DEVELOPMENT OF A PERSONAL VEHICLE TYPE CHOICE MODEL FOR WESTERN PROVINCE OF SRI LANKA

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Degree of Master of Science

Department of Civil Engineering

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Thesis submitted in partial fulfilment of the requirements for the degree Master of Science in Transportation

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DECLARATION OF THE CANDIDATE & SUPERVISOR

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I acknowledge all my family and friends. I declare special gratitude to my loving father, my mother, my spouse, and my little daughter; for all whose words of confidence, encouragement expedite constant perseverance and generous precise tolerance throughout this journey. I also declare my heartiest gratefulness to many of my friends who have aided me throughout the process. I will always appreciate everything they did, especially, Dileepa Fernando who helped me develop my software skills. I am hugely thankful to my supervisor, Dr Dimantha de Silva, for guiding me through the entire work.

ABSTRACT

Vehicle ownership is a chief determining factor in many country's economy. In the Sri Lankan context, the vehicle ownership rate is expressively increased, over the last decade. The road congestion in urban and suburban areas also has increased significantly. The predominant objective of the research was to examine how new vehicle choice may vary in the context of household socioeconomics characteristics. Besides, the management of new pricing reformations for annual and variable charging on vehicle price itself, fuel, insurance and other operational aspects and change of user requirements such as enhancing vehicle seating capacity, shifting vehicle operating method etc.

This paper examines the development of a type of personal vehicle ownership model using a sample of people living in Western Province Sri Lanka. A sample survey is being conducted in the Western Region to collect household data in 2013. ALOGIT software is used to obtain the results of this research. This research considers several potential determinants of vehicle choice, including socio-demographic status.

This study initially attempts to identify how to recognize the family's monthly income, age, occupation, social status, and the number of licensed drivers in the family's influence on the ownership of the car and their criticality for the utilities of the vehicle ownership models. Initial assessment on those factors identified that most influential factors are average household income, number of driving license holders in a household and number o household members. Besides, the result of this research is to assist the GoSL in imposing the required taxes and providing as much funding as possible to maximize a sustainable and environmentally friendly transportation system in Sri Lanka.

It was envisaged that three models would be developed separately for single vehicle only, two vehicles only, and at least three personal use vehicles owning HHs. Also, it was expected to have a nested structure of two and three or more vehicles own HHs, but the model results reveal that there is no nested structure where the entire variant is rooted and that it appeared as a single-level logit structure.

Key words: *Choice Model, Vehicle Ownership, Logit Model, ALOGIT, Household*

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LIST OF ABBREVIATIONS

Abbreviation	Description
DSD	Divisional Secretariats Divisions (DSD)
HH	Household
JICA	Japan International Cooperation Agency (JICA)
LC	Letter of Credits

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1 INTRODUCTION

1.1 General Background

Evolution of automobile industry in Sri Lanka was started in February 1902 with an imported steam car by Mr. Z. G. Money of Boustead Ltd. The following year, the first motorcycle arrived on the island, had a belt-driven engine to the rear wheel, and had a paddle shifter and starter. Meanwhile, initial petrol car was imported to the island in 1905.

In general, changes in the socio-economic environment have a direct impact on people's choices on vehicle ownership parameters such as the number of vehicles that household own, type of vehicles, as well as fuel type. Basically, the income level of consumers has risen in a few years, thus purchasing power has increased, and it is clear that the rate of car purchase has increased in recent years. Additionally, some other factors also influenced the choice of vehicle types and the number of owners. According to the literature, the number of family members, the number of men, the number of women, the number of driving licenses, the number of adult workers, the number of students and the number of non-workers is some of the key determining factors [1].

With the country's income increases, the demand for comfortable and quality transportation systems is increasing. However, public transportation systems have not improved to meet changing economic enhancement, which led to more people using private vehicles. Although macro and fiscal policy measures can use to temporarily limit vehicle imports to Sri Lanka, the quality and efficiency of public transportation systems are essential to be improved in the long run if this problem is to be resolved and the external imbalances caused by excess vehicles are to be reduced. Good and cost-effective public transportation systems will not only improve the trade balance, but also reduce congestion, pollution, and fuel waste. In addition, efficiency improvements will save this time, allowing individuals to set aside more time for productive and leisure activities.

New car registrations decreased 23.6% to 367,303 in 2019, compared to 480,799 vehicles registered in 20202 as per the central bank annual report 2019. A further reduction by 44.8% to 202,628, compared to new car registrations recorded in 2020.

Significant discounts were recorded for almost all vehicle classes in both 2019, and 2020 years. As a result, registrations of three-wheelers, cars, buses and freight vehicles decreased by 52.7%, 45.5%, 23.6%, and 44.3%, respectively in 2019. More significant vehicle registration reductions have occurred in 2020, whereas registrations of three-wheelers, cars, buses and freight vehicles decreased by 45.0%, 64.2%, 44.8%, and 24.5%, respectively. Policy measures taken by the central bank and the government in 2018 to reduce car imports led to a significant drop in car registrations in the first half of 2019. However, some of these restrictions, such as margin deposit requirements and restrictions on opening letters of credit (LC) have been lifted to import cars with soft permits in mid-2019, which led to a gradual increase in vehicle registrations in the second half of the year. These restrictions have been further extended in 2020 due to the pandemic situation which has been directly impacted the cash flow from and to the county.

However, in recent decades, the number of vehicles has increased dramatically in Sri Lanka. In addition, there has been a steady increase in the average number of vehicles per household and a steady increase in the proportion of families with access to more than one vehicle. It is vital to consider about the importance of vehicle ownership in transportation, land-use planning, and its relationship to energy consumption, the environment and health.

New registration of motor vehicles has varied significantly over the last decade due to the several reasons, government policies on imports and taxes, as well as due to the economic conditions of the country. It has shown that a significant drop in 2016 due to the increase in vehicle prices, and taxes and increased again in 2017 and 2018. Later, yet again dropped significantly in 2019 due to Easter attack and in 2020 due to the COVID pandemic outbreak. Consequently, road passenger transport has also performed poorly in public and private sector transport operations recently, mainly due to the reduction in passenger traffic after the Easter attacks. The total vehicle number of Sri Lanka as well as within Western province has grown steadily over the past decade, and the average of 25% vehicle population belong to the Western Province.

This research was carried out to understand the private vehicle ownership behaviour of Sri Lankan households, with the data obtained in the Western province. The outcome of this research signifies understanding future claimed vital policy settings to regulate the requirement of Sri Lankan households on private motorized vehicles. Similar research has been conducted in different countries for the same goal, in order to design effective policies to regulate family dependence on private motor vehicles. Significantly meritorious conclusions have been obtained in these studies, which explore the determinants affecting families of owning one, two or more cars. The most common determinants that have been recognized from studies in different countries are household income; the number of workers in the family, the profession of the head of the family and some other factors. Among the research reviewed, Kim & Kim (2004) developed the US-ranked test model and inferred variables such as number of drivers licensed, number of workers, income (record), household size (record), and stage of the household life cycle, connected to home car numbers.

Moreover, some research focused on the separate choice model of the family decision to own zero, one, two, three or more cars in Britain and revealed some variables that affect the number of cars in a HH such as market saturation, and license possession, household income and structure, domestic labor, company vehicle availability, purchase and use cost (Whelan, 2007).

Also, most research on car ownership explores the relationship between car choice and some other factors such as the environment and alternative cars. In addition, some research has revealed variables such as family demographics; characteristics of household location, characteristics of the built environment, characteristics of the household head, characteristics of vehicles that influence home vehicle ownership and use (Chandra et al., 2009) and other variables such as income, public transportation quality, and employment included in the number of cars per household modeling (Matas and Raymond, 2008). Furthermore, Potoglou & Kanaroglou (2008) considered variables such as family structure, socio-economic characteristics, and accessibility to the place of residence on the number of cars a HH owns.

All the above-discussed findings were used and evaluated when setting up appropriate variables that suit the Sri Lankan context against the available data under each category. Data used for the research explain under section 1.4, under the heading of the scope of the study.

1.2 Research Background

Currently, the major transportation problem associated with urban areas is traffic congestion. In fact, what happened is that most of the urban areas developed in an ad hoc manner without proper planning from the start and as a result mixed trade area mainly developed in the Colombo area. Even most of the popular public and private schools are also located in the heart of Colombo, which leads to massive traffic jams in the morning and mid-peak. Most importantly, most of the private and public institutes were central to the Colombo city area until the recent past when some government institutes moved to Battaramulla. Due to this resolute development model, the tourist attractions are concentrated in a small neighborhood and as a result, the main access roads are very crowded during the morning rush hour and also during the evening rush hour. Besides, poor rail services, railway access problems as well as railway quality, bus and other public road transport problems, road network problems are some of the problems that identified as major transportation issues in the western region.

Traffic control and management is a key aspect of any context that must be applied wisely and dynamically. However, due to the lack of technological progress, Sri Lanka lags far behind the developed countries in the context of traffic management. In order to deal with this enormous burden on the state, it is evident that a long-term solution is necessary to admire sustainable traffic management such as the introduction of efficient mass transit facilities, electrified railway networks, properly connected highway network, etc. Since all of these options are medium to long-term infrastructure projects, short-term traffic management strategies also to be incorporated. Control vehicle entrances to major city limits by accrediting and increasing parking fees within city limits, managing lanes and prioritizing mass transit options are some of the strategies that can be adopted.

However, to overcome these problems, the country's transportation specialists have developed various transport planning and demand modelling tools. There are different modelling methods, and they are evolving towards increasingly classified modelling techniques. With an activity-based modelling approach, information is needed at an individual level. One vital piece of information on an individual level is vehicle ownership. The first is the number of vehicles a person/household has, which have been done in previous studies. Thus, this study focuses on the selection of vehicle types once the number of vehicles is known. The result of this study gives some indications that can be used to determine in detail the direction of vehicle type choice by people so that it can be used as the key input to an activity-based modelling approach. Further, this can be taken into account the decision-making at the political level.

Accordingly, it is a vital idea to examine how people's choice vary on new vehicle purchases in the context of household socioeconomics characteristics which consider as the main objective of this research.

The main factors that are considered as socio-economic characteristics are the level of income, the number of families, the age of the user, the gender of the user, etc., the system of new tariff reforms of the annual tariff and the variable on the price of the car itself, fuel, insurance and other operational aspects and adjustment of user needs, such as improving the number of seats in the car , changing the way the car is operated, etc.

1.3 Research Objectives

1. Identifying possible vehicle ownership combinations and most relevant socioeconomic factors based on household survey data of the Western Province.
2. Developing a choice model to estimate a selection of a personal vehicle type for a household in the Western Province.

1.4 Scope of the Study

This research conducted using data from the 2013 Household Activity Survey and the Personal Travel Survey (Home Visit Survey) conducted by the Ministry of Transport and the Japan International Cooperation Agency for the Urban Transport Development Project for the Colombo Metropolitan Area and Suburbs. During the survey period, more than 35,000 personal data were obtained, which used to develop type of personal vehicle ownership model in this research. There are 40 Divisional Secretariats Divisions (DSD) in the Western Province. Thirteen DSDs in each Colombo and Gampaha districts and fourteen DSDs in Kaluthara district.

Table 1: Study areas (DSDs within Western province, Sri Lanka)

No.	District	DSDs		
01	Colombo	1. Colombo 2. Dehiwala 3. Homagama 4. Kaduwela 5. Kesbewa	6. Kolonnawa 7. Kotte 8. Maharagama 9. Moratuwa 10. Padukka	11. Rathmalana 12. Hanwella (Seethawaka) 13. Thimbirigasyaya
02	Gampaha	1. Attanagalla 2. Biyagama 3. Divulapitiya 4. Dompe 5. Gampaha	6. Ja-Ela 7. Katana 8. Kelaniya 9. Mahara	10. Minuwangoda 11. Mirigama 12. Negombo 13. Wattaa
03	Kaluthara	1. Agalawatta 2. Bandaragama 3. Beruwala 4. Bulathsinhala 5. Dodangoda	6. Horana 7. Ingiriya 8. Kalutara 9. Madurawela 10. Mathugama	11. Millaniya 12. Palindanuwara 13. Panadura 14. Walallavita

During the Home Visit Survey (HVS), the survey team collects the most recent information about residents' travel activities as well as socioeconomic information about families and individuals by visiting households in the study area. This was the first time that a comprehensive and large-scale survey of HVS transmission had been conducted in Sri Lanka. Given survey coverage and HVS survey sample size covering the entire western province, comprising all three districts, comprising 2,496 total GN divisions.

1.4.1 Survey coverage and sample size

Originally, the target sampling rate was set at 3.0% of the population of the survey area and the sample size was estimated to be approximately 44,000 households. This figure was calculated from the population and average family size published in the preliminary report of the 2012 Population and Housing Census and the 2009 Household Income and Expenditure Survey, respectively.

Table 2: Estimation of Target Sample Size

Category	Colombo District	Gampaha District	Kalutara District	Total
Population*1	2,309,809	2,294,641	1,217,260	5,821,710
Sampling rate	3%	3%	3%	3%
Average household size*2	4.0	4.0	4.0	4.0
Approx. households to be surveyed	17,500	17,300	9,200	44,000

Source: Technical Report No. 4; Urban Structure and Socio-economic Framework, CoMTrans Study

1.4.2 Sampling Method

To obtain a representative sample of households, samples of households were drawn randomly from the lists of addresses available in the survey area during which care was taken to ensure an equitable spatial distribution of the sample over the entire survey area.

