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Determinants of Private Car Ownership in Kenyan Households

Eric Kombe Randu

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THE KENYA INSTITUTE FOR PUBLIC POLICY RESEARCH AND ANALYSIS (KIPPRA)

YOUNG PROFESSIONALS (YPs) TRAINING PROGRAMME

Determinants of Private Car Ownership in Kenyan Households

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Infrastructure and Economic Services Division
Kenya Institute for Public Policy
Research and Analysis

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Abstract

In Kenya, policies in the transport sector largely support motorized transport at the expense of Non-Motorized and Intermediate Modes of Transport (NMIMT). These policies, together with the absence of vehicle retirement programmes among other factors, have contributed to increasing numbers of vehicles especially in cities, towns and urban areas. This increase is not equal in all categories; motor and auto cycles, saloon cars and station wagons are increasing faster than other categories such as buses, minibuses/matatus and coaches that are mainly used for public transportation.

The rise in the number of saloon cars and station wagons is the main focus of this study as they are predominantly used for private transport in cities, towns and urban areas, and are largely privately owned. Their predominant use is a cause of concern as it has the potential of worsening the traffic problems being experienced now, thus reversing the gains that are intended to be achieved by the ongoing transport improvement projects. This will include increase in congestion, pollution and spending on infrastructure, energy scarcity and green house gas emissions.

By employing Binary Logistic Regression analysis, the research analyzed the determinants of private car ownership at the household level, with a view of deducing policy recommendations aimed at managing private car populations in Kenyan cities, towns and urban areas. The study findings indicated that geographical area, gender, education, house tenure, employment status, type of dwelling and household income, influence private car ownership in Kenyan households.

The study recommends adoption of the compact city model of urban planning, which is high density, mixed-use cities, with efficient public transport systems that also encourage cycling and walking; taxation of benefits from employers to employees that encourages car ownership including car loans, car parking refunds and mileage claims as a disincentive to reduce private car ownership; and introduction of congestion charges and area licensing systems (ALS) to reduce the propensity of private car use, especially access to the central business district (CBD).

Abbreviations and Acronyms

HGV	Heavy Commercial Vehicles
NMIMT	Non-Motorized and Intermediate Modes of Transport
CBD	Central Business District
INTMP	Integrated National Transport Master Plan
NRSP	National Road Safety Programme
MRT	Mass Rapid Transit
LRT	Light Rail Transit
BRT	Bus Rapid Transit
EMR	Extended Metropolitan Region
ITS	Intelligent Transport System
VQS	Vehicle Quota System
CoE	Certificate of Entitlement
CSN	Car Sharing Network
ALS	Area Licensing Systems
SMG	Seoul Metropolitan Government

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1. Introduction

1.1 Background

Globally, motorization represents an important force driving metropolitan development. Motorization, urban development, economic growth, growth of real incomes, transportation policies and investments interact in a complex process across developing metropolitan regions worldwide. Growth of real incomes drives motorization, as wealthier individuals tend to prefer the privacy, speed, flexibility and status conveyed by motor vehicle ownership. Motor vehicle ownership facilitates urban expansion by giving vehicle owners access to a greater number of potential destinations and residential choices (Chen, 2010).

Developing countries are at a stage where a rapid takeoff in car ownership is expected (Chamon, 2008). The number of cars is predicted to increase by 2.3 billion between 2005 and 2050; out of these 1.9 billion will be in emerging markets and developing countries (Chamon, Paolo and Yohei, 2008). This increase in vehicle numbers and prerequisite for car use has the potential of increasing congestion, pollution, spending on infrastructure provision, energy scarcity and green house gas emissions.

Kenya had roughly 1.4 million registered vehicles in 2011; approximately 60 per cent are used in and around Nairobi. Private vehicles carry 22 per cent of travelers, but account for 64 per cent of traffic volume (Cameron, Laura and Seton, 2012). Traffic conditions in Nairobi and other cities including Mombasa and Kisumu are characterized by inadequate supply of public transport, congested and unsafe roadways, a large number of cars and Heavy Goods Vehicles (HGVs), traffic congestion during peak hours, and stiff competition for road space among motorists, pedestrians and cyclists (Government of Kenya, 2010). Traffic congestion not only contributes to local air pollution, but also leads to economic losses as time and fuel is spent on traffic congestion (Cameron, Laura and Seton, 2012).

It is estimated that in 2002, in Nairobi, 50 million vehicle hours were lost during peak hour congestion, wasting 63 million litres of fuel costing US$25 million. Air pollution in Nairobi is high, with mean daytime concentrations of fine particles ranging from 10.7 micrograms per cubic meter at the edge of the city to 98.1 micrograms per cubic meter in the Central Business District (CBD). These high levels of suspended particulate matter (up to five times global standards), are attributed to vehicular exhaust fumes (Cameron, Laura and Seton, 2012).

The Government of Kenya through the Vision 2030 recognizes the transport sector as a critical enabler in achieving economic development. The Vision's flagship projects include: an Integrated National Transport Master Plan (INTP); development of Mass Rapid Transport systems (MRT) including Rapid Bus Transit (RBT) and Light Rail Transit (LRT) for Nairobi; development of a transport corridor to Southern Sudan and Ethiopia; and a National Road Safety Programme (NRSP).

In the Integrated National Transport Policy 2010-INTP 2010 (Government of Kenya, 2010), the government seeks to improve the institutional and legal framework of transport in Kenya by establishing the Department of Transport; consolidating transport functions under one Ministry; separation of policy, regulatory and service provision functions; consolidation of urban public transport; focus on user-and polluter-pays models; and promotion and integration of Non-Motorized and Intermediate Modes of Transport (NMIMT) into the transport systems.

