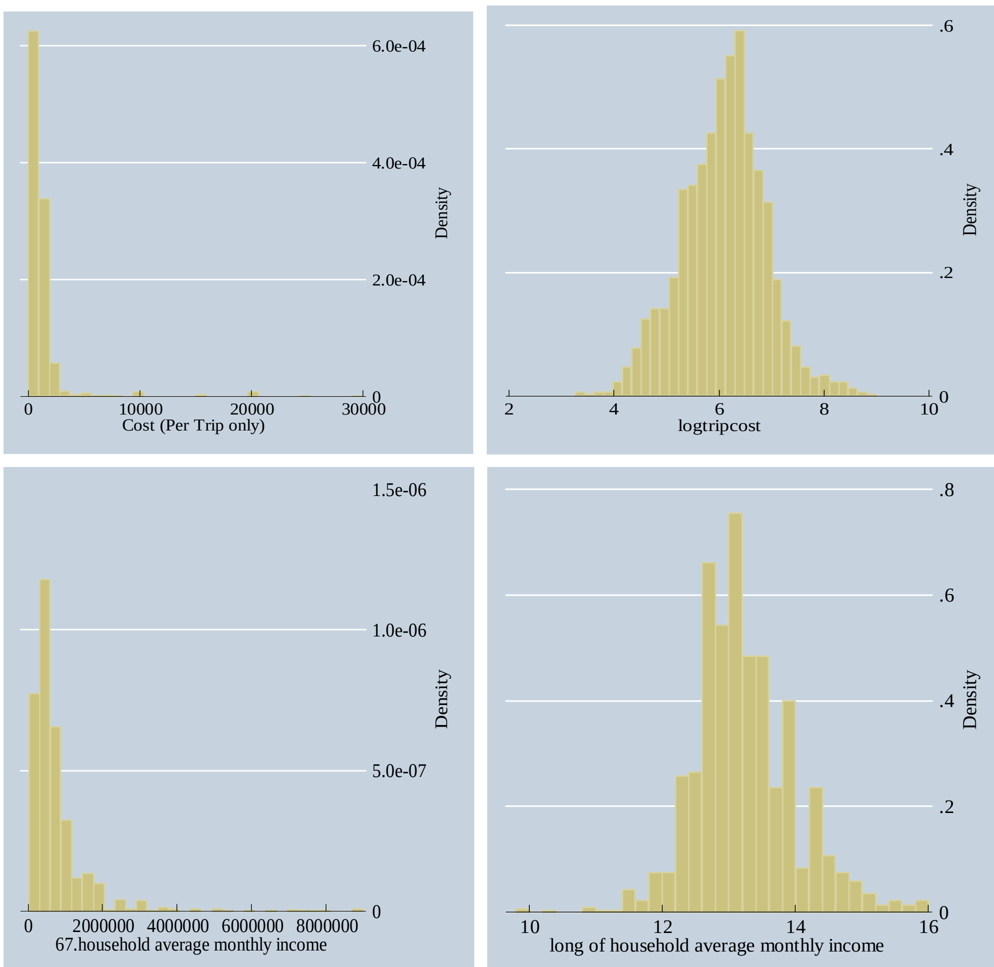
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
Ho: Constant variance
Variables: fitted values of hhtrips