During the preparation phase of the survey, several lists of addresses were obtained from different institutions to select the sampled households. After evaluating and immediately verifying the addresses received from these sources, it was decided to use the " Election Registration List 2011" provided by the Elections Department. This decision was made with three main advantages in mind, the availability of the names of family members aged 18 or over allows checking whether the surveyor is doing their job properly, sufficient address details to determine which GN department they belong to and their availability, latest list from 2011.

Vehicle ownership is a huge field involved in two different choices that people make, specifically, choosing the number of vehicles and then choosing the type of vehicle. Among them, a choice model for selecting the number of vehicles in the western province was developed as undergraduate research. Therefore, this research examines how a person chooses the type of vehicle and not the number of vehicles.

1.5 Thesis outline

The thesis contains six chapters and one appendix.

Chapter 1, the present chapter, provides an overview of the research area, objectives and the summary of the methodology adopted.

Chapter 2 presents the literature review providing an overview of previous work conducted in the research area related to aspects of personal vehicle type choice decisions and concepts of choice modelling.

Chapter 3 explains the detailed methodology adopted in the research

Chapter 4 analyses the household survey dataset used in this research and presents the model development approach based on the results of the primary data analysis, which associate with the first research objective.

Chapter 5 explains the development of the personal vehicle type choice model, which associate with the second research objective.

Chapter 6 summarizes the conclusions outlined from the research and lists down recommendations for future research area enrichment.

2 LITERATURE REVIEW

New registration of motor vehicles has varied significantly over the last decade due to the several reasons, government policies on imports and taxes, as well as due to the economic conditions of the country. According to the new vehicle registration statistics, there was a significant drop in 2016 due to the increase in vehicle prices, and taxes as shown in Figure 1. However, new vehicle registrations have increased again in 2017 and 2018. The situation has changed adversely due to Easter attack in 2019, where number of vehicle registration has dropped to 367,303 from 480,829, which has been recorded in 2019 [2]. COVID pandemic outbreak in 2020& 2021, which has led to reducing the number of vehicle registrations, where in 2020, new vehicle registration has dropped significantly by 44.8% to 164,675 new vehicle registrations.

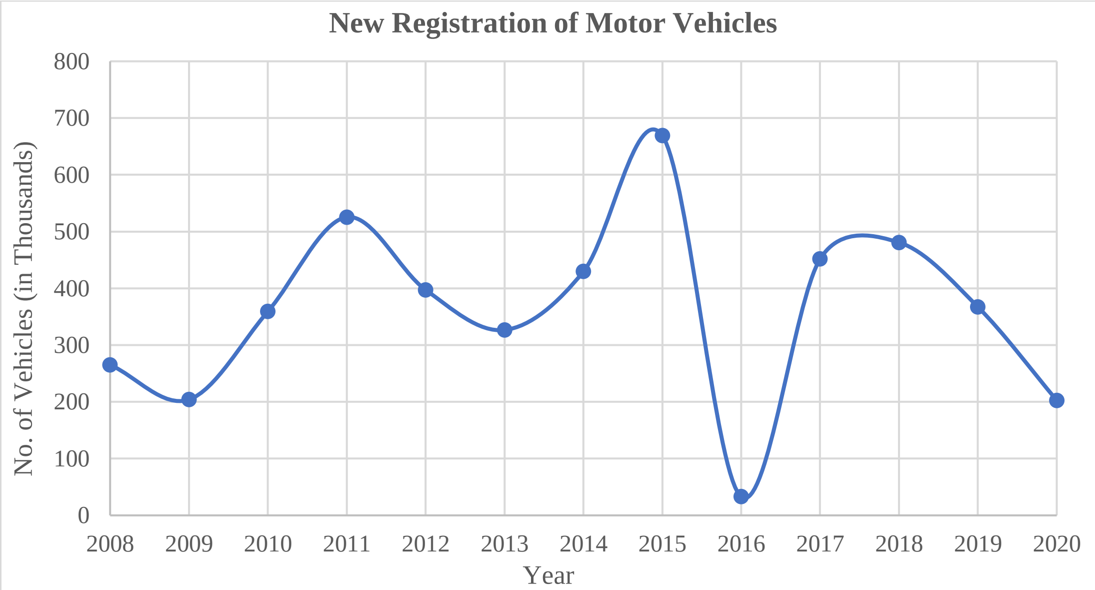


Figure 1: New registration of motor vehicles

Consequently, road passenger transport has performed poorly in public and private sector transport operations recently, mainly due to the reduction in passenger traffic after the Easter attacks. As a result, the total mileage travelled by SLTB buses fell 3.4% to 431.3 million kilometres meanwhile total passenger mileage registered a significant drop of 22.7% to 12 billion kilometres compared to the previous year [2]. Meanwhile, operational mileage and the number of private buses decreased by 2.3% to 1.1 billion kilometres and 2.2% to 54.2 billion kilometres respectively compared to 2018. This mass transport demand reduction in recent years due to Easter attaches and

COVID pandemic outbreak since early 2020 provides a potential tendency in increasing private vehicle ownership. Hence, additional private vehicle purchases increase drastically can be expected considering safety and security. The research outcome is vital to identify future vehicle purchases based on the vehicle type, hence required policy settings and economic decisions inclusive of tax reforms to be set up or adjusted accordingly.

Total vehicle population over the last decade has gradually increased notwithstanding slight drops in-between in new vehicle registrations shown in Figure 2. Meantime, the vehicle population in the Western province also gradually increased despite a small contraction in the year 2017. Accordingly, an average of 25% out of the total vehicle population of Sri Lanka belongs to Western province.

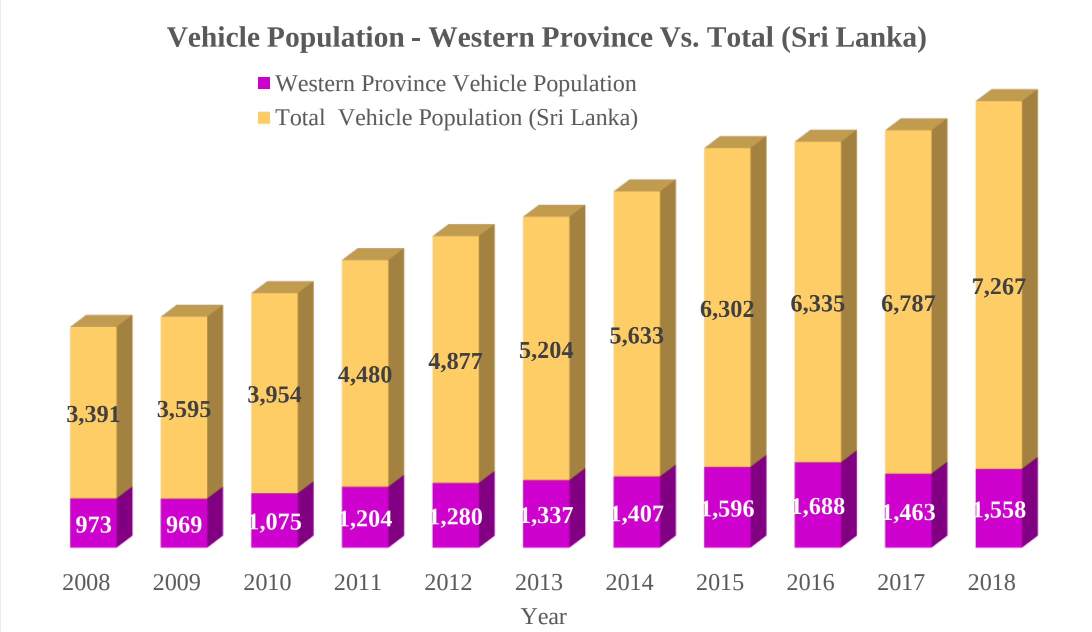


Figure 2: Total motor vehicles population

California state-wide travel demand model, version 2.0 [3] is a technical note that provides more details on vehicle ownership modelling associated with this research. This technical note is the first in a series of three technical notes outlining the Personal Short Distance Travel Form component of Version 20 of the updated state-wide travel application form. (Cambridge, 2014)

In it, they have concentrated for the chapter entitled " Household auto ownership models " within the long-term decision models is closely related to this research.

Household auto availability is a main department of its trip making behaviour. And this is quite important for travel demand forecasting as well. Driving license holdings and the number of drivers in a household are directly related to the house hold's choice of auto ownership model.

Auto ownership model foresees the number of vehicles owned by each hous4ehold as a function of number of household drivers, composition, and income, as well as accessibility measures to work, school and other activities. To realize the choice behaviour for each household a multinomial logit model structure is applied. It yields the probabilities of having a certain number of vehicles owned by household. Here as choice alternatives, it is selected the number of autos in each household. The multinomial logit model for auto ownership choice model has the following form:

$$p(i) = \frac{exp\ (Vi)}{\sum_{j=0}^{5} exp\ (Vj)}$$

Equation 1

where:

i, j = 0,1,2,3,4,5= available choice alternative.

P (i) = probability of each alternative to be chosen; and

V_i= Utility associated with each alternative

The model was estimated by the application of the ALOGIT package with combined household interview survey data from the combined travel behaviour data set. During model estimation, a series of model specifications were performed on the estimation dataset. The variables and their forms ultimately retained in the model were based on how well the estimated coefficients confirmed expectations about their relative signs and magnitudes and their accessibility parameters of the demographic logarithmic sum and the high probability of disaggregation of car ownership. [4]

Dash et al [4] conducted research with the aim of recognizing the factors influencing the private vehicle ownership model of Indian households and building models to measure the effect of different factors on vehicle ownership. Due to differences in socioeconomic and demographic factors, two separate models are offered, one for urban and rural areas. It is speculated that due to the huge differences in lifestyle, economic activities and requirements, the factors affecting vehicle ownership in urban and rural areas could be different. By developing two distinct models, it is possible to compare vehicle ownership models in urban and rural areas.

Rather than an explanatory variable that established the main explanatory variable to be used for the development of a vehicle ownership model unbundled for all of India, other explanatory variables that can be used to develop the model from the information provided by the ONSS (in India, ONSS conducts annual surveys to collect data on spending if Indian households) around 68 data sets have been identified. Information on potential variables that can be used to develop such a model in the Indian context presented by Dash et al [7] is discussed as follows: family size, regular salary, presence of children, presence of young adults and presence of people 60.

The comparison of vehicle ownership model [5] of Delf University of Technology have suggested that MNL is the preferred model structure for household car ownership among the Ordered Response Models and Unordered Response Models. The research has further divided discrete choice modelling structure as ordered logit (ORL)/ ordered probit (ORP) models and multinomial logit (MNL)/ multinomial probit models (MNP). The study has done as an empirical study though, had used three databases Baltimore (2001 data), Dutch (2005 data) and Japanese (2005 data).

Potoglouet al [5] presented that the purposes of their research is to find out whether the unordered response model (multinomial logit model) is better than the Ordered models. The researcher has used an empirical survey to analyse the research question. In this empirical study, the researcher highlighted that if, the number of vehicles of the family n - denoted by (Yn) - derives from a latent dimensional index, as follows Y * y. The propensity of a household to own a vehicle, k is a set of parameters to be estimated associated with a set of k explanatory variables (Xnk). The distribution of the error terms explains the variation between the ordered logit and ordered probit models [5].

$$Y_n^*(z) = \sum_{n=1}^{k} \beta_k X_{nk} + \varepsilon_n$$

Equation 2propensity of a household to own vehicles

Source: [5]

It is assumed that the number of cars is related to the latent ownership index of the car is given in equation 02. In the previous equation, using the familiar probability (n) and (i) of the number of cars we obtain the standard accumulation of normal distribution. By substituting the Gumbel distribution (Λ) into the standard cumulative normal distribution (Φ), it can use an ordered logical model. But when the model changes the ownership levels of the car, the ordered response mechanism is no longer able to provide an adequate response.

$$[P_n[y = i] = P_n = \Phi(\mu_i - \beta X_n) - \Phi(\mu_{i-1} - \beta X_n)]$$

Equation 3 probability of household n to own i number of cars

Source: [5]

In MNL or MNP unordered response models, the random utility maximization framework states that Ui, n represents the utility of a family n that owns the number of cars, βi, n is a vector of parameters to be estimated and εi , n is the random component that takes unobserved utility or uncertainty from the viewer's point of view.

$$U_{i,n} = \beta_{i,n} X_n + \varepsilon_{i,n}$$

Equation 4 Utility

Source: [5]

Here the error term εi, n is distributed identically and independently and the probability of possessing a certain number of cars i in the form of MNL is given in equation 01.

Independence of irrelevant alternative property (IIA) implies that the probability ratio of two alternatives is independent of any other available alternatives. The unordered model, MNL has this undesirable property. Compared to MNL, the MNP model is more flexible because it reduces the impact of the IIA hypothesis of IID errors (distributed identically and independently). The MNP model contains problems such as the proliferation of random effects and parameters. The conclusion of this study explains that among the ordered models and the unordered models, the unordered models, i.e. the MLN model, provide a strong behavioral framework and flexibility, therefore they refer to the preferred model structure for domestic car ownership. A discrete choice model of Tehran's family car choice behavior aimed at developing a discrete choice model to explore the relationship between common factors and family mode choice behavior. The researcher used market-specific factors such as critical consumer expectations, critical car characteristics, sales method and preferred brand. The researchers also took into account typical demographic factors, such as the user's age, gender, marital status, and income level. Multinomial logit and nested logit models were used to explore customer choices for critical integrated decision making of the target population in Tehran. The data was extracted via mail-out and mail-back from 681 families living in Tehran in 2006 [6].