Although various forms of NMIMT are already in use in various parts of the country, they have not been incorporated into the road transport network or national transport system (Government of Kenya, 2010). In Nairobi for instance, 51.6 per cent of the population uses various modes of motorized transport. Walking, which is the single largest transport mode for urban residents, accounts for 47 per cent of the modal split (Table 1.1) and is rarely provided with the requisite infrastructure. This scenario is replicated in most cities, towns and major urban areas throughout the country.

Vehicle population in Kenya increased by 46 per cent between 1992 and 2001, and there is a large influx of "new" vehicles into Kenya each year ("new"- imported vehicles are required to be less than eight years old). However, with no vehicle retirement programme in place, the fleet of older vehicles remains in use in the broader pool of vehicles (Cameron, Laura and Seton, 2012).

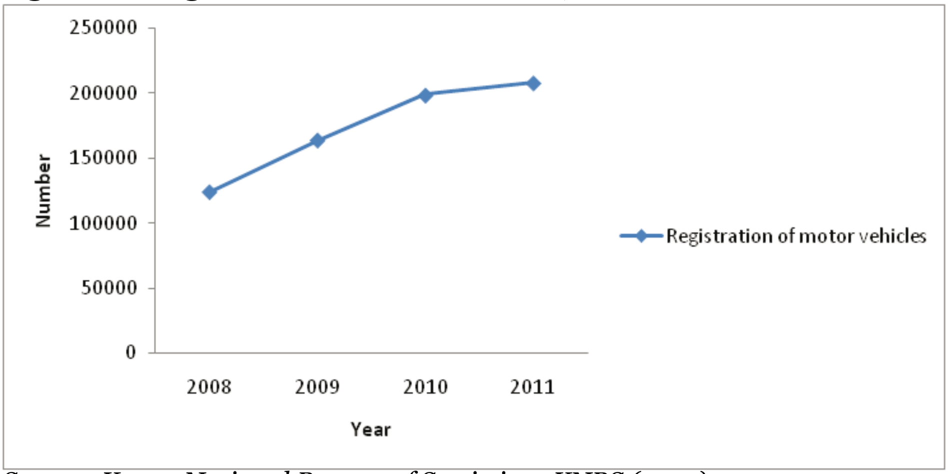
Registered vehicle population in Kenya rose by 82.2 per cent between 2008 and 2011 (KNBS, 2012). This increase, together with transport policies supporting motorized transport and the absence of vehicle retirement programmes among other factors, contributes to the increase in number of vehicles on Kenyan roads. Figure 1.1 shows the trend in motor vehicle registration between 2008 and 2011.

Table 1.1: Transport modal split for Nairobi

Transport mode	Walking	Cycling	Private cars	Matatus/ minibus	Bus	Train	Institution bus	Others
Modal split (%)	47.0	1.2	15.3	29.0	3.7	0.4	3.2	0.2

Source: Omwenga (2011), Integrated Transport for Liveable City Environments

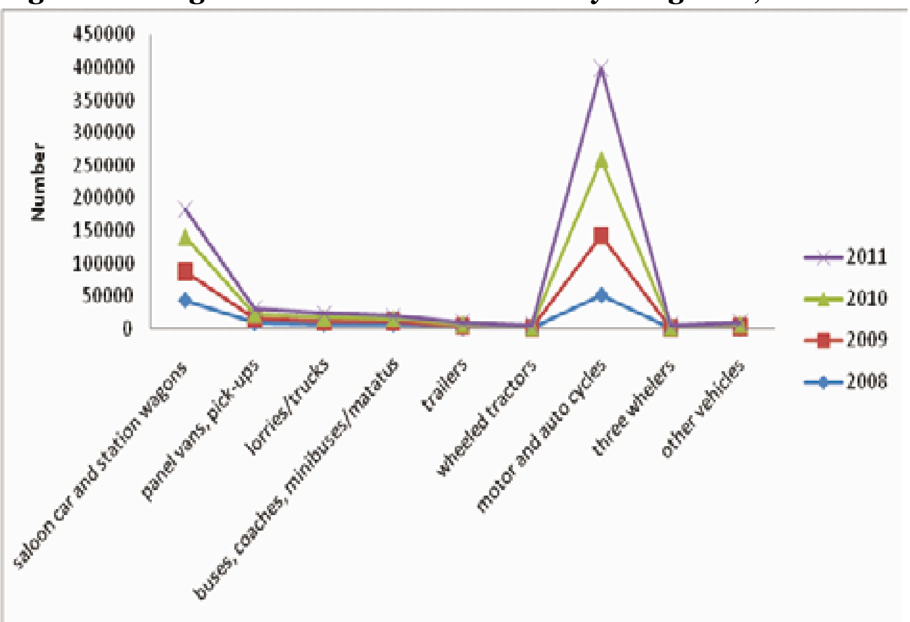
Figure 1.1: Registration of motor vehicles, 2008-2011



Source: Kenya National Bureau of Statistics - KNBS (2012)

The rise in the number of registered motor vehicles is not uniform in all categories for the period 2008-2011 (Figure 1.2). It is rising faster in motor and auto cycles, saloon cars and station wagons than in the other categories of motor vehicles (panel vans, pick ups, lorries/trucks, buses, coaches, minibuses/matatus, trailers and wheeled tractors among others).