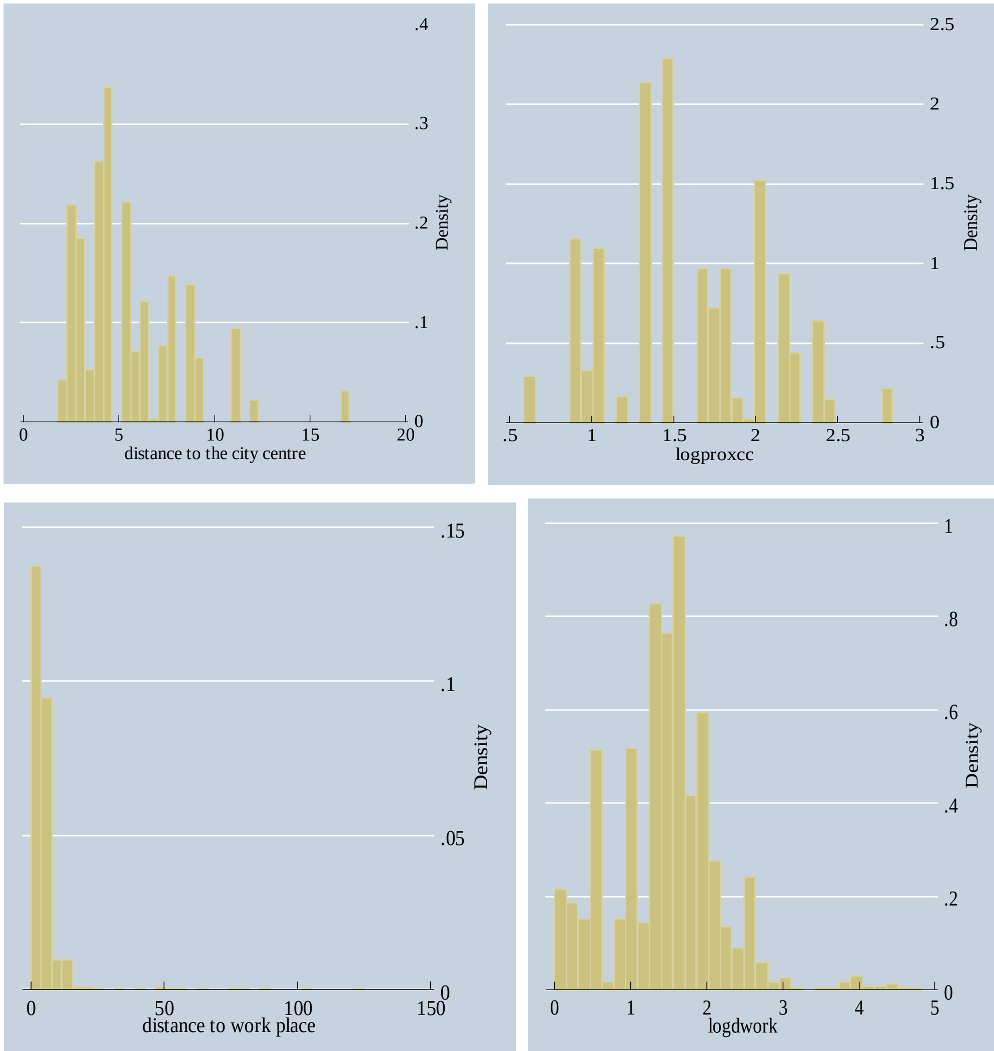
chi2(1) = 112.08
Prob > chi2 = 0.0000

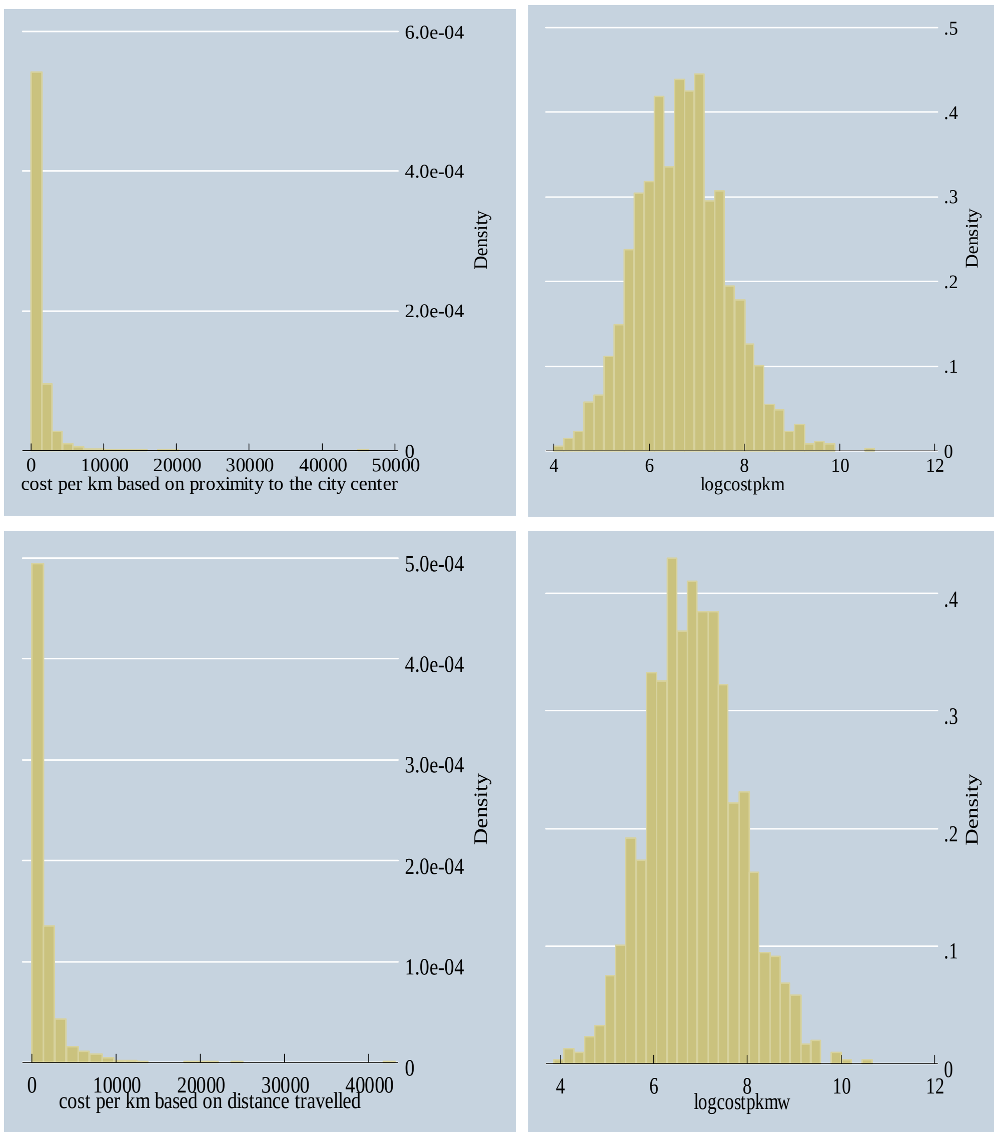
Source: Author's computation from KCCA 2011 survey data.