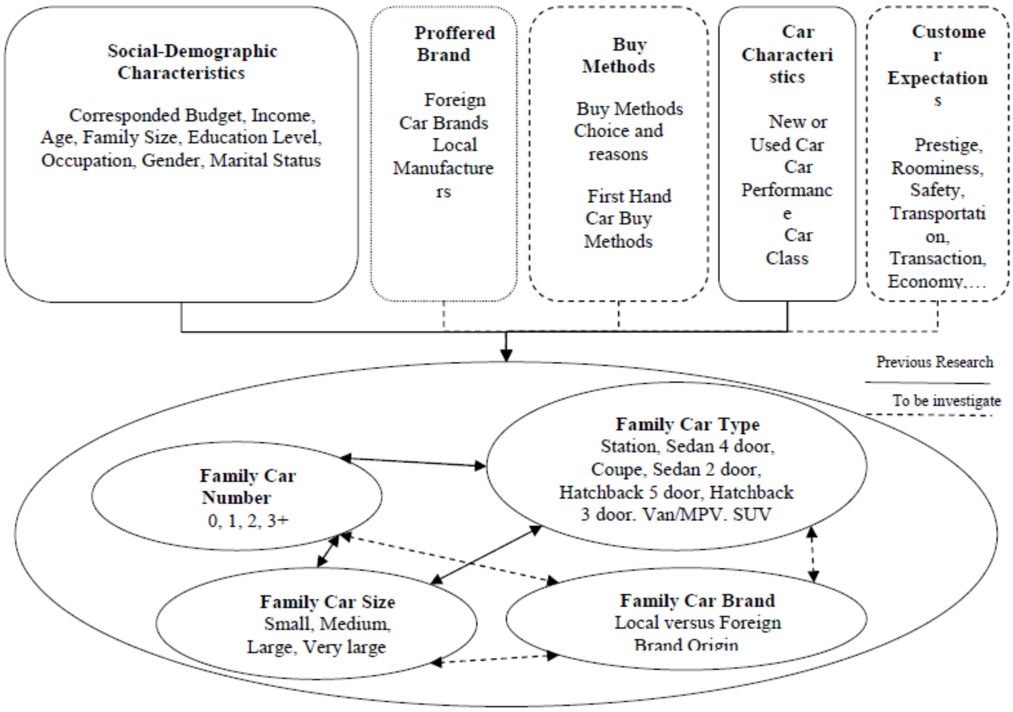


Figure 3: Conceptual framework

Source: [6]

The researcher's conceptual framework of family car choice and corresponding variables includes the results of the desk-based survey as well as the variables that the researcher intends to test during this modeling. Variables from previous studies are represented by lines, and variables that are below the survey level are represented by scattered lines. The study developed a discrete choice model with a multinomial logit model and a nested logit model for family car decision to estimate the combined effect of the main variables of each car choice. The study also shows that within each class of variables there are some variables that have a significant impact on the modeling of car choice compared to the rest of the variables in the same cluster. Empirical study factors, such as critical consumer expectations, critical car characteristics, sales methods, preferred brand origin, family characteristics variables were highlighted as an important factor in this survey.

In 2016 a study of the piecewise linear multinomial logit model of the ownership behavior of private vehicles of Indian families was conducted. Although India is one of the most populous countries in the world, the availability of empirical studies in the area of vehicle ownership decision making has been limited. Due to the lack of research conducted in the areas of the disaggregated vehicle ownership model, the researcher should rely on the research on the disaggregated vehicle ownership model that has been conducted in developed countries as a guideline for the study.

The multinomial logit model presented in the empirical survey was taken as the base model in this survey. The first step of the study was to highlight the importance and advantages of disaggregating vehicle ownership models versus aggregated models. The disaggregated model of domestic vehicle ownership behavior with multiple explanatory variables in the Indian configuration has not been discovered in the contemporary literature.

The socio-economic and ownership information of the private vehicles used in the research was obtained from the secondary database, while no information on the number of vehicles owned by the household was recorded. The data on consumption expenditure of the NSSO (National Sample Survey Office) were used by the researcher to design a proxy variable corresponding to the economic level of households and was called Annual Per Capita Regular Expenditure (APCRE). The study classifies ordinary expenses as.

Regular expenditure = total expenditure – (bedding + education + medical (institutional) + durable goods

$$\text{Regular expenditure} = \text{total expenditure} - \sum(\text{bedding} + \text{education} + \text{medical} + \text{durable goods})$$

Equation 5: Regular expenditure definition

Source: [7]

The explanatory variables used in the MNL model is as follows.

1. APCRE
2. Household size.
3. Rural/urban location of residence
4. Regular salaried member
5. Children
6. Youngsters
7. Seniors

The segmented MNL model: Vehicle ownership behavior in the vehicle purchase decision making process of wealthier Indian households may not be affected by rising economic status. The researcher explained that in this context, the other factors could be more influential on their decisions. To analyse this hypothesis, households were classified into two categories: the high-spending group and the modest-spending group.

The Simulation Test: the researcher has used MATLAB version 7.10 for the analysing of this I traditions in the simulation study. Each and every iteration has been used to predict the choices generated by the various alternatives calculated by the model.

3 METHODOLOGY

3.1 Methodology Approach

The literature review was carried out to identify concepts of choice modelling while understanding the previous research methodologies, which used to find the personal vehicle type choice models in other countries. Relevant socio-economic factors were analyzed based on Home Visit Survey data, and current personally used vehicle type ownership distribution was derived using the same data set.

The personal vehicle type choice model was developed by determining the choice model structure and estimating the choice models using the "Alogit" module. Figure 4 presents the summary view of the adopted research methodology.

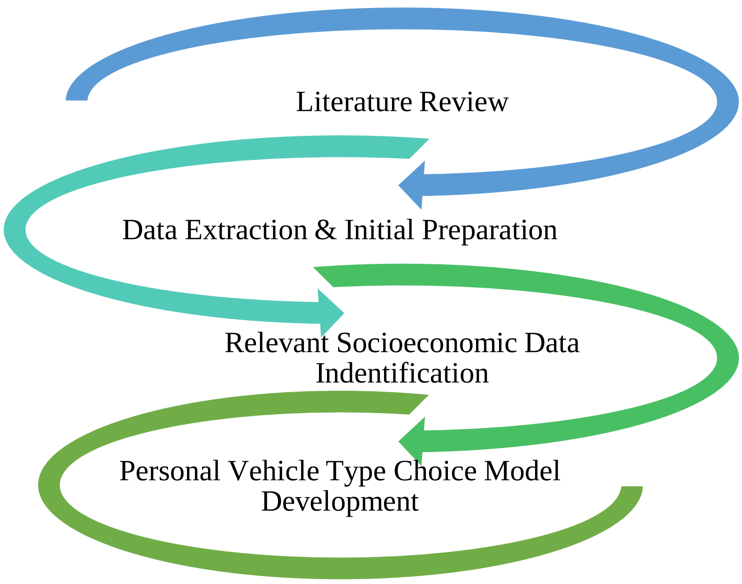


Figure 4: Summary of methodology

According to the results of the literature review, car ownership analysis models can be distinguished into two types: disaggregated and aggregated. Disaggregated models focus on the family level; while aggregate models reflect car ownership as an aggregation of family decisions at different geographical intervals such as traffic analysis area, regional levels, etc. Furthermore, disaggregated models predominate over aggregate models, mainly due to their behavioral structure and better ability to distinguish general relationships [8]. Furthermore, the disaggregated models have overcome the shortcomings and constraints of the aggregated models. Furthermore, the extensive use of disaggregated models prevails in their tendency to conduct policy-sensitive investigations and their compatibility with up-to-date agent-based approaches in transport modelling [9].

Empirical studies of domestic car ownership have used two types of discrete choice modelling structures, ordered and unordered. In ordered structures such as ordered logit and ordered probit, the choice of the number of vehicles in a family is derived from a one-dimensional latent index that reflects a family's tendency to own vehicles. On the other hand, unordered response models are based on the principle of random utility maximization, in which a family associates the utility value with different levels of vehicle ownership and prefers the value with the maximum benefits [5]. Following the previous research results cited in the literature, the multinomial logit model is chosen to conduct this research.

3.2 Data Collection

The relevant data required for this research was obtained from a person trip survey (home visit survey) conducted by the Ministry of Transport and the Japan International Cooperation Agency from November 2012 to February 2013 in the Western Province of Sri Lanka for the Urban Transport Development Project. There are more than 35,000 data about people living in the western province collected through this household survey. This data collection includes general information on basic information for family members, vehicle ownership in each household, and additional information on members. All this data in the access database and all survey data are interpreted according to the table. For this search, related data is filtered by running queries on the Access database.

3.3 Primary Data Analysis

Using the Microsoft Access database file, the required data from the survey data has been filtered and placed in an appropriate table. With reference to previous research papers and articles on car ownership modelling and the type of household car ownership modelling, the attributes most relevant to this study were selected. As a result, some important features have been selected and the context for each feature is described in the section of Data Analysis and Findings.

As per the primary data analysis, vehicle ownership details were analysed based on the number of vehicles owned by each HHs, which realised that out of 35,850 HHs considered, the number of vehicles owned by each HHs varied between 0 to 6. However, when considering the HHs with 1 vehicle, 2 vehicles and so forth, the sample size is gradually declining from 1 to 6. Accordingly, in this research vehicle ownership was categorized into mainly three categories, HHs with 1 vehicle, HHs with 2 vehicles and HHs with 3 or more vehicles. Therefore, this data was used as the main infusion.

3.4 Modelling

The choice model for personal vehicle type ownership in the Western province was developed using Alogit software.

3.5 Mathematical Application

Choice modelling is a powerful analytical method that uses the estimation of the probability that individuals make a particular choice among the alternatives presented. Choice modelling is also known as joint modelling, discrete choice analysis, and conditional logistic regression.

In disaggregated behavioural modelling, perspective is the choice made by individual travellers. Travel behaviour can be viewed as a range of different types of choices made by individuals, such as choosing a place of residence, choosing a workplace, choosing a travel destination, choosing a travel time, etc. The general idea of modelling an individual's likelihood of choosing a given alternative is a function of the individual's socioeconomic characteristics and the relative attractiveness of the alternative. The attraction of the alternative is represented by the concept of utility. It is a numerical measure of the attractiveness that an individual associates with an alternative.

$$U\ (a, i) = f\{\mathrm{X(a)}, \mathrm{C(i)}\ , \mathrm{K}\ \}$$

Equation 6: (Utility Function)

Were

U (a, i) = utility individual I associates with Alternative a

X(a) = vector of numeric measures of attributes of alternative a

C(i) = vector of numeric measures of characteristics of individual I

K = vector of utility function parameter

The key hypothesis in the choice modelling is that "the individual will always choose the alternative that satisfies him/her the most" this assumption is called the theory of rational choice behaviours. In mathematical terms the theory of rational choice behaviour becomes the rule that the individual always chooses the alternative with the highest utility, as human behaviour is exceedingly complex, it's not possible to write out into a formula describing it directly. So, this leads to the assumption that there are two components to utility as measurable component and error component.

$$U\ (a, i) = V(a, i)\ + E\ (\ a, i)$$

Equation 7: (Equation 03)

Were

$V_{(a, i)}$ = the measurable component of the utility individual I associates with alternative a

$E_{(a, i)}$ = the error component of the utility individual I associates with alternative a

4 DATA ANALYSIS AND FINDINGS

4.1 Primary Data Analysis

Of the 35,806 households considered, 16,489 households owned at least one vehicle, which represented about 46% of households in the Western Province that owned at least one vehicle as shown in Table 3. However, of these, about 80% of households belong to one vehicle and about 17.4% of households belong to two vehicles out of at least one vehicle own households. As a result, only 2.75% of households own 3 or more cars.

Table 3: Vehicle ownership statistics summary

Number of Vehicles at per Household	Number of Households	Cumulative of Number of HHs	%	Cumulative %
6	1	1	0.003	0.003
5	16	17	0.045	0.048
4	61	78	0.170	0.218
3	374	452	1.045	1.263
2	2,876	3,328	8.032	9.295
1	13,161	16,489	36.756	46.051
0	19,317	35,806	53.949	100
Total	**35,806**		**100%**	

Source: CoMTrans HHS database

4.1.1 Household income

During the data collection, income data has been captured under the predefined income categories as shown in Table 4. For this analysis, the average income of each range is considered.

Table 4: Income ranges used for data collection in the HHs

No.	Income Range	Low	High	Average
1	Less than Rs. 40,000	0	40,000	**20,000**
2	Rs.40,000 – Rs.79,999	40,000	80,000	**60,000**
3	Rs.80,000 – Rs.119,999	80,000	120,000	**100,000**
4	Rs.120,000 – Rs.159,999	120,000	160,000	**140,000**
5	Rs. 160,000 – Rs.199,999	160,000	200,000	**180,000**
6	Rs. 200,000 – Rs. 299,999	200,000	300,000	**250,000**
7	Rs. 300,000 – Rs. 399,999	300,000	400,000	**350,000**
8	Rs. 400,000 and above	400,000	500,000	**450,000**

According to the income ranges, vehicle ownership statistics has been analysed in order to identify whether there is a relationship between household income and the number of vehicles owned by households.