Figure 1.2: Registration of motor vehicles by categories, 2008-2011



Source: Kenya National Bureau of Statistics - KNBS (2012)

The rise in the number of saloon cars and station wagons was the main focus of this study as they are predominantly privately owned and used for private transport in most cities, towns and major urban areas at the household level. Private vehicles also account for 64 per cent of traffic volume in Kenyan cities, towns and urban areas (Cameron, Laura and Seton, 2012).

The growing use of light duty vehicles (motor and auto cycles, saloon cars and station wagons), principally private cars, has been related to traffic congestion, emissions that affect human health and climate change. The contribution to CO_2 emissions attributed to this category of motor vehicles has also added a new dimension to these concerns (Amin, 2009).

1.2 Problem Statement

The Kenyan government has embarked on various transport improvement projects including road construction, railway line extensions, railway terminal construction among other projects aimed at alleviating traffic congestion in Kenyan towns and cities, especially in Nairobi. However, the continued rise in the number of private cars (saloon cars and station wagons) and their predominant use for private transportation at the household level is of concern. This continued increase in numbers and use of private cars has the potential of creating greater traffic problems in future; and reversing the gains intended to be achieved by the ongoing transport improvement projects. These traffic problems include local air pollution, economic losses in terms of time and fuel spent during traffic congestion, environmental degradation and lowering the overall quality of life in cities, towns and urban areas.

This study sought to analyze the determinants of private car ownership in Kenyan households, review literature on how other countries have dealt with increasing ownership and use of private cars, and make policy recommendations aimed at managing the population of private cars and their use in Kenyan cities, towns and urban areas.

1.3 Objectives

1.3.1 Main Objective

This research had one major objective which aimed to analyze the factors responsible for increase in private car ownership at the household level, with a view of deducing necessary policy recommendations to counter the increasing ownership and use of private cars in Kenyan cities, towns and urban areas.

1.3.2 Specific Objectives

The specific objectives include:

(a) Analyze the determinants of private car ownership in Kenya

(b) Deduce policy implications from the findings

1.4 Justification

The Kenyan government has embarked on major road infrastructure projects aimed at achieving the Vision 2030 and the Millennium Development Goals (MDGs) in the transport sector. The challenges that abound are whether these efforts will be able to address the problems of peak hour congestion, local air pollution, economic losses in terms of time and fuel spent on traffic congestion, environmental degradation and lowering the overall quality of life in cities, towns and urban areas. All these challenges are bound to increase as private car ownership and use increases in Kenya.

The envisaged Mass Rapid Transit (MRT) systems including Light Rail Transit (LRT) and Rapid Bus Transit (BRT) systems as planned for in Nairobi need a certain threshold population density to be sustainable (high densities). In a situation of low density developments and over reliance on private car use, Mass Rapid Transport (MRT) systems are unsustainable.

Traffic problems emanating from reliance on transportation by private cars, even in the presence of MRT systems, can only be eliminated by getting people out of the comfort of private cars into MRT systems through policy instruments. These policy instruments can only be informed by understanding the determinants of private car ownership. An understanding of the underlying determinants fuelling the increase in private car ownership provides important insights into policy issues that may arise.

1.5 Assumptions

The following assumptions were made with regard to this study:

(a) Saloon cars and station wagons were considered to be privately owned and provide a private means of transport at the household level;

(b) Pick-ups were considered a private means of transport at the household level and were included in the analysis as private cars

(c) A household was assumed to own only one car despite its economic status and other factors influencing car ownership at the household level.

1.6 Limitations

The study exclusively relied on secondary data, thus limiting the number of independent variables that could be included in the analysis. However, an extensive literature review availed much information that was used to make meaningful conclusions.

1.7 Structure of the Study

This paper is organized into five chapters. Chapter one covers the background, problem statement, objectives, justification, limitations and assumptions; chapter two literature review, empirical literature and the overview of literature; and chapter three discusses the methodology, covering the conceptual framework, model specification, data type and data sources. While chapter four covers the results and discussion of the results; chapter five provides the conclusion and policy recommendations.

2. Literature Review

2.1 Private Car

The private car continues to be the predominant transport mode in developed countries and its dependence is on the rise in developing countries. This growth is likely to follow that of per capita income, particularly in rapidly developing countries (De Jong, 2008). Motorized vehicles grew from an estimated 75 million to 675 million between 1950 and 1990 worldwide. Up to 80 per cent of these vehicles were used primarily for personal transportation (Steg, 2003).

Different reasons exist for choosing private cars over public transportation. They offer more flexibility for fulfilling complex travel related needs and challenges; users are influenced by the emotional enjoyment they get from using them; and they are a means of self-expression, identity and create a sense of social affiliation with certain social groups (Halko, 2012). Car users experience some immediate advantages as it appears to be a cheap form of transportation, it creates feelings of freedom and independence, and it is convenient and efficient (Gerard, Dik and Ben, 1997).

Cars, though the increasingly the favoured transport mode, are also the most damaging (Chapman, 2007). The private car is a highly inefficient mode of transportation, because, generally, its occupancy is very low (Helsinki, 2007). When compared with public transportation, extensive private car use is energy consuming and space intensive, including roads and parking (Halko, 2012). It also results in serious collective disadvantages such as traffic congestion, accidents, pollution and damage to the environment (Gerard, Dik and Ben, 1997).

Increasing private car use generates various environmental, social and economic problems. Evidently, scarce raw materials are exploited to manufacture and use cars, extension of roads fragments and disrupts natural habitats (Steg, 2003).