Appendix 5: Graphical Appearance of the Distribution of Variables Before and After Log Transformation

Before Logarithmic Transformation | After Logarithmic Transformation




.4
.3
.2
.1
0
Density
0
5
10
15
20
distance to the city centre
2.5
2
1.5
1
.5
0
Density
.5
1
1.5
2
2.5
3
logproxcc
.15
.1
.05
0
Density
0
50
100
150
distance to work place
1
.8
.6
.4
.2
0
Density
0
1
2
3
4
5
logdwork



Source: Author's computation from KCCA 2011 survey data.

Appendix6: Results of the Poisson Estimation

	Model 1	Model 2	Model 3
Household trips	Economic factors	Social factors	All Socio-Economic factors
Log (trip cost)	-0.124***		-0.098***
	(0.011)		(0.010)
Log (income)	0.154***		0.051***
	(0.011)		(0.02)4
Log (distance to city centre)	-0.046**		-0.042**
	(0.011)		(0.014)
Household size		0.111***	0.097***
		(0.006)	(0.058)
Age of household head		0.003***	0.002***
		(0.001)	(0.001)
Gender of household head		0.01	0.013
		(0.020)	(0.023)
Vehicle ownership		-0.054***	0.034
		(0.013)	(0.021)
Education level	Base = no education		
Primary		0.112**	0.04
		(0.031)	(0.061)
Secondary		0.115**	0.016
		(0.029)	(0.058)
Tertiary		0.114**	0.023
		(0.039)	(0.059)
Employment sector	Base = public sector		
private		-0.048**	-0.048**
		(0.012)	(0.021)
Others		-0.055**	-0.061**
		(0.016)	(0.017)
Constant	1.077***	1.581***	1.776***
	(0.201)	(0.053)	(0.201)
N	1357	1906	1357
Pseudo R^2	0.04	0.08	0.095
Walds Chi2(3,9,12)	219.62	602.03	732.52
Prob > Chi2	0	0	0

Standard errors are in parentheses * *p* < 0.10, ** *p* < 0.05, *** *p* < 0.01

Source: Author's computation from KCCA 2011 survey data.