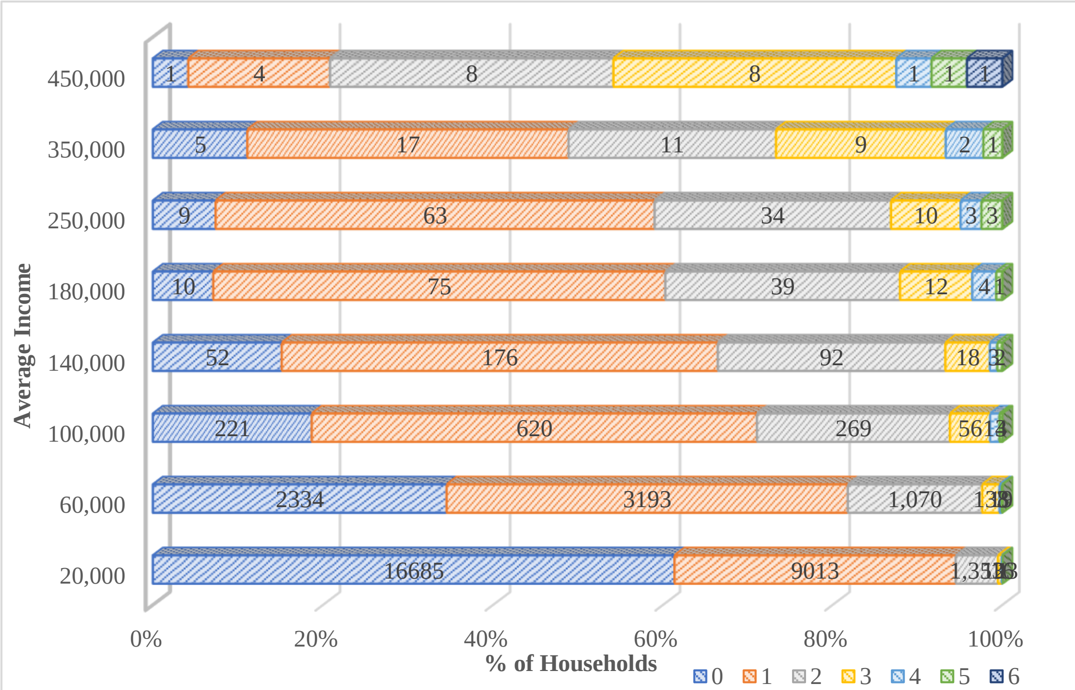


Figure 5: Vehicle ownership in relation to average income

As per the statistics, there is a correlation between household income level and vehicle ownership statistics. Thus, it is observed that more than 60% of the families with an average income of less than Rs 20,000 do not own a car, and more than 30% of them own only one car. Besides, it is noted that the statistics regarding the ownership of zero cars gradually decrease according to the income group. Thus, only one household at least without one car is observed in the higher income category where the average income exceeds Rs 450,000. Moreover, there is only one household with six vehicles in the database which belongs to the higher income group.

The income range of the respondents who own at least one car examined further, to determine whether there is an accurate relationship between the level of income and the type of car ownership under corresponding income categories as shown in Table 5. Thus, more than 60% of the respondents belong to the income category of less than Rs 20,000, but only less than 40% of them own at least one vehicle. Also, about 27% belong to the income group between 20,000 and 39,999 with a round of 65% of vehicle ownership. Likewise, the number of households under each income category is reduced with the increase of income range while vehicle ownership percentage is gradually increased as shown in Figure 6. Accordingly, the upper income range has more than 95% of vehicle ownership range.

Table 5: Income distribution of respondents own at least one vehicle

No.	Income Range (Rs.)	Number of Total Households	Households with at least one vehicle	Vehicle Ownership %
1	Less than 40,000	27,191	10,506	38.64%
2	40,000 –79,999	6,757	4,423	65.46%
3	80,000 –119,999	1,183	962	81.32%
4	120,000 –159,999	343	291	84.84%
5	160,000 – 199,999	141	131	92.91%
6	200,000 –299,999	122	113	92.62%
7	300,000 –399,999	45	40	88.89%
8	400,000 and above	24	23	95.83%
Total		**35,806**	**16,489**	**100**

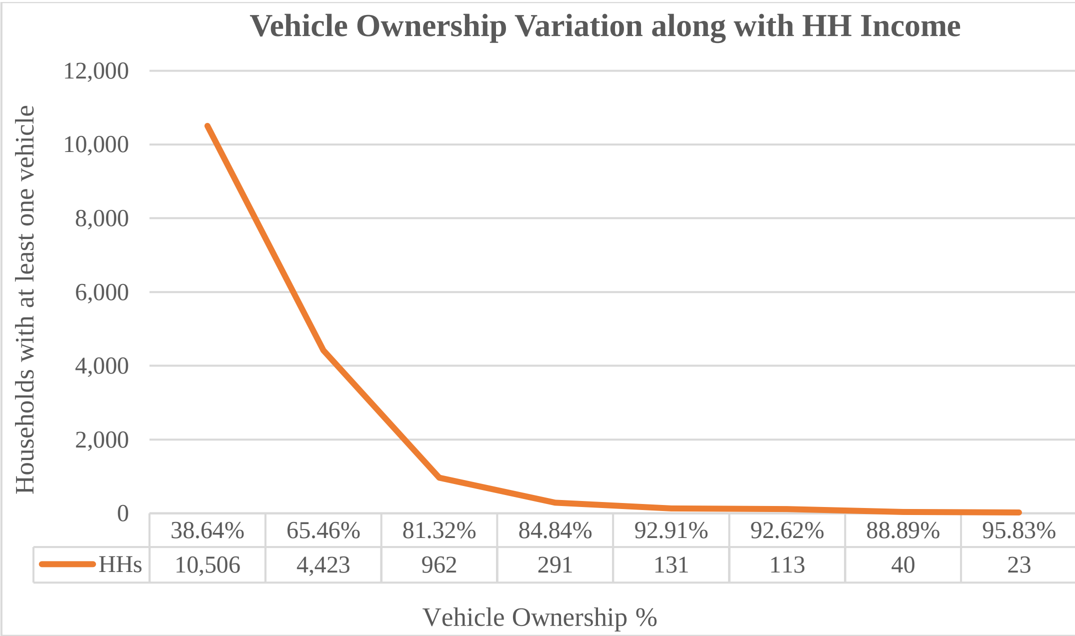


Figure 6: Vehicle ownership variation along with HH income

In general, for a macro-level analysis, income is considered under three categories: high-income, middle-income, and low-income households. Therefore, the analysis is expanded to include three income groups, as shown in Table 6, which include the three income segments considered for high, middle, and low-income groups. As a result, about 64% of the vehicles fall into the low-income category, so there may be a direct impact on the type of vehicle owned and household income. Therefore, the relationship to be further examined under the objective of this research.

Table 6: Vehicle ownership statistics under income categories

Income		Number of Vehicles Own by Households						Count	%
Group ID	***Range (Rs.)***	***1***	***2***	***3***	***4***	***5***	***6***		
A – High Income	>80,001	955	453	113	26	12	1	1,560	9.46
B – Medium Income	40,001-80,000	3,193	1,070	138	19	3	0	4,423	26.82
C – Low Income	0-40,000	9,013	1,353	123	16	1	0	10,506	63.72
Total		**13,162**	**2,878**	**377**	**65**	**21**	**7**	**16,489**	**100.0**

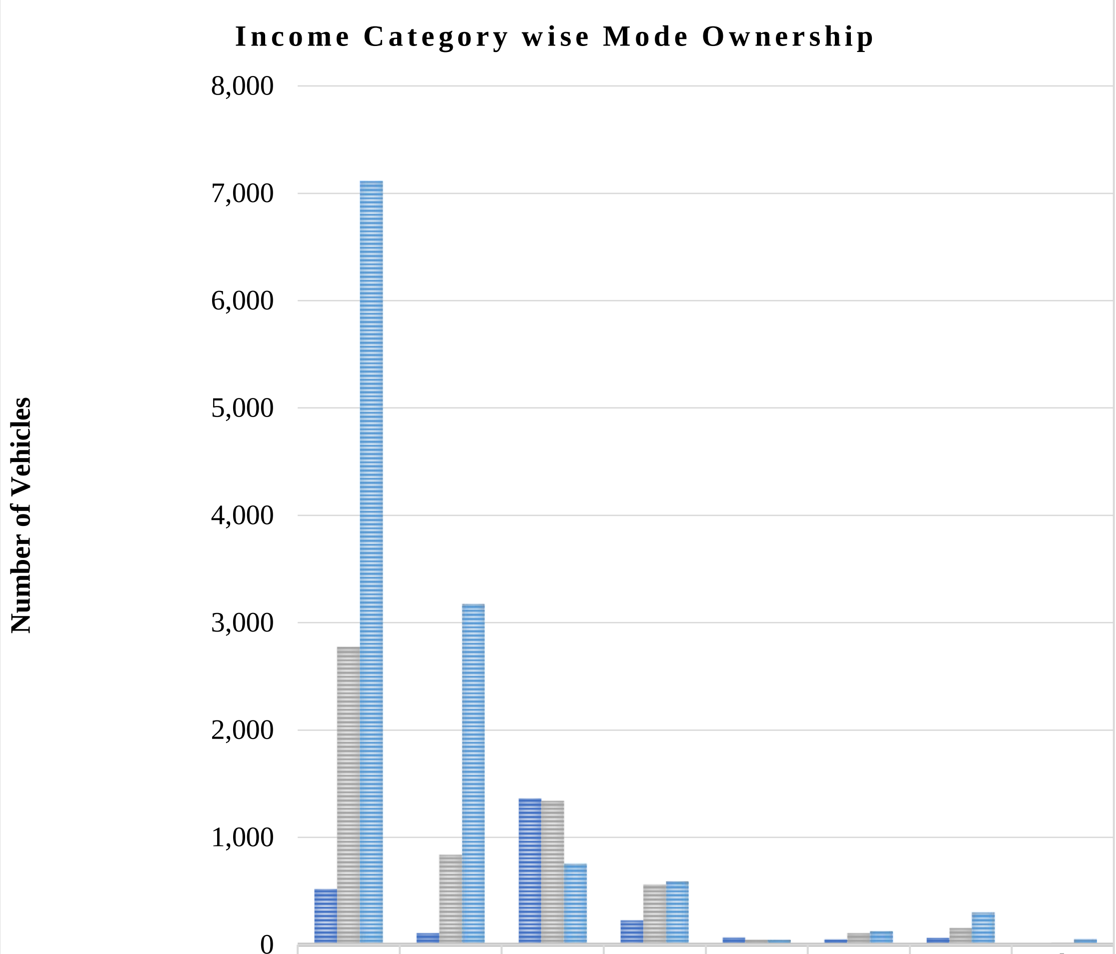
4.1.2 Vehicle types

Of the 16,489 households, that considered as at least one vehicle owns, there are altogether 20,365 vehicles according to the data collected in the Western province as shown in Table 7. Accordingly, more than 50% of the vehicle composition belongs to Motorcycles along with another 20% belongs to three-wheelers. Further, 25% of vehicle composition belongs to personal vehicles used for private purposes including cars, jeeps, vans, and pickups. Rest is account just 4.23% from total vehicle composition including trucks.

Table 7: Vehicle ownership by vehicle type

Original Mode Number in the Database	Mode Description	Total	%
1	Motorbike	10,405	51.09
2	Three-wheelers	4,118	20.22
3	Car / Jeep	3,455	16.97
4	Van	1,374	6.75
5	Pickup	151	0.74
6	Truck	278	1.37
7	Other	516	2.53
9	Unknown	68	0.33
Total		**20,365**	**100.00**

The above total number of vehicles for each mode is examined in more detail under three income groups, as shown in Table 6. As a result, about 70% of motorcycles belong to households with the low-income while more than 75% of the three-wheelers also belong to the same category as shown in Figure 7. These two modes give a clear picture of the choice of people's determinations concerning household income where the cost of a vehicle is a vital fact about deciding the type of vehicle. This trend turns into the opposite direction when it comes to the car/jeep and pickup (single / double cab) categories, where car ownership is higher among households belonging to the higher income group while the car ownership is lower in low-income households. However, again, van, truck and other vehicle ownership are higher among households belonging to the low-income group which related to the transportation of goods.



Modes	MB	3W	Car / Jeep	Van	Pickup	Truck	Other	Unknown
A [High Income]	518	106	1,362	225	64	46	62	4
B [Medium Income]	2,775	837	1,339	559	44	107	154	14
C [Low Income]	7,112	3,175	754	590	43	125	300	50

Figure 7:Vehicle ownership statistics under income categories by vehicle type

Based on the additional details provided by the respondents regarding the fuel type for the 20,365 vehicles identified, the responses are summarized in Table 8. As a result, more than 85% of the vehicles are gasoline-powered vehicles while another 13% is diesel-powered. However, due to the preparation of this database based on the details obtained in 2012, the use of hybrid and electric vehicles in Sri Lanka was low and hence, these percentages may have changed at this time, so a survey sample is necessary to update the most recent details. Therefore, a further study on the vehicle type selection tendency versus the fuel type to be studied as an expanded area of this research.