Although, it is desirable to cut down on the use of cars or shift to more environmentally acceptable transportation modes (Gerard, Dik and Ben, 1997), attempts to reduce the use of cars often evokes resistance (Marsh and Collet, 1986). However, as people own more cars, those without access to cars become socially isolated and disadvantaged at work places, leisure facilities and shops, and recreational facilities as these facilities suit car users more (Steg, 2003).

2.2 Increase in Private Car Ownership and Use

Whereas many factors are attributed to the increased use and ownership of private cars, the failure of policy instruments aggravates these factors further, leading to increased ownership and use (Amin, 2009). This failure of policy instruments includes: neglect of urban planning, lack of urban containment policies, absence of adequate public transport and absence of pedestrian-friendly environments.

Neglect of urban planning gives rise to numerous urban problems, including urban sprawl which increases motorized travel particularly by private cars. Transport being key to urban mobility, is a major component of an urban planning system. In a strong urban plan, urban mobility becomes a sub-component of urban development plans. However, in cases where strong urban planning is absent, overall urban development is dictated by other sub-components such as housing development. In the latter case, suburbanization, urban sprawl and Extended Metropolitan Regions (EMR) become features of cities, thus encouraging the predominance of the private car (Amin, 2009).

Urban containment policies limit sprawl by restricting out-of-town development (Gabrielson, Jeff and Richard, 1997). Specifically, they work by restricting development outside designated zones and provide accessibility to all destinations in an urban area. In developing countries, effective implementation of urban containment policies is limited, encouraging cities to expand along road corridors, making car ownership and use more favourable (Amin, 2009).

Public transportation plays a major role in reducing energy use, air pollution, global warming, and can compensate, in part, for inefficient land development patterns (Nash, 2006). For public transport to have a greater share of the urban transport system, the service must be reliable, adequate and comfortable. As the need for passenger transport grows, the increased use of private cars and a reduction in passenger numbers per car will negatively affect the improvements gained from vehicle efficiency. Poor quality public transport systems tend to discourage users who have an alternative option, mostly private cars (Amin, 2009).

A sufficient pedestrian-friendly environment can encourage people to walk or ride bikes, thus reducing the use of private cars. Pedestrian-friendly environments are still rare in many developing countries, including Kenya. In the absence of a pedestrian–friendly environment, there is likely to be an increase in private cars ,with all its associated negative consequences.

2.3 Global Efforts in Reducing Private Car Ownership and Use

Globally, numerous policies have been formulated geared towards reducing the ownership and use of cars. They include urban planning, transport planning, car use reduction and public transit systems.

A master plan in Curitiba, Brazil, utilized urban planning practices that integrated transport planning into the master plan. Through this, urban sprawl was minimized, a transit-oriented city was created and overall traffic reduced. Some key urban planning strategies included restructuring the city's radial configuration into a linear model of expansion and creating an urban planning agency responsible for developing, supervising and updating the master plan. Key transportation strategies included building an extensive Bus Rapid Transit (BRT) network, determining bus fares based on cross-subsidization and integrating public transit with biking and walking (Matsumoto, 2002).

In Beijing, China, the development of the transport system focused on reducing worsening traffic conditions and improving the commuting situation. The objectives were to improve urban transport efficiency, promoting socio-economic development, make land use development more efficient, create a good transport environment, and combine parking fees with transport management. Three major plans of action were an extension of the road infrastructure, improving parking management system, and establishing an Intelligent Transportation System (ITS). The efforts reduced traffic flow in central urban areas, reduced congestion and increased traffic management efficiency. The high parking fees have also increased revenues (Jiang, 2003).

The government of Singapore imposed demand management policies (usage and ownership measures) to avoid the effects of vehicle growth. When initial incentive measures (vehicle ownership measures, taxes, registration fees and excise duties) proved inadequate in restricting growth at a sustainable pace, quantity measure, that is Vehicle Quota System (VQS), along with a supporting mechanism (the Certificate of Entitlements-CoE) were introduced. The VQS/ CoE success in reducing vehicle growth depended on continuous assessment and refinement, technical feasibility studies, economic affordability estimates and a transparent and impartial bidding process. The existence of a relatively inexpensive and efficient public transport system resulted in public acceptance of restrictions (Foo, 1998; Omar and Rahman, 2006).

In Jakarta, chronic public transportation problems spurred action that led to the creation of the Trans-Jakarta; Asia's largest BRT system. Before Trans-Jakarta came into operation, public transport was highly unsatisfactory with no orientation to comfortably serve users. An old fleet, questionable attitude of public bus drivers and persistently ubiquitous congestion, triggered an increase in private car users and a constantly degrading urban air quality. This crucial decision, amid strong resistance from private car users, was behind the success of the BRT's development. Providing special buses for women also contributed to Trans-Jakarta's image. Early evidence showed that 14 per cent of passengers moved from private cars to the BRT system (Institute for Transportation Development Policy 2005).

2.4 Principle of Triple Convergence

Down (2004) describes the principle of triple convergence as a complex adaptation process, where sectors of a metropolitan transport system adapt to changes in other sectors such as modes of travel, time and location. This principle can be explained by visualizing a major highway experiencing traffic congestion every morning. If the highway is doubled in capacity, traffic flows would increase as the same number of vehicles would have access to twice as much space.

However, when word gets round that this highway is no longer congested; drivers who traveled before or after the peak hour would shift back. Drivers using alternative routes would shift onto this highway. Commuters using public transport would start driving using their cars. In a short span, the triple convergence principle upon this highway makes it as congested as before. Downs (2004) concludes that congestion on a highway cannot be eliminated by expanding its capacity as is part of a larger transport network.