Appendix 7A: OLS Regression using Distance from Home to Work Place of The Household Head as a Measure of Distance Travelled

Distance traveled	Model 1 Economic factors	Model 2 Social factors	Model 3 All Socio-Economic factors
Log(costperkm to the city centre	0.667***		0.664***
	(0.0192)		(0.0193)
Log (cost per km to work place)	-0.866***		-0.864***
	(0.0194)		(0.0194)
Log (income)	0.0606***		0.0398**
	(0.0149)		(0.0183)
Household size		-0.00506	0.00474
		(0.0119)	(0.00758)
Age of household head		0.00238	0.000221
		(0.00194)	(0.00122)
gender of household head		-0.00355	0.00542
		(0.0571)	(0.0321)
Vehicle ownership		0.286***	0.0292
		(0.0410)	(0.0357)
Education level	Base = No education		
Primary		-0.187	-0.127
		(0.158)	(0.0806)
Secondary		-0.239	-0.159**
		(0.149)	(0.0743)
Tertiary		-0.128	-0.0925
		(0.148)	(0.0724)
Employment sector	Base = Public		
Private		0.0151	-0.00139
		(0.0460)	(0.0289)
Others		0.0381	0.0186
		(0.0592)	(0.0353)
Constant	2.051***	1.455***	2.410***
	(0.198)	(0.168)	(0.241)
N	1157	1157	1157
adj. R^2	0.675	0.043	0.675
pseudo R^2			

Standard errors are in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Dependent Variable is the distance from home to the city centre and distance from home to the work place respectively

Source: Author's computation from KCCA 2011 survey data.

Appendix 7B: OLS Results of Demand for Travel Using Distance to Work as a Measure with Categorized Household Size and Age

	(1)	(2)	(3)
	Economic factors	Social factors	All Socio-Economic factors
Log(cost per km to work)	0.667***		0.665***
	(0.0192)		(0.0193)
Log(income)	0.0606***		0.0378**
	(0.0149)		(0.0179)
Household size	Base = 1 - 3	.	.
		.	.
4 - 6		-0.0105	0.0495*
		(0.0420)	(0.0268)
Above 6		-0.0825	-0.0210
		(0.108)	(0.0946)
Age (in years)	Base = 15 - 24	.	.
		.	.
25 - 34		-0.00736	-0.0646*
		(0.0605)	(0.0385)
35 - 44		0.0874	-0.0454
		(0.0655)	(0.0412)
45 - 54		-0.0426	-0.0969**
		(0.0731)	(0.0470)
Above 54		0.131	-0.0193
		(0.0985)	(0.0596)
Gender		-0.00606	0.00786
		(0.0573)	(0.0319)
Vehicle ownership		0.288***	0.0296
		(0.0412)	(0.0360)
Education level	Base = no education	.	.
		.	.
Primary		-0.173	-0.109
		(0.160)	(0.0799)
Secondary		-0.222	-0.139*
		(0.150)	(0.0732)
Tertiary		-0.110	-0.0759
		(0.149)	(0.0717)
Employment sector	Base = Public	.	.
		.	.
Private		0.0169	-0.00527
		(0.0459)	(0.0291)
Others		0.0334	0.00803
		(0.0595)	(0.0356)
_cons	2.051***	1.489***	2.482***
	(0.198)	(0.157)	(0.246)
N	1157	1512	1157
adj. R^2	0.675	0.046	0.677
pseudo R^2			

Standard errors are in parentheses   * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Dependent Variable is the distance from home to the city centre and distance from home to the work place respectively

Source: Author's computation from KCCA 2011 survey data.

Appendix 8: Multi-collinearity Test Results for Both NBR and OLS Model Estimators

Variable	NBR Estimators			OLS Estimators		
	VIF	SQRT VIF	Tolerance	VIF	SQRT VIF	Tolerance
Log (trip cost)	1.05	1.02	0.96			
Log (distance to city centre)	1.01	1.01	0.99			
Log (cost per km to the city centre)				2.45	1.57	0.41
Log (cost per km to the work)				2.36	1.54	0.42
Log (income)	1.44	1.2	0.69	1.49	1.22	0.67
Household size	1.38	1.18	0.72	1.38	1.17	0.72
Age	1.30	1.14	0.77	1.31	1.15	0.76
Gender	1.07	1.03	0.93	1.05	1.03	0.95
Vehicle ownership	1.34	1.16	0.75	1.34	1.16	0.74
Education level	Base = primary/no education					
Secondary	2.58	1.61	0.39	2.89	1.7	0.34
Tertiary	2.86	1.69	0.34	3.13	1.77	0.31
Employment sector	Base = Public					
private	1.88	1.37	0.53	1.78	1.33	0.56
others	1.87	1.37	0.54	1.78	1.33	0.56
Mean VIF	**1.62**			**1.91**		

Source: Author's computation from KCCA 2011 survey data.