Table 8: Fuel types of vehicles

Vehicle Type	Fuel Types						
	Petrol	**Diesel**	**Hybrid**	**Electricity**	**Gas (LPG, LNG etc.)**	**Other**	**Total**
1. Motorcycle	10,121	79	6	4	1	2	10,213
2. Three-wheeler	3,797	251	1	1	1	0	4,051
3. Car / Jeep	2,845	511	37	2	2	0	3,397
4. Van	316	1,029	3	4	2	0	1,354
5. Pick up	25	124	0	0	0	0	149
6. Truck	40	234	1	0	0	0	275
7. Other	46	394	0	0	0	4	444
Grand Total	**17,190**	**2,622**	**48**	**11**	**6**	**6**	**19,883**

Accordingly, original modes considered for the data collection summarize into four groups as shown in respecting the purpose of the research in order to identify the people's mode choice behaviour related to the vehicle type and to identify the tendency of choosing vehicle type when going to purchase a new vehicle to their household. At the same time, vehicle type grouping is done considering the available data percentage as small data groups are merged with most suitable vehicle types such as pickups are joined to car category considering the small number of respondents.

Table 9: Modes considered in the data collection

No.	Mode	Modes as per the Data Collection
1	Car	Car / Jeep [3], Van [4], Pick up (Single / Double Cap) [5]
2	Motorcycle	Motorcycle [1]
3	Three-wheeler	Three-wheeler [2]
4	Other	Truck [6], Other [7], Unknown [9]

When considering three-wheelers, there are two types as privately used and hired. As per the data collection, it was considered three-wheelers as one mode without considering its use. However, as this research is focusing on the personal vehicle types, it is vital to segregate three-wheelers by its use. Therefore, in this research trip information captured during the survey under form 3 (see section 3.1) is further examined to have an idea on its composition. They're up to three transfers are considered shown in Figure 8.

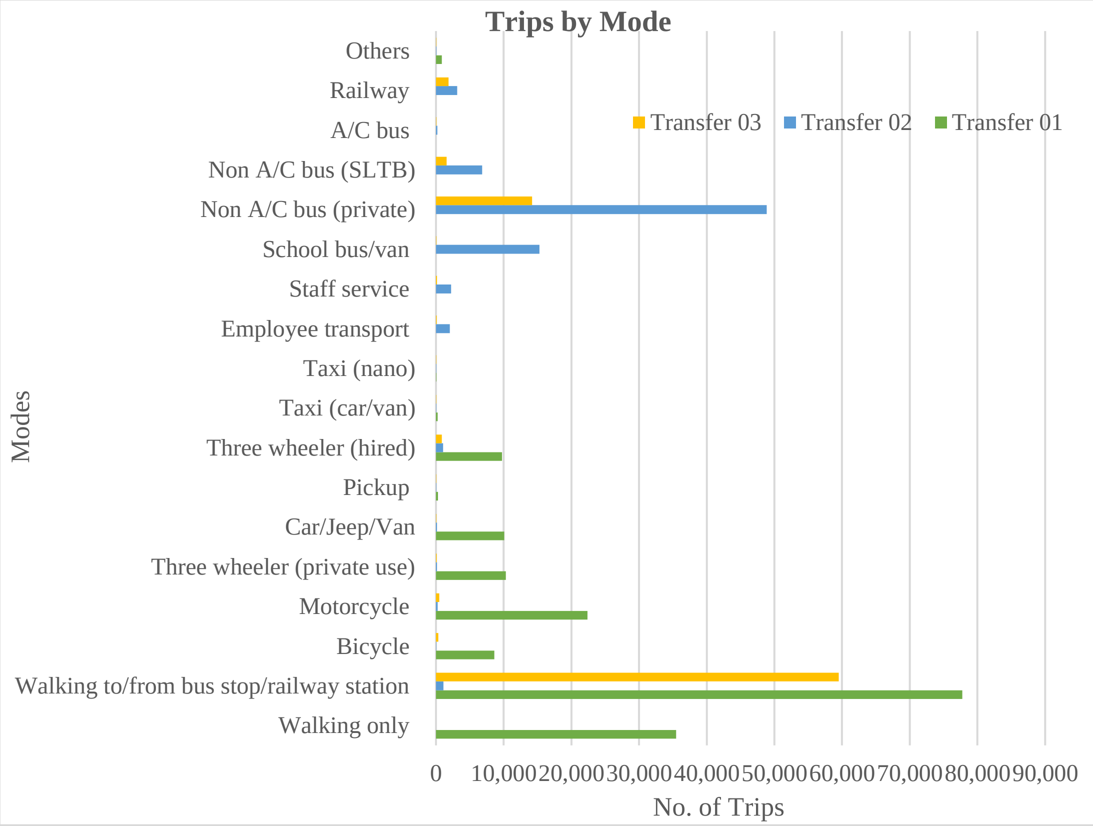


Figure 8: Trips made by household members by mode up to 3 transfers

Regarding the first transfer, about 51% of the three-wheeler transfers were made by three-wheelers for private use as the remaining 49% were using hired three-wheelers. This combination is significantly changed if the second and third transfers were considered, since more than 85% of the transfers were made by hired three-wheelers. Therefore, in this research, 50% of three-wheel vehicle ownership was eliminated at the development stage of the personal vehicle type model. Based on the analysis of trip information, it is assumed that out of a total of three wheels ownership, half of all of it is used as an aid to the family's income, and not as a means of personal use.

4.1.3 Gender and age distribution of household members

According to the literature, it has been observed that the needs of men and women for motorcycles and cars use have the same share. However, due to the cultural influence, women are less likely to use a car in Asian countries particularly in South Asia, but more to use motorcycles, especially in rural areas. However, due to the busy schedules of urban lifestyle, women have started to use vehicles for the intra household interaction, which also affects departure time and mode choice to commute in the morning. On choosing a mode of transport, however, due to the safety factors associated with the urban road network, there is a greater tendency to use cars despite the simplicity of the motorcycle which allows for great diversity concerning the transportation patterns of many family members. Therefore, gender and age composition are considered against the household vehicle ownership statistics as shown in Figure 9 and Figure 10.

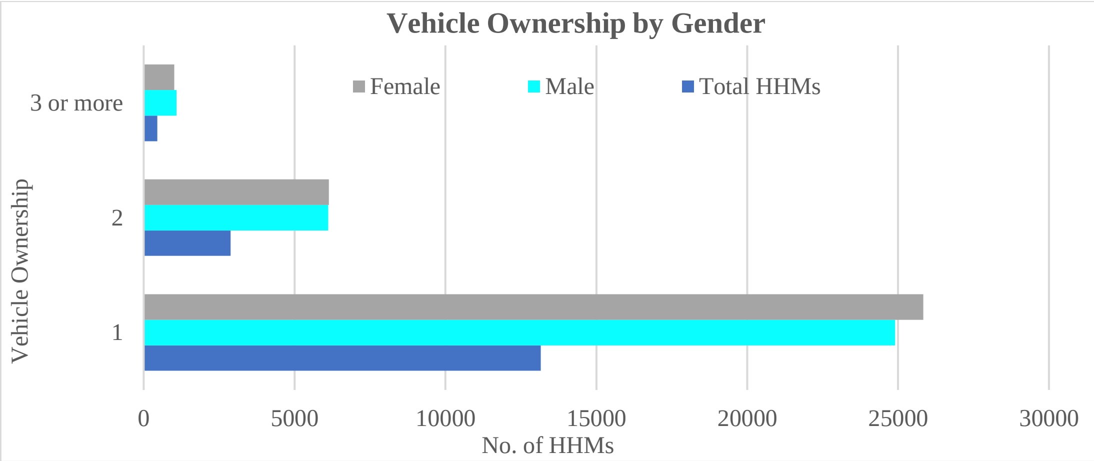


Figure 9: Vehicle ownership by gender

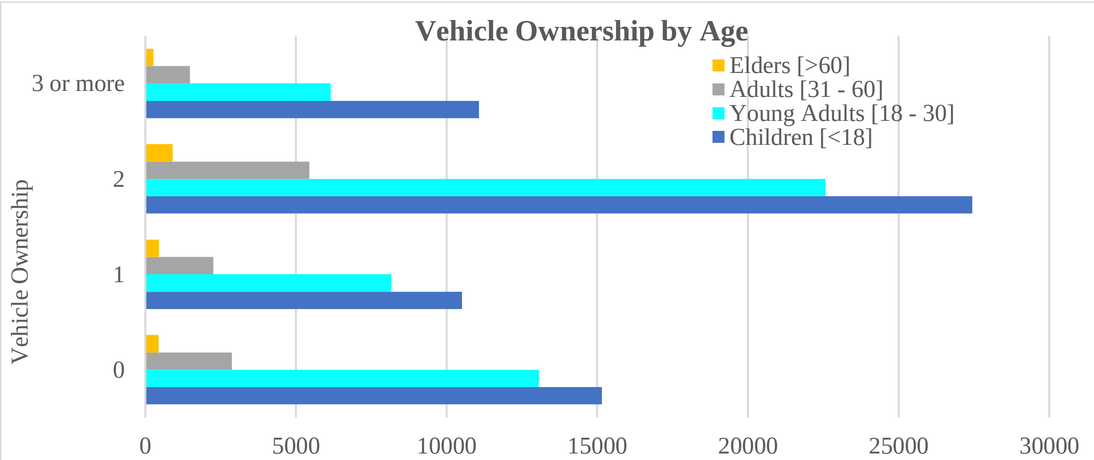


Figure 10: Vehicle ownership by age groups

According to the statistics, the gender distribution in the database is somewhat equal with men accounting for 48% and the rest 52% of women. This overall classification by gender also appears in each vehicle ownership category; however, it is important to consider this relationship with the choice of vehicle type, so gender is one of the criteria that was taken into account in developing the model. Likewise, age is considered under four categories where children (under 18 years old), young people (between 18 and 30 years old), adults (between 31 and 60 years old) and elderly (over 60) despite considerations of previous studies, which took into account. All persons between the ages of 18 and 60 are considered to be the age group of youth adults in previous studies (Zhang, 2016). Accordingly, in the analysis of vehicle ownership by age groups considered the composition of HHs members against the number of vehicles own by each HH. Based on the demographic and social characteristics of Sri Lanka, people between the ages of 18 and 30 are likely to be full-time students or interns in various disciplines. Therefore, the contribution to the family income of people in this income group is considered less.

Personal vehicle ownership type also considered under each age group indicating children, young adults, adults and elders against the vehicle type as shown in Figure 11, Figure 12, Figure 13 and Figure 14. There, car, motorbike, and three-wheelers are considered as main personal vehicle types and ownership for one and two vehicles as three and more vehicle ownership is less compared to this. Accordingly, Car_1 is representing households own one car while Car_2 is representing households own 2two cars. Likewise, MB represents the motorbikes and 3W represents three-wheelers along with the ownership number.

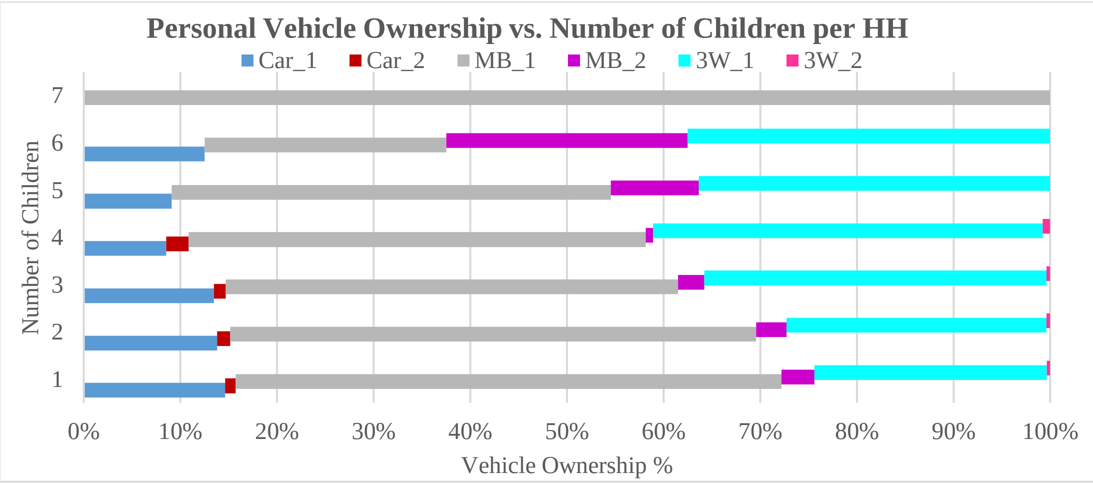


Figure 11: Personal vehicle ownership vs. number of children per household

When the number of children in a household is increasing, one car would not be sufficient and hence ownership of 2 or more cars increase. However, when considering the motorbikes, the same pattern is observed where owning one motorbike is reducing while ownership of two motorbikes increases with the increase in the number of children in a household. With respect to the three-wheeler ownership, a similar pattern as cars is observed.