The principle affects other remedies to traffic congestion as well. For instance, if workers commute less at particular times of the day, it will free congested roads. However, as the speed of traffic increases, drivers from other roads, and other modes, shift onto this improved road. The same thing would happen when workers become telecommuters. Only road pricing or higher gasoline taxes are exempt from this principle (Downs, 2004).

2.5 Empirical Literature

De Jong (2004) explored different types of car ownership models in a bid to explain car ownership. The models were compared on the basis of 16 criterions, which were based on data availability, policy objectives and the application context. In environments that are rich in data and policy requirements where the model is to provide number of cars by vehicle type for forecasting purposes the criteria 'car types' and 'impact of car cost' are important. De Jong *et al.* (2004) concludes that the preferred model varies from context to context.

Chen (2010) sheds light on the dynamics of car ownership in Beijing, China. He examines car ownership at the household level to establish factors influencing ownership over time. It emerges that income, household size, home ownership, and access to company car have strong influences towards car ownership.

However, changing periods of urbanization, motorization and urban transformation factors influenced private car ownership much more than just socio-economic and demographic variables. Relative location variables like inner-city versus suburb, did not seem to have a simple relationship to private car ownership. Heterogeneity in lifestyle/attitude also exists in car ownership decisions. The big, growing, young and affluent households continued to account for the majority of car ownership increase. Chen (2010) concludes that job-housing balance policies might not be an effective measure to reduce car ownership because the groups with the strongest car ownership propensities, are not as sensitive to commuting demand as the low-income unstable groups.

Dargay and Dermot (1997) projected the growth of cars and vehicle stocks to the year 2015 in OECD countries and developing economies, including Pakistan, India and China. Using an econometric estimating model, the findings established a strong relationship between per-capita income growth and the growth of car ownership. As per-capita income grows, so does car ownership.

Kermanshah and Ghazi (2001) employed the utilitarian approach of micro-economic modeling concepts and used the nested/hierarchical logit model structure. In this approach, when an individual or household encounters a set of alternatives, they evaluate them based on their characteristics defined through utility functions. The alternative with the most utility is then selected.

A major drawback of the logit structure is attributed to lack of independence of irrelevant alternatives (IIA) property. Car ownership decisions are formulated as a choice process among different alternatives using nested logit structure. One limitation of using the nested logit estimation procedure is that the same explanatory variables cannot be used in the two different levels of the structure. This implies that the set of independent variables has to be partitioned into two in order to be used for estimation of the lower and upper level models.

El-Hifnawi (1998) used cross sectional data from home surveys in a multinomial logit model to estimate the probabilities of certain levels of car ownership by households. The household was assumed to have four options; no vehicle, one vehicle, two vehicles, and three or more vehicles. Three categories of explanatory variables were used which dealt with economic and demographic characteristics of the households, the availability, cost and convenience of competing modes.

Button, Pearman and Fowkes (1982) employed a sigmoid function approach where a variety of functions were applied. The main modelling thrust employed a quasi-logistic approach which has been extensively used for forecasting in industrial countries. Taking *P* as the aggregate ratio of total registered vehicles to the population, S as an ultimate saturation point of car ownership per capita, *X1*, *X2*, …., *Xn* being a set of socio-economic influences on ownership and *a, b1, b2, ….., bn* being parameters, the model can be depicted as:

$$\mathrm{P} = \frac{S}{1 + e^{-a} X_1^{-b1} X_2^{-b2} \ldots . X_n^{-bn}} \quad (2.1)$$

This was converted into natural logarithmic form, as below:

$$1n\left(\frac{p}{s-p}\right) = a + b_1 1nX_2 + \ldots\ldots b_n 1nX_n \quad (2.2)$$

Button, Pearman and Fowkes (1992) concluded that the independent variable determining per capita vehicle ownership was income. Additional variables included the levels of urbanization, price of fuel and the industrialization levels.

Cundill (1986) analyzed the relationship between income and car ownership in Kenya. This was done by following the approach adopted by Bates *et al.* (1978) for the United Kingdom Regional Highway Traffic Model. The probability *P* of a household in the United Kingdom owning one or more cars was related to the household income *I* by the 'quasi-logistic' expression:

$$P = \frac{S}{1 + e^{-a_l - b}} \quad (2.3)$$

Where *S* is the level of saturation (the probability of a household with very high incomes owning one or more cars), *a* and *b* are constants. Assuming *S* is unity, equation above was rewritten as:

$$\frac{p}{1-p} = e^a l^b \quad (2.4)$$

or in logarithmic form as:

$$Ln\left(\frac{p}{1-p}\right) = a + bLn(1) \quad (2.5)$$

Cundill (1986) kept the analysis simple, citing that the quantity and accuracy of the data could not justify the use of more sophisticated techniques such as maximum likelihood analysis or weighted regression. He also took into account the possibility that the saturation level *S* might be slightly less than unity.