Appendix 9: Travel Demand by Sector

				Public sector	Private sector	Public sector	Private sector
Household trips	Public sector	Private Sector	Distance traveled	Distance to city centre	Distance to city centre	Distance to work	Distance to work
Log (trip cost)	-0.0940***	-0.102***	Log (cost per km to city centre)	-0.385***	-0.321***	0.612***	0.676***
Log (income)	0.0860***	0.0615***	Log (cost per km to work)	0.173***	0.129***	-0.824***	-0.868***
Log (distance to city)	-0.0766**	-0.0121	Log (income)	0.0355	0.0165	0.0365	0.0187
Household size	0.107***	0.0933***	Household size	-0.00166	0.0123	-0.00227	0.0119
Age of household head	0.000738	0.00327**	Age of household head	0.00219	-0.000766	0.00222	-0.000795
Gender of hh head	-0.0315	0.00132	Gender of head	0.168***	-0.0243	0.169***	-0.0253
Vehicle ownership	0.00712	0.00222	Vehicle ownership	-0.053	0.107**	-0.0502	0.105**
Education level	Base=no educ		Education level	Base= no education			
Primary	-0.0599	0.0321	Primary	-0.0927	-0.0862	-0.0922	-0.0834
	-0.146	-0.0906		-0.201	-0.0981	-0.201	-0.098
Secondary	-0.0122	-0.0133	Secondary	-0.187	-0.0877	-0.185	-0.0878
	-0.0886	-0.0832		-0.122	-0.0878	-0.122	-0.088
Tertiary	-0.0272	-0.00119	Tertiary	-0.064	-0.0297	-0.0624	-0.0301
	-0.053	-0.0824		-0.105	-0.0853	-0.106	-0.0854
Constant	1.421***	1.579***	Constant	2.362***	2.623***	2.346***	2.596***
	-0.441	-0.311		-0.523	-0.334	-0.521	-0.331
Lnalpha	-4.343***	-16.16***					
	-0.709	-5.557					
N	244	675		244	675	244	675
adj. R^2				0.328	0.211	0.684	0.648
pseudo R^2	0.078	0.076					

Source: Author's computation from KCCA 2011 survey data.

Appendix 10: Travel Demand with Cost of Travel as a Categorical Variable

	1		2	3
Travel demand	Household trips	Distance traveled	Distance to work place	Distance to city centre
		C1 (0.00 - 500.00)	Base .	
C1 (0.00 - 1000.00)	Base	C2 (500.01 - 1000.00)	-0.189***	
C2 (1000.01 - 2000.00)	-0.142***		-0.0528	
	-0.0321	C3 (> 1000)	-0.589***	
C3 (> 2000)	-0.0809		-0.0526	
	-0.0584	C1 (0.00 - 500.00)	Base	
Log (income)	0.0388***	C2 (500.01 - 1000.00)		-0.0621**
	-0.0148			-0.0292
Log (distance to work)	-0.0331**	C3 (> 1000)		-0.324***
	-0.0138			-0.025
Household size	0.100***	Log (income)	0.0620*	0.00529
	-0.00671		-0.0326	-0.0161
Age of hh head	0.00290***	Household size	0.0107	0.00314
	-0.000958		-0.0119	-0.00716
Gender of hh head	-0.00165	Age of hh head	0.00463**	0.000507
	-0.0289		-0.00205	-0.00107
Vehicle ownership	0.0155	Gender of hh head	-0.0233	0.0188
	-0.0291		-0.0559	-0.0277
Education level	Base = no educ	Vehicle ownership	-0.077	0.00163
Primary	0.137**		-0.054	-0.0343
	-0.0664	Education level	Base = no educ	
Secondary	0.0896	Primary	-0.179	-0.0144
	-0.0628		-0.159	-0.0774
Tertiary	0.0926	Secondary	-0.225	0.00012
	-0.0618		-0.148	-0.0746
Employment sector	Base = public	Tertiary	-0.082	0.0671
Private	-0.0423		-0.145	-0.0741
	-0.0263	Employment sector	Base = public	
Others	-0.0534*	Private	-0.0318	-0.0155
	-0.0305		-0.0455	-0.0282
Constant	1.230***	others	-0.0103	0.0129
	-0.2		-0.0608	-0.0328
Lnalpha_constant	-4.721***	_cons	0.859*	1.488***
	-0.483		-0.441	-0.215
N	1248		1248	1546
Adj. R^2			0.147	0.111
Pseudo R^2	0.065			

Source: Author's computation from KCCA 2011 survey data.