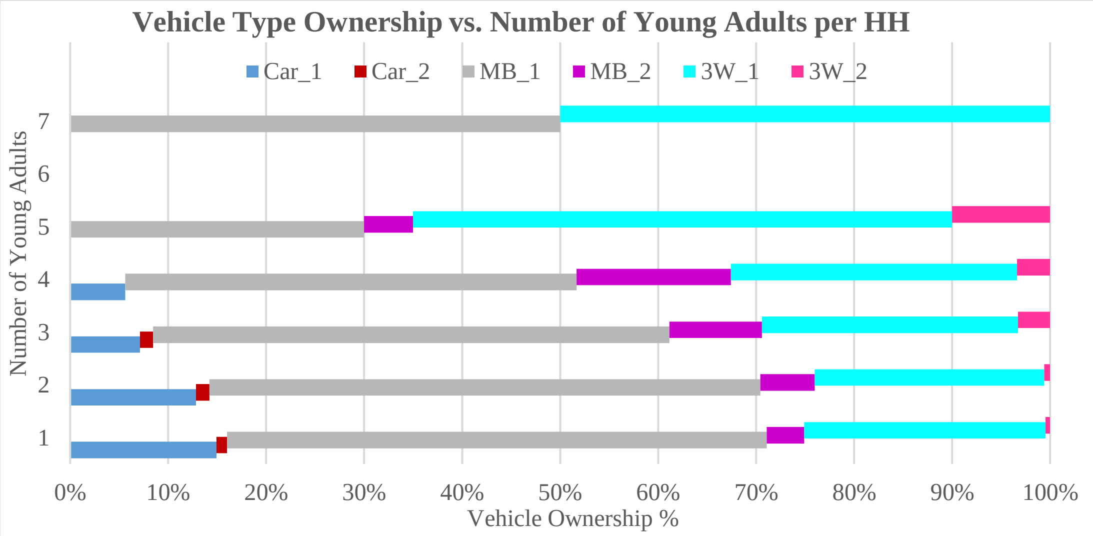


Figure 12: Personal vehicle type ownership vs. number of young adults

When the number of young adults in a family increase, one car will not suffice and the ownership of at least two cars increase. However, when considering about motorcycles, the same pattern is observed as motorbike ownership decreases while ownership of two motorcycles increases with the number of young adults in the household. When it comes to owning three-wheelers, a trend similar to that of cars is observed.

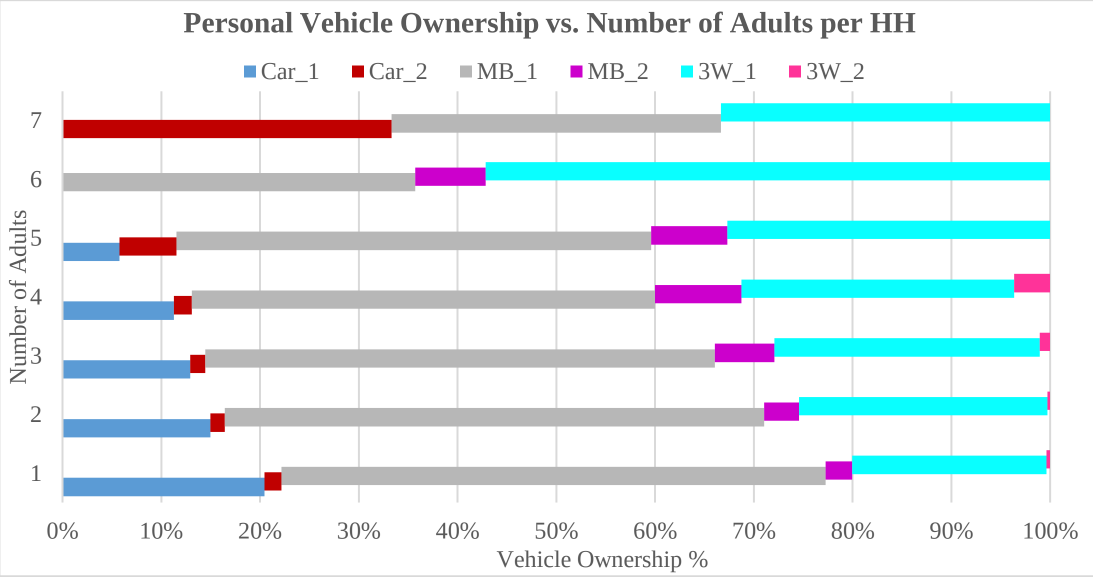


Figure 13: Personal vehicle ownership type vs. number of adults

Up to the number of adults in a household is four is showing the similar vehicle type ownership pattern, however, when there are five or members, the pattern is changing than the previous two figures representing children and young adults. When considering the personal vehicle type ownership variation with the number of elders in a household is slightly different as three-wheel usage is less where car and motorbike ownership percentage is higher than all the other three scenarios.

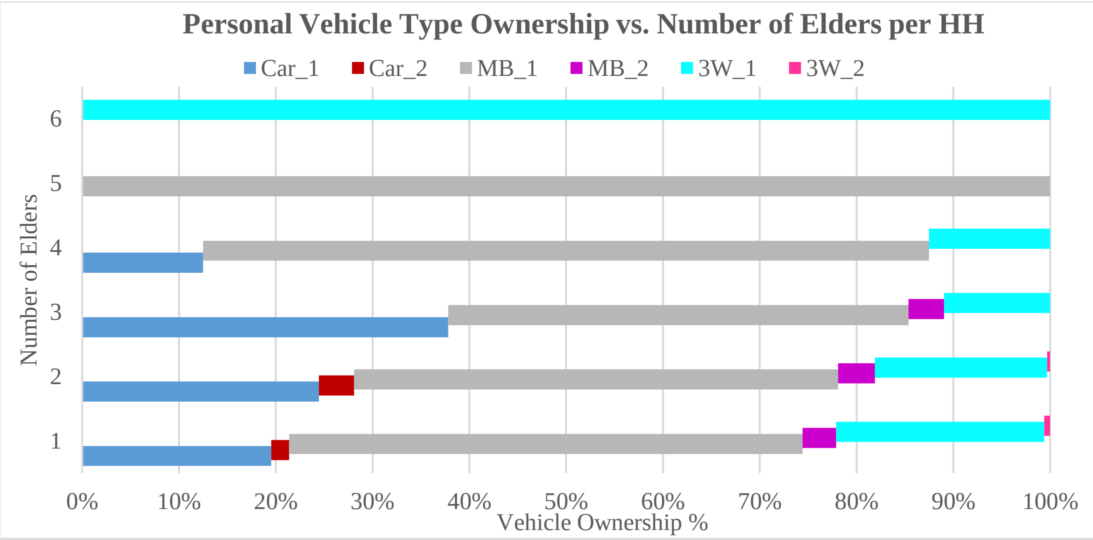


Figure 14: Personal vehicle type ownership vs. number of elders per household

In addition to age and gender, the total number of household members is an important attribute of this study as the number of household members is evaluated against vehicle ownership statistics, as shown in Figure 15. From the illustration, it is evident that families with fewer individuals are likely to own no vehicle or only own one or two vehicles. But if the number of members increases, the family will tend to have more vehicles. Figure 15 below clearly shows that the percentage of private vehicles 2, 3, 4 and 5 own by a household increases with the rise in the number of family members in the family. Also, it is noted that the car ownership percentage decreases with this trait. Since this research focuses on personal vehicle type ownership in three main categories namely cars, motorcycles, and three-wheelers, a more in-depth analysis is carried out regarding personal vehicle type ownership type with the number of household members. As shown in Figure 16, car ownership decreases as the number of family members increases. However, though motorcycle ownership remains constant, the use of three wheels has increased. It is important to note that this three-wheeler share is consisting of both privately used ones as well as hired ones.

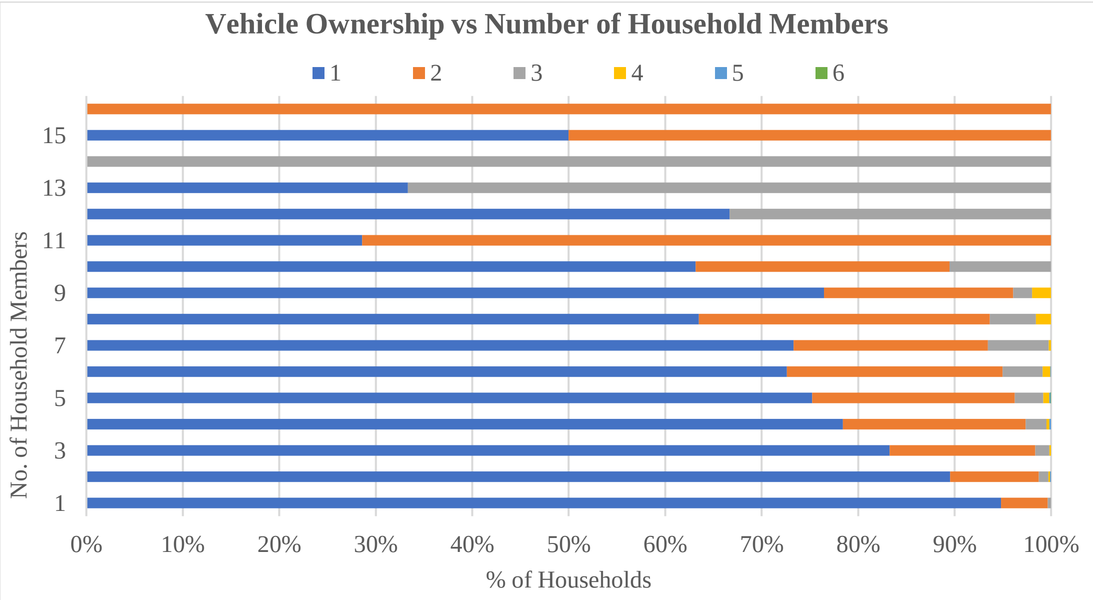


Figure 15: Vehicle ownership vs number of household members

At the same time, it is also vital to note that the mode selection behaviour differs when the number of family members is more than ten because of the sample decreases gradually which is not indicate fair sampling.

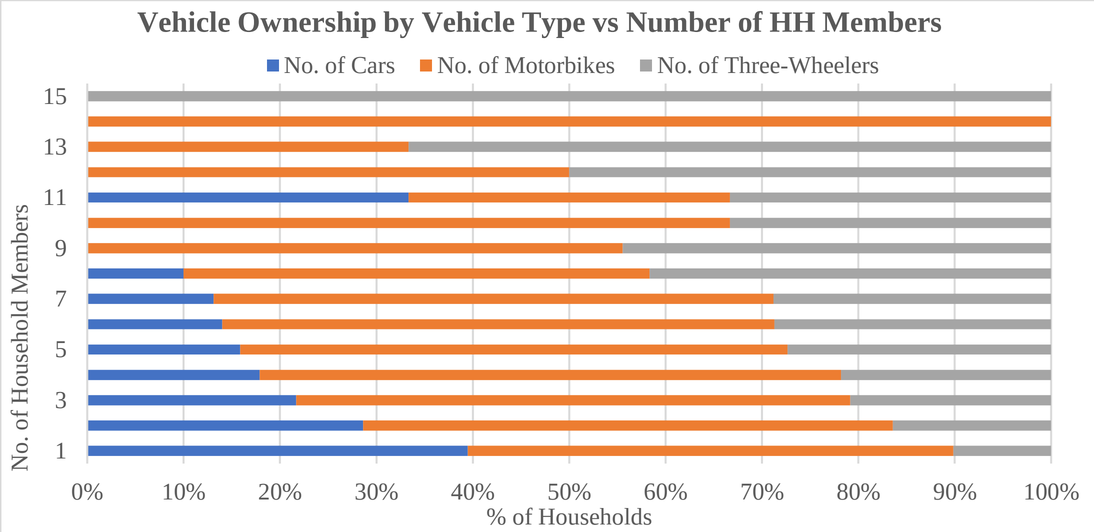


Figure 16: Vehicle ownership by vehicle type vs number of HH members

4.1.4 Number of licenced drivers in households

In the literature, the number of licensed home drivers has been identified as the most influencing factor in whether or not to own a vehicle (Cambridge Systematics, 2014). There is a great tendency to own more vehicles if the number of licensed drivers in the household is high. Figure 17 shows that the percentage of households that own vehicles and the number of vehicles owned is related to the number of drivers in a household. Among households with one driver, 3.83 per cent have no car, while there are no households with four or more drivers without a car. The somewhat surprising finding is that about 30% of households without a driver's license owns at least one car. The average number of vehicles per household closely tracks the number of drivers, which ranges from 1.24 for families with one driver, 2.10 for families with two drivers, 3.08 for families of three drivers, and 3.50 for families with four drivers.