2.7 Overview of Literature Review

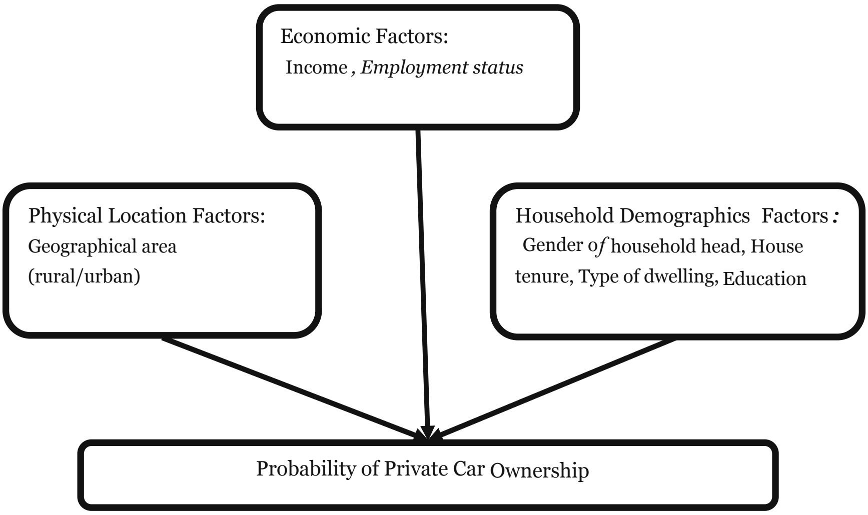
Private cars are the predominant mode of transport in many developing countries and car dependency is also rising. Private car ownership is influenced by factors such as family status, employment status, age, location of the residential area in relation to the work place, alternative means of transport, household income, annual costs of ownership, access to company car, heterogeneity in lifestyle, per capita income, population density, road density, price of fuel and levels of urbanization. Other factors influencing car ownership include neglect of urban planning, lack of urban containment policies, absence of adequate public transport systems, and the absence of a pedestrian friendly environment.

Models that have been used over time to explain private car ownership vary depending on data availability, policy requirements and specific context under which the research is carried out. No specific variables or models are best suited for all situations. In this study, a logistic regression model resembling Button, Pearman and Fowkes (1992) and Cundill (1986) was considered. The variables were as explained by El-Hifnawi (1998), mainly economic and household demographics variables.

3. Methodology

3.1 Conceptual Framework

Figure 3.1: Conceptual framework



Source: Own analysis based on conceptual framework, 2013

The conceptual framework depicts the dependent and independent variables in the model. The dependent variable was the probability of private car ownership which was tested against the independent variables: economic factors, household demographic factors and physical location factors.

The independent variables; economic factors (income, employment status) depict the financial status of the household in terms of earnings and the type of employment the head of the household engages in. The household demographic factors (household size, gender of household head, household tenure, type of dwelling and education) were also investigated to establish whether they had any influence on private car ownership. The physical location factors (geographical area - rural/urban) depict the locality of the households, whether in a urban or rural setting.

3.2 Logistic Regression Models

Logistic regressions models are suited for testing and describing hypotheses about interrelationships between a categorical variable and one/more categorical or continuous predictor variable.

In its simplest form, it would be:

$$\log it(Y) = natural\log(odds) = \ln\left\{\frac{\pi}{1-\pi}\right\} = \alpha + \beta X \tag{3.1}$$

It predicts the probability of the outcome as:

$$\pi = \Pr obability(Y = outcome\frac{\text{int}\,erest}{X} = x, aspecificvalueofX) = \frac{e^{\alpha+\beta x}}{1+e^{\alpha+\beta x}} \tag{3.2}$$

Taking, π as the probability of the outcome of interest, α as the Y intercept, β as the regression coefficient, and e=2.71828 as the base of the system of natural logarithms. *X* can be categorical or continuous, but *Y* is always categorical.

The extension of the logic to multiple predictors yields:

$$\log it(Y) = l\,\text{n}\left\{\frac{\pi}{1-\pi}\right\} = \alpha + \beta_1 X_1 + \beta_2 X_2 \tag{3.3}$$

Thus:

$$\pi = \Pr obability(Y = outcomeof\ \text{int}\,erest / X_1 =_{X1}, X_2 =_{X2} \tag{3.4}$$

Where π represents the probability of the occurrence of the event, α as the Y intercepts, β as regression coefficients, and X as a set of predictors variables.

3.3 Odds and Odds Ratios

Odds are a concept that presents a way to analyze contents on quantitative variables. It is a ratio of the probability of an event happening to the probability that the event does not happen. Thus, the odd of event A is defined as:

Odds of event A= P (A) / 1-P (A) (3.5)

Where *P (A)* is the probability of event *A* happening.

The probability of event *A* happening can also be defined in terms of the odds of event *A* as:

P (A) =Odds of event A / 1+ odds of event A (3.6)

The Logistic Function (mathematical expression) can be represented as:

$$1n\left(\frac{p}{1-p}\right) = \alpha + bXor\frac{p}{1-p} = e^{\alpha+bX} orP = \frac{e^{a+bX}}{1+e_{a+bX}} \tag{3.7}$$

Log (odds) =logit (p) =ln P/(1-P) (3.8)

The Logistic Regression Model can be represented as:

$$1n\left(\frac{p}{1-p}\right) = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_nX_n + \varepsilon \tag{3.9}$$

The Logistic Prediction Equation will thus be of the form:

$$1n\left(\frac{p}{1-p}\right) = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_nX_n \tag{3.10}$$

3.4 Model Specification

The model in this study was based on a Binary Logit Regression Model, which is of the form:

$$\Pr(y = 1/x) = \frac{\exp(x\beta)}{1+\exp(x\beta)} \quad (3.11)$$

The same model can further be presented as:

$$P = \frac{e^{a+bX}}{1+e^{a+bX}} \text{ or } P = \frac{1}{1+e^{-a+bX}} \quad (3.12)$$