Appendix 11: Descriptive Statistics for Transport Mode Choice

Appendix 11A: Distribution of Transport Mode by Age Group

Age group	Cell values	Transport mode			Total
		Private car	*Boda-boda*	Taxi	
15 - 25yrs	frequency	2	13	38	53
	percentage	0.82	5.31	15.51	21.63
25 - 35yrs	frequency	12	22	72	106
	percentage	4.9	8.98	29.39	43.27
35 - 45yrs	frequency	16	7	29	52
	percentage	6.53	2.86	11.84	21.22
45 - 55yrs	frequency	8	2	11	21
	percentage	3.27	0.82	4.49	8.57
Above 55yrs	frequency	8	0	5	13
	percentage	3.27	0	2.04	5.31
Total	frequency	46	44	155	245
	percentage	18.78	17.96	63.27	100

Source: Author's computation from own survey data.

Appendix 11B: Distribution of Transport Mode by Education Level

Education level	Cell values	Transport mode			Total
		Private car	Boda boda	Taxi	
Basic or no education	frequency	7	4	21	32
	percentage	2.86	1.63	8.57	13.06
Secondary education	frequency	13	15	63	91
	percentage	5.31	6.12	25.71	37.14
Post secondary education	frequency	26	25	71	122
	percentage	10.61	10.2	28.98	49.8
Total	frequency	46	44	155	245
	percentage	18.78	17.96	63.27	100

Source: Author's computation from own survey data.

Appendix 11C: Distribution of Transport Mode by Trip Length

Trip length	Transport mode			total
	Private car	*Boda-boda*	Taxi	
less than 4 km	6.5	9.8	21.2	37.5
4- 5 km	4.9	3.7	19.6	28.2
above 5 km	7.4	5.0	22.5	34.3
Total	18.78	17.96	63.27	100

Source: Author's computation from own survey data.

Appendix 11D: Distribution of Transport Mode by Distance to Trip Destination and Distance from Home to City Centre

Distance to destination (distance from home to the city centre	Cell values	transport mode			Total
		Private car	Boda - boda	Taxi	
less than 4 km	frequency	16 (11)	24 (18)	52 (53)	92 (82)
	percentage	6.5 (4.5)	9.8 (7.4)	21.2 (21.6)	37.5 (33.5)
4- 5 km	frequency	12 (21)	9 (19)	48 (63)	69 (103)
	percentage	4.9 (8.6)	3.7 (7.8)	19.6 (25.7)	28.2 (42.1)
above 5 km	frequency	18 (14)	11 (7)	55 (39)	84 (60)
	percentage	7.4 (5.7)	5.0 (2.9)	22.5 (15.9)	34.3 (24.5)
Total	frequency	46	44	155	245
	percentage	18.78	17.96	63.27	100

Values for distance from household location to the city centre in parentheses

Source: Author's computation from own survey data.

Appendix 11E: Distribution of Automobile Ownership by Household Size

Household size	Automobile ownership				
	Private car	Motorcycle	Both	None	Total
1 - 3	5	6	0	52	63
4 - 6	12	5	1	16	34
Above 6	2	0	0	1	3
Total	19	11	1	69	100

Source: Author's computation from own survey data.

Appendix 11F: Distribution of Automobile Ownership by Gender of Household Head

Gender of household head	Automobile ownership				
	Private car	Motorcycle	Both	None	Total
Female	2	0	0	12	14
Male	18	10	1	57	86
Total	20	10	1	69	100

Source: Author's computation from own survey data.

Appendix 11G: Distribution of Transport Mode by Gender of Household Head

Gender of household head	Transport mode			
	Private Car	*Boda-boda*	Taxi	Total
Female	11	2	1	14
Male	52	17	17	86
Total	63	19	18	100

Source: Author's computation from own survey data.

Appendix 11H: Distribution of Transport Mode Choice by Income

Household monthly income	Cell values	Transport mode			Total
		Private car	*Boda-boda*	Taxi	
0 - 410000	Frequency	4	21	78	103
	Percentage	1.63	8.57	31.84	42.04
410001 - 1000000	Frequency	25	21	63	109
	Percentage	10.2	8.57	25.71	44.49
above 1000000	Frequency	17	2	14	33
	Percentage	6.94	0.82	5.71	13.47
Total	Frequency	46	44	155	245
	Percentage	18.78	17.96	63.27	100

Source: Author's computation from own survey data.