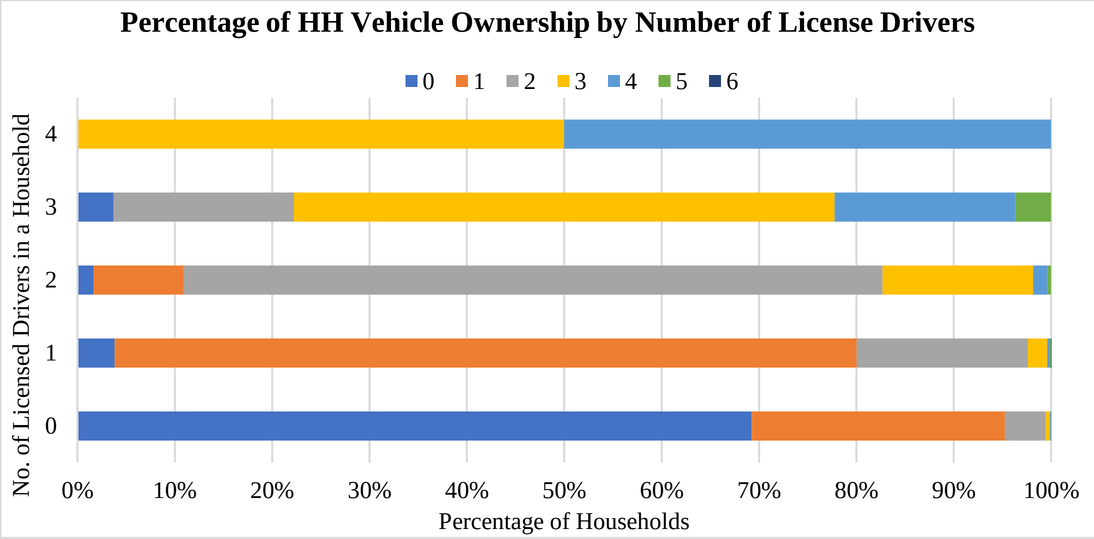


Figure 17: Percentage of HH vehicle ownership by number of license drivers

Since this research focuses on the type of household personal owned vehicles, the above analysis regarding the relationship of vehicle ownership by households and the number of licensed drivers extends to the categories of vehicle ownership considered in this research, as shown in Figure 18. Accordingly, it is important to note that motorcycle ownership is higher even without a driver's license and when only one licensed driver because some types of motorcycles are not required licenses to drive in Sri Lanka. Cars and three-wheelers have reasonable relationship between two considered traits, and therefore, this relationship will be taken into account when developing the model.

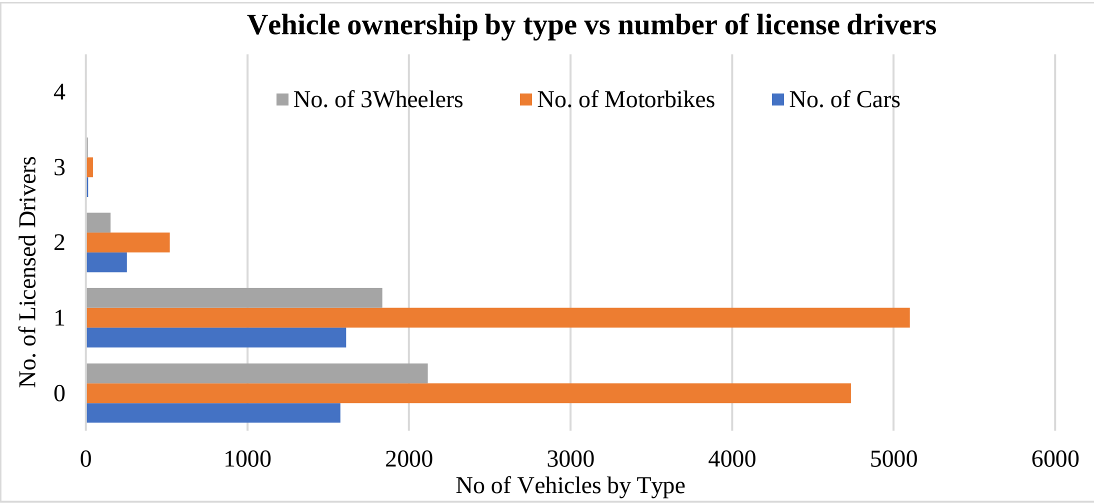


Figure 18: Vehicle ownership by type vs number of license drivers

4.1.5 Social status of household members

During the data collection social status data has been captured under 17 categories as Working (full time) [1], Working (part-time) [2], Kindergarten [3], Student (grade1-grade5) [4], Student (grade6-grade8) [5], Student (grade9-grade10) [6], Student (G.C.E (O/L)) [7], Student (G.C.E (A/L)) [8], Student (Graduate) [9], Student (Postgraduate) [10], Student (Ph.D.) [11], Other Students [12], Unpaid family worker [13], Housewife [14], Retired [15], Unemployment [16], and Others [17]. In order to reduce the complexity of analysis when developing the logit model, these categories were summarized into three main categories as category 01 represent workers including both full time and part-time workers, category 02 represent all types of students considered all categories between 3 and 12 and category 03 as all none earning categories including unpaid family worker, housewife, retired, and unemployment. However, Others [17] category is not considered in this model development as it is difficult to project without proper details of employment status.

As shown in Figure 19, household car ownership is analysed concerning social status categories that represent adult workers, adult none-workers, and students. As a result, it shows that households without a car have a higher number of unemployed adult workers as compared to adult workers. This difference reduces when considering households with only one car where the difference is minimal. If households with 2 and 3 or more cars were considered, then adult workers are higher than adults without workers.

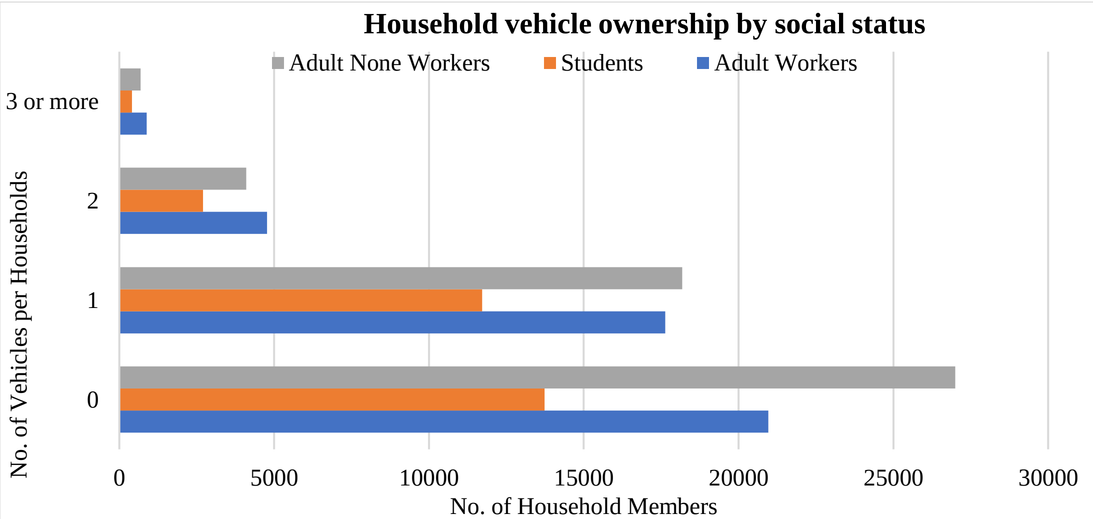


Figure 19: Household vehicle ownership by social status

The above analysis is expanded by vehicle type to determine the percentage of households that distribute cars, motorcycles, and three-wheelers. As a result, there is no significant difference in the percentage distribution of household members based on vehicle type, as shown in Figure 20. However, since this analysis is based on cumulative data, it is vital to take into account the social status of each household member. When developing the personal car type ownership model, the social status of the household members is a feature of the model.

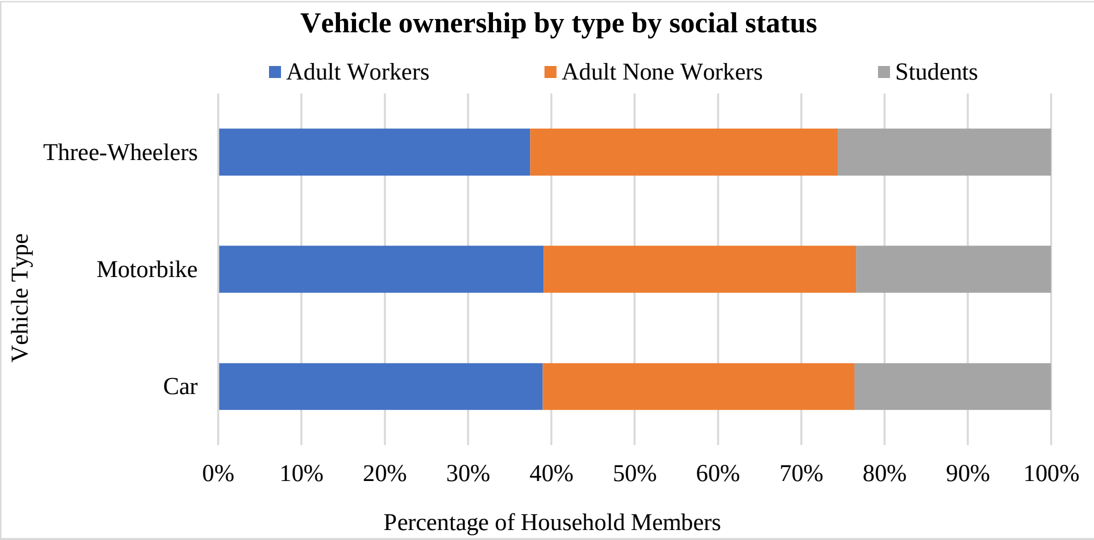


Figure 20: Vehicle ownership by type by social status

5 MODEL ESTIMATION

This section introduces the methodology for developing a household vehicle type choice model and discusses the results obtained.

5.1 Vehicle Type Choice Combinations

As the initial preparation for developing the model, prioritizing mode choice is vital for a household. According to the analysis of data obtained within the Western province based on vehicle ownership by type, the highest vehicle owners represent motorcycles as it is an economical and easy-to-move vehicle in heavy traffic in urban areas. The second highest vehicle ownership percentage is shown by three-wheelers where nearly 50% of it used for rental. The third-highest category for vehicle ownership is cars, including pickups and vans. Lowest vehicle ownership represents other vehicle categories that also include commercial vehicle types.

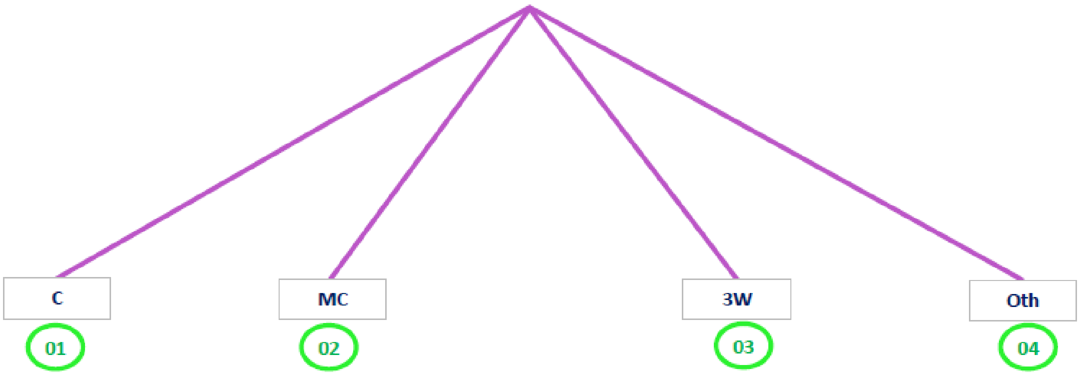


Figure 21: Choice combinations for single vehicle ownership

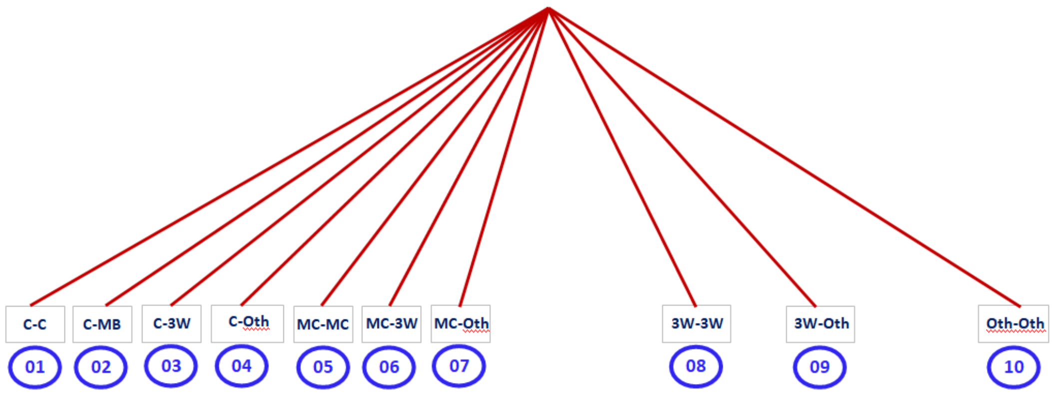


Figure 22: Choice combinations for two vehicle ownership

Despite the vehicle ownership analysis, as in general regarding safety and comfortability people's most priority vehicle type is assumed as cars for the model development. Meanwhile, motorbike and three-wheelers are considered as second and third priority vehicle consequently. This order is further continued for second and third vehicle choice and accordingly, combinations are created as shown in Figure 21, Figure 22 and Figure 23.