This is a similar model to that used by Button, Pearman and Fowkes (1982). Assuming that the probability of owning a car is *P*, and not owning a car is (*1-P*), then the odds of owning a car would be:

$$odds = \frac{p}{1-p} \quad (3.13)$$

In logistic regression, this can be presented in the form:

$$\log(odds) = \log it(P) = \ln\left\{\frac{p}{1-p}\right\} \quad (3.14)$$

Thus:

$$Logit = (P) = \alpha + bX \quad (3.15)$$

The logit is assumed to be linearly related to *X*. Taking the log out of both sides of the equation and converting the odds to a simple probability becomes:

$$1n\left(\frac{p}{1-p}\right) = \alpha + bX \quad (3.16)$$

This can also be written as:

$$P = \frac{1}{1+e^{-a+bX}} \quad (3.17)$$

(Thus, Binary Logit Regression Model)

In this study, the model that was used for the estimation was of the form:

$$p = \frac{1}{1+e^{-(\alpha+b1X1+b2X2...+bnXn+\varepsilon}} \quad (3.18)$$

Where, P is the probability of a household either owning a car or not owning a car (owning a car = 1, 0 if otherwise). *X1, X2 ... Xn* represent: economic factors, household demographic factors and physical location factors as described earlier. a, b1, b2... bn are parameters.

The equation was further converted into logarithmic form, yielding the equation below:

$$1n\left(\frac{p}{1-p}\right) = \alpha + b_1 \ln X_1 + b_2 \ln X_2 = b_3 \ln X_3 + \varepsilon \quad (3.19)$$

3.5 Data Source and Analysis

The data was sourced from Kenya Integrated Household Budget Surveys (KIHBS) for the year 2005/2006. This data was analyzed using STATA statistical packages. Binary Logistic Regression analysis was used to examine the likelihood that private car ownership is influenced by economic factors, household demographic factors and physical location factors as specified earlier.

4. Results and Discussions

Table 4.1: Logistic regression results

Logistic regression				Number of obs = 490	
				LR chi2(10) = 21.03	
				Prob > chi^2 = 0.0209	
				Log likelihood = -0.339888	
				Pseudo R^2 = 0.2574	
Variables	**Coefficients**	**Std. Err.**	**P>|z|**	**[95% Conf. Interval]**	
Geographic area	1.78989	0 .8573659	0.037	0.1094842	3.470297
Gender	-2.134305	1.153284	0.064	-4.3947	0.126089
Education	-1.30211	1.232672	0.291	-3.718103	1.113884
House tenure					
Rented	-2.483279	1.465705	0.090	-5.356008	0.3894503
Employment status					
Working employer	2.248677	1.34227	0.094	-0.382124	4.879478
Own account worker	-1.122992	1.119411	0.316	-3.316998	1.071013
Type of dwelling					
Bungalow	10.24289	2.418395	0.000	5.502919	14.98285
Household income					
Earning up to Ksh 150,000 per month	0.8479307	1.052215	0.420	-1.214373	2.910234
Constants	-12.72571				

Source: Own Compilation Based on Regression Results, 2013

From Table 4.1, the Prob > chi2 = 0.0209 indicates the model is significant at 0.05. The predictors of private car ownership with a significance level of 5 per cent are geographical area, gender, house tenure, employment status and type of dwelling.

4.1 Interpretation of Regression Results

Logistic regression coefficients usually give the change in the log odds of the outcome of one unit increase in the predictor variable. Thus, for every unit change in geographical area, the log odds of owning a private car increases by 1.79; employment (working employer), the log odds of owning a private car increases by 2.25; type of dwelling (bungalow), the log odds of owning a private car increases by 10.24; and household income (earning up to Ksh 150,000), the log odds of owning a private car increases by 0.85.

Indicator variables with –ve signs have different interpretations. For instance, gender (female), decreases the log odds of owning a private car by 2.13; education (having no education), decreases the log odds of owning a private car by 1.30; household tenure (rented), decreases the log odds of owning a vehicle by 2.48 and employment (own account worker), reduces the log odds of owning a vehicle by 1.12.

4.2 Discussion of Findings

From the findings, four independent variables are briefly discussed because of their potential contribution to policy.

The geographical area within which a household is located (rural/urban) can influence the decision of a household either to own a car or not. If public transport is non-existent, unreliable, costly or inefficient, a household that can afford a car would buy one to meet its transportation needs. The same would happen where settlements are dispersed or sparsely populated making public transport unsustainable. For households living in or near the Central Business District (CBD), where most jobs, banks, shopping malls and entertainment places are located; private car ownership might not be a priority as members of the household can walk to these places.

The influence of geographical areas on car ownership is attested to by Flachsbart (1997), where he explains that as urban areas populate and expand, land at the edges of the urban area is developed. High cost of housing in the city centers forces people to pursue affordable housing in the suburban areas. As distances of these residential locations from the city centre increases, so does the need for motorized travel, often in private vehicles. The need for private vehicles is reinforced as declining population and employment densities with distances from urban centers reduce the economic viability of mass transit.

Employment influences households to own private cars in various ways. If the employers provide benefits such as car loans, car importation tax exemptions, mileage compensation and parking fees for their employees; an employee might consider buying a car to benefit from these provisions. Secondly, if the nature of the job is such that it is more convenient to use a private car than public transport, an individual in a household employed in such a field might probably own a car.

Sullivan (2003) found a strong relationship exists between car ownership and employment status. Having access to a car affords advantages in locating and maintaining employment (Kasarda, 1989), as it reduces the fixed costs of employment and avails time for alternative uses (Steven, 2000). Considering that remaining in employment requires showing up regularly on time, access to a car lowers the likelihood of losing the job due to absenteeism. Alternatively, owning a car can be determined by a steady employment that enables saving and increases access to the capital necessary for car purchase (Steven, 2000).