Appendix 11I: Distribution of Automobile Ownership by Income

Household income	Automobile ownership				
	Private car	Motorcycle	Both	None	Total
0-235000	3	5	0	29	37
235000-335000	4	4	0	31	39
335000-410000	2	3	0	27	32
410000-1000000	24	12	2	67	105
>=1000000	14	2	1	15	32
Total	47	26	3	169	245

Source: Author's computation from own survey data.

Appendix 11J: Distribution of Income by Household Size

Household income	Household size (All members including children)			
	1 - 3	4 - 6	Above 6	Total
0-235000	11	4	0	15
235000-335000	11	5	0	16
335000-410000	10	3	0	13
410000-1000000	25	17	1	43
More than 1000000	7	5	1	13
Total	64	34	2	100

Source: Author's computation from own survey data.

Appendix 11K: Distribution of Income by the Number of Adults in a Household

Household income	Household size (number of adults)			
	1 - 3	4 - 6	Above 6	Total
0-235000	14	1	0	15
235000-335000	14	2	0	16
335000-410000	11	2	0	13
410000-1000000	36	7	0	43
More than 1000000	11	2	0	13
Total	86	14	0	100

Source: Author's computation from own survey data.

Appendix 11L: Distribution of Income by Gender of Household Head

Household income	Gender of household head		
	Female	Male	Total
0-235000	3	12	15
235000-335000	3	13	16
335000-410000	3	10	13
410000-1000000	4	39	43
More than 1000000	1	12	13
Total	14	86	100

Source: Author's computation from own survey data.

Appendix 12: Distribution of Continuous Variables after Logarithmic Transformation

Variable	N	Mean	Standard deviations	Minimum	Maximum	Skewness	Kurtosis
Log of monthly income	245	13.06	0.75	10.82	15.69	0.03	3.79
Log of distance from home to city centre	245	1.41	0.38	0.41	2.20	-0.40	3.26
Log of trip cost	245	7.59	0.69	6.21	10.13	0.65	3.40
Log of trip length	245	1.41	0.55	-0.69	2.48	-1.16	5.64
Log of trip travel time	245	3.53	0.69	1.39	5.89	0.31	3.67

Source: Author's computation from own survey data.

Appendix 13: ASCLOGIT Preliminary Estimates Indicating the Model Coefficients and Odds Ratios

	Dependent Variable : Choice of mode of transport ; Coefficients			Odds Ratios		
Variable	Base(taxi)	Private Car	*Boda-boda*		Private Car	*Boda-boda*
Choice specific variable						
Log of time taken by mode	-0.965*(0.548)			0.38*(0.21)		
Case specific variables						
Log of travel cost		4.058***(0.686)	1.809***(0.460)		57.8***(39.7)	6.107***(2.809)
Log of trip length		-2.354***(0.672)	-1.230**(0.536)		0.095***(0.064)	0.292**(0.0.157)
Log of hh monthly income		2.726***(0.630)	-0.083(0.316)		15.27***(9.62)	0.920(0.291)
Age2		-0.0002(0.0003)	-0.001(0.0004)		0.010(0.0003)	0.999(0.0004)
Gender		0.131(1.060)	1.232*(0.691)		1.140 (1.208)	3.427*(2.367)
Trip volume		-0.268**(0.133)	-0.056(0.118)		0.765**(0.102)	0.945(0.112)
Household size		0.870***(0.256)	-0.103(0.165)		2.387***(0.612)	0.902(0.149)
Trip purpose*		-0.520(1.105)	0.707 5(0.552)		0.595(0.561)	2.028(1.120)
Secondary education*		1.540 (1.056)	0.226(0.687)		3.669 (4.055)	1.253(0.861)
Post secondary education*		1.540(1.056)	0.549(0.662)		4.663(4.922)	1.732(1.147)
	No. of cases 240 No. of Observations=720 Wald chi2 (23) = 69.44 Prob > chi2 = 0.0000 log likelihood = -115.107					

*Standard errors are in parentheses: * p < 0.10, ** p < 0.05, *** p < 0.01*
Marginal effects after Alternative Specific Conditional Logit estimation
Source: Author's computation from own survey data.

Appendix14: Alternative Summary Statistics after ASCLOGIT

Alternative	Cases present	Frequency selected	Percent Selected
Taxi	240	153	63.75
Private Car	240	46	19.17
Boda-boda	240	41	17.08

Source: Author's computation from own survey data.