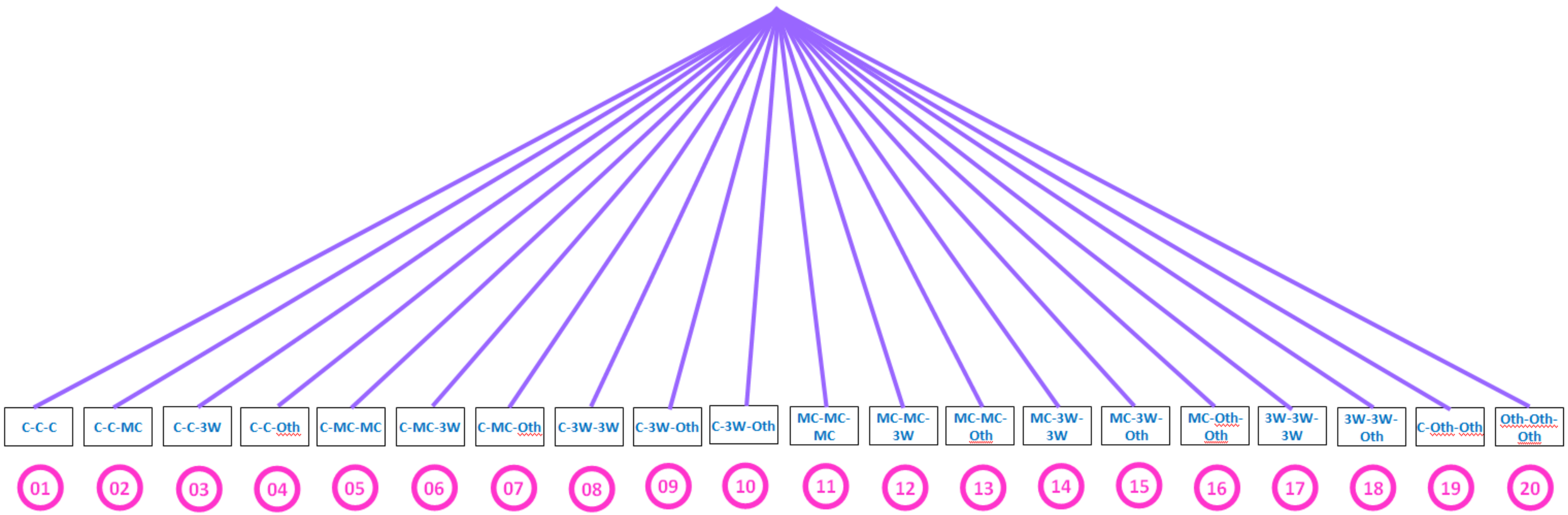


Figure 23: Choice combinations for three or more vehicle ownership

5.2 Choice Model Structure

5.2.1 Single vehicle ownership model

As discussed in the section 5.1 vehicle type choice combinations, for the model development, 3 separate models of vehicle ownership were considered as households (HHs) with only one personal use vehicle, HHs with only two personal use vehicles and HHs with 3 or more personal used vehicles. Accordingly, initially, the data file is prepared with the choice for 1st vehicle while considering the basic data items including, number of HH members, number of males, number of females etc as shown in Table 10. Accordingly, 12 attributes were considered exhaustively. The analysis was done under four scenarios, to identify the best option that to be used in the developing other two levels.

The reason for this analysis is that to find the same information at a different level of detail, the primary attempt of analysis is to find out at which level it is much better, which is most aggregated considering the whole as an aggregate of HH members. Next, the model results envisage the classification of men and women, then their classification by age group and finally considered according to the classification of workers, students and non-workers.

Table 10: Attribute summary for considered four alternative options

No.	Data Item	Alternative 01	Alternative 02	Alternative 03	Alternative 04
01	Number of HH Members	√			
02	Number of Male		√		
03	Number of Female		√		
04	Number of Children_<18			√	
05	Number of Young Adults_18-30			√	
06	Number of Adults_31-60			√	
07	Number of Elders_>60			√	
08	Average Income [Rs]	√	√	√	√
09	Number of License Drivers	√	√	√	√
10	Number of Adult Workers				√
11	Number of Students				√
12	Number of Non Workers				√

Consequently, four different estimations were obtained using the same data file to identify the best attributes to be considered. The methodology behind preparing four alternatives are as follows.

A. Alternative 01 – Considered the number of household members as the foremost variable, which have incorporated with the average household income and the number of licensed drivers
B. Alternative 02 – Considered the number of males and number of females being the gender-based categories as the main variables, which have incorporated with the average household income and the number of licensed drivers
C. Alternative 03 – Considered the number of children, number of young adults, number of adults and number of seniors being the age-based categories as the main variables, which have incorporated with the average household income and the number of licensed drivers
D. Alternative 04 – Considered the number of adult workers, number of students and number of adult non-workers being the social status-based categories as the main variables, which have incorporated with the average household income and the number of licensed drivers

The model results for each alternative is summarized in the Table 11.

Table 11: Model estimation results for initial model for HHs with single vehicle

ID	Explanatory Variables	Description	Alternative 01 [No. of HH Members]	Alternative 02 [Gender]	Alternative 03 [Age]	Alternative 04 [Social Status]
01	Number of Household Members	Estimated Coefficient	0.3070			
		Standard Error	0.0196			
		“T” Ratio	15.7			
02	Number of Male	Estimated Coefficient		0.4096		
		Standard Error		0.0288		
		“T” Ratio		14.2		
03	Number of Female	Estimated Coefficient		0.2205		
		Standard Error		0.0258		
		“T” Ratio		8.5		
04	Number of Children (<18)	Estimated Coefficient			0.2250	
		Standard Error			0.0284	

ID	Explanatory Variables	Description	Alternative 01 [No. of HH Members]	Alternative 02 [Gender]	Alternative 03 [Age]	Alternative 04 [Social Status]
		"T" Ratio			7.9	
05	Number of Young Adults (18-30)	Estimated Coefficient			0.4928	
		Standard Error			0.0352	
		"T" Ratio			14.0	
06	Number of Adults (31-60)	Estimated Coefficient			0.4402	
		Standard Error			0.0359	
		"T" Ratio			12.3	
07	Number of Elders (>60)	Estimated Coefficient			-0.07937	
		Standard Error			0.0360	
		"T" Ratio			-2.2	
08	Number of Adult Workers	Estimated Coefficient				0.6960
		Standard Error				0.0369
		"T" Ratio				18.8
09	Number of Students	Estimated Coefficient				0.1831
		Standard Error				0.0272
		"T" Ratio				6.7
10	Number of None-Workers	Estimated Coefficient				0.1630
		Standard Error				0.0301
		"T" Ratio				5.4

The coefficient of the number of household members is positive where moreover, it is profoundly important. Meanwhile, the value of the t-ratio is higher than 1.96. Thus, the parameter differs significantly from 0. A comparison of the estimated coefficients associated with men and women reveals that when the number of males in a household increases, the inclination to own motorcycles and three-wheelers is higher than the tendency to own motorcycles and three-wheelers than the women population. However, both variables have t-ratio greater than 1.96, so the two variables differ significantly from 0.

Given the relevant explanatory variables within the age group, three of the four variables correlate positively with other conditions compared to the vehicle. It means that when children, young adults and adults are higher in a household, the propensity to own motorcycles, three-wheelers and other types of vehicles are positive compared to cars. At the same time, the coefficient for the number of adults is negative, but t-ratio is -2.2, so it is significant with a 95% confidence level because t-statistics is less than 1.96.

The explanatory variables for the social status categories, the three variables, the number of adult workers, the number of students, and the number of adult non-workers have positive coefficients and t-statistics greater than 1.96. Among these three variables, where the number of adult workers is higher in a household, a higher tendency to own motorcycles, three-wheelers and other types of vehicles compared to cars could be observed. These coefficients gradually decrease with the increase in the number of students and the increase in the number of non-workers in the household.

Besides, each variable was summarized under two basic explanatory variables that are typical of all the alternatives and the constants for motorcycles, three-wheelers and other types of vehicles. The intention is to finalize the best alternative of these, for use in the following two models.

The average income and number of drivers are considered as the major variables in deciding the type of vehicle by each household. As expected, that when income rises, the tendency for having motorbikes, three-wheelers, or another vehicle compared to the car has a negative sign. For all four alternatives, expected negative results are obtained. Concerning the number of licensed drivers, the higher the number of licensed drivers, the more likely, they will own cars than other vehicles.

According to the model estimation results, all four alternatives have positive coefficients for motorbikes and three-wheelers, where the negative coefficient for the other-vehicle category. This result indicates that when there is only a single vehicle at a household when the number of drivers increases, more tendency is to have a Motorbike or three-wheelers, compared to the car, but vice versa for other vehicle types. Therefore, considering all these behaviors, it seems that all alternatives depict similar nature with the relationship regarding the vehicle ownership for single vehicle ownership. Subsequently, estimation results are evaluated thoroughly to identify which alternative gives a better indication, which is more suitable to use in the other two models. Eventually, alternative 01 is selected where HH size is more related to the vehicle ownership of households along with the income level and the number of licensed drivers.

Among the 16,489 of 35,806 total sample details of households identified with at least one vehicle owned within the western province, initial analysis was carried out against number of household members, licensed drivers, and average income. The estimated coefficients and related statistics of the model are shown in Table 12.

Table 12: Model results of single vehicle HHs on HH members, income, and drivers

No.	Variable Code	Estimations			T-ratio			Std. Error		
		MB	3W	Other	MB	3W	Other	MB	3W	Other
1	HH members	0.2592	0.4421	0.299	0.202	0.0232	0.0414	12.8	19.1	7.2
2	Income	-0.0000379	-0.000048	-0.000027	0.000000982	0.0000014	0.00000232	-38.6	-34.5	-11.7
3	Drivers	0.607	0.37	-0.841	0.0519	0.0605	0.135	11.7	6.1	-6.2

Observations accepted for processing	*13161*
Likelihood with Zero Coefficients	-18245
Likelihood with Constants only	-14487.4
Initial Likelihood	-18245
Final value of Likelihood	-12851.6
"Rho-Squared" w.r.t. Zero	0.2956
"Rho-Squared" w.r.t. Constants	0.1129

According to the model estimations, the Coefficients of household members concerning motorbikes, three-wheelers, and other vehicles are positively correlated and significant. The t-ratios for all variables under all three mode categories are less than 1.96, suggest that the parameters are not statistically significantly different from 0 at the 95% confidence level. As can be observed from Table 12, the ρ2(0) value is low. This may be due to available attributes being insufficient to distinguish between the different choices. However, the goodness of fit measures like adjusted rho square has reduced compared to the rho with respect to zero. Likelihood value was also calculated with zero coefficients and with constants only, which also indicate that model fit better.

The coefficients of vehicle types against the number of household members suggest that number of households is more related to the three-wheelers, as compared to motorbikes and other vehicle types. Actual data set analysis also inclined the same trend as depicted in Figure 24. This is because when the number of family members increased, preference for three-wheelers increased, a possible reason for this is vehicle occupy level. On the other hand, owning a car is a costly option that is not affordable for all households.

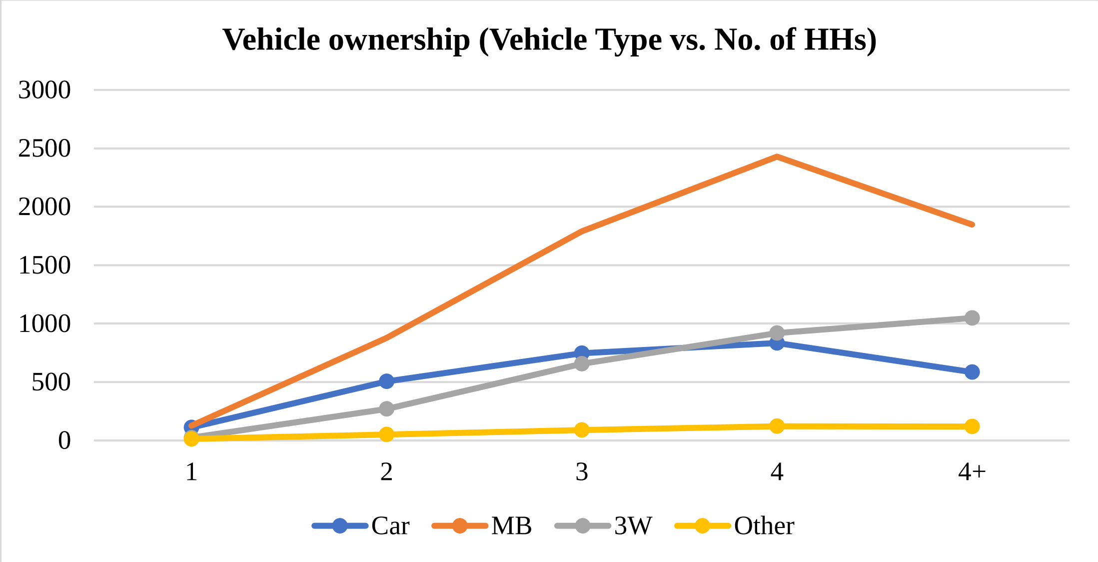


Figure 24: Vehicle ownership (Vehicle Type vs. No. of HHs)

As can be observed from Table 12, all coefficients of the model are highly significant. However, in general there is a significant variation concerning the number of household members and income ranges. Hence, considering the potential of variations that can appear within the outcome, parameter estimations could be average estimations due to data is being spread over large ranges of both numbers of households and income categories.

Accordingly, in this research, household members are categories into five main categories as 1, 2, 3, 4, and 4+. Also, three main household income categories were defined where the low-income group (L) set the HH income less than Rs. 40,000, the medium-income group (M) set the HH income between Rs. 40,000 and Rs. 80,000 and the high-income group (H) set the HH income greater than 80,000. According to the above categorization, 15 data fields (5*3) were considered as shown in Figure 13, and estimations are done against the available mode combinations for each level separately according to the discussion in section 5.1.

Table 13: Description of 15 data fields

No.	Category Code	Description
1	HHS1_HHIL	HHs with 01 Member and belongs to Low Income Group
2	HHS2_HHIL