The type of dwelling a household lives in could also influence the decision to own a car in various ways. If the dwelling provides ample parking spaces and in a neighbourhood where every household owns a car, a household with adequate financial resources might be obliged to buy a car to make use of the available space and to fit in the social class where that particular type of dwelling is located. The type of dwelling is also an indicator of the social class in which a household belongs. In the findings, the bungalow (as a type of housing) featured as one of the predictors of private car ownership. Considering that the people who live in bungalows are mostly the well-off in the society, this could mean indirectly that private car owning households also posses financial wealth. Thus, it could be inferred that financial wealth determines private car ownership.

Income is considered the primary impetus to car ownership, and it is used in many car ownership forecast models as the only explanatory variable (Dargay, 2001; Button, Pearman and Fowkes, 1982; Dargay and Gately, 1999). This implies that an increase in a household's real income increases the disposable income that might be used towards the acquisition of a car. As incomes rises, there is likely to be an increasing proportion of shifts, first to motorcycles and, as income increases further, to private cars (Flachsbart, 1997). Households earning low incomes are more likely to be without cars and comprising a large proportion of public transit-dependent households than other income groups.

5. Conclusion and Policy Recommendations

5.1 Conclusion

This paper sought to analyze the determinants of private car ownership in Kenyan households, by employing Binary Logistic Regression analysis. The study found that geographical area, house tenure, employment status, type of dwelling and household income are the most significant determinants of private car ownership in Kenyan households.

The four determinants can be influenced by land use planning policies that countries, cities and towns subscribe to. Land use policies influence the location of activity centers that urban residents' access. These activity centers include: work places, shopping centers, churches, schools, recreation centers and the routes available to get to these places. Through the allocation of various land uses to specific sites, an urban structure can be created that either makes public transport systems unsustainable due to low density developments; encourages mass private car ownership and use due to urban sprawl or concentrates jobs, shopping malls, banks and entertainment places in the CBD making it congested as everyone needs to access it.

Through policy interventions such as adopting appropriate land use planning policies, together with tax incentives and disincentives, the propensity towards owning and using private cars in Kenyan cities, towns and urban areas could be reduced.

5.2 Policy Recommendations

The following recommendations should be considered:

Adapting the compact city model of urban planning

The Compact City Model is based on efficient public transport systems that encourage cycling and walking, mixed-use cities and high densities (Burton, 2002). It also encourages low car dependency, preservation of green areas, better access to services, conservation of the countryside, regeneration of inner urban areas and efficient use of infrastructure (Brehemy, 1995).

The reduction of car dependency decreases air pollution and CO_2 emissions, high-density developments increase efficiency of public transport and reduce costs of physical infrastructure provision (Cereda, 2009). Urban densification promotes and supports fairness in distribution of resources in the society, in favour of the disadvantaged groups (Burton, 2001).

Introduction of tax incentives and disincentives

Tax incentives aimed at reducing car ownership could be in form of tax relief to employers who provide benefits such as mortgages, loans for investments in the stock markets or finances towards investments in physical infrastructure as part of their employment packages as opposed to benefits that promote car ownership.

Tax disincentives through introduction of taxes by employers to their employees on car loans, car parking and mileage could reduce car ownership. Other taxation measures include: congestion charges and Area Licensing Systems (ALS).

Similar global efforts that have been successfully implemented include congestion charges in London which resulted to reductions in congestion averaging 26 per cent in the charging zones, reduced traffic accidents and emissions, improved pedestrian safety and increased revenue generation (Transport for London, 2006).

5.3 Areas of Further Research

Future research should focus on the determinants of private car ownership at the macro-level.

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Appendix

Logistic Regression Results

. xi: logit Vehicleownership Geographic_area Gender Education i.House_tenure i.Emplyment i.Type_of_dwelling i.Household_income						
Iteration 0: log likelihood = -40.854046						
Iteration 1: log likelihood = -34.385781						
Iteration 2: log likelihood = -31.201193						
Iteration 3: log likelihood = -30.42667						
Iteration 4: log likelihood = -30.342291						
Iteration 5: log likelihood = -30.340263						
Iteration 6: log likelihood = -30.340025						
Iteration 7: log likelihood = -30.339938						
Iteration 8: log likelihood = -30.339906						
Iteration 9: log likelihood = -30.339894						
Iteration 10: log likelihood = -30.33989						
Iteration 11: log likelihood = -30.339888						
Iteration 12: log likelihood = -30.339888						
Iteration 13: log likelihood = -30.339888						
Iteration 14: log likelihood = -30.339888						
Iteration 15: log likelihood = -30.339888						
Logistic regression				Number of obs = 490		
				LR $chi^2(10)$ = 21.03		
				Prob > chi^2 = 0.0209		
Log likelihood = -30.339888				Pseudo R^2 = 0.2574		
Vehicleownership |	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
-------------+--						
Geographic_area |	1.78989	0.8573659	2.09	0.037	0 .1094842	3.470297
Gender|	-2.134305	1.153284	-1.85	0.064	-4.3947	0.126089
Education |	-1.30211	1.232672	-1.06	0.291	-3.718103	1.113884
Tenure rented |	-2.483279	1.465705	-1.69	0.090	-5.356008	0.3894503
Working employer |	2.248677	1.34227	1.68	0.094	-0.382124	4.879478
Own account worker|	-1.122992	1.119411	-1.00	0.316	-3.316998	1.071013
Bungalow|	10.24289	2.418395	4.24	0.000	5.502919	14.98285
Up-to Ksh 150,000/- |	0.8479307	1.052215	0.81	0.420	-1.214373	2.910234
_cons | -12.72571	.	.	.	.	.	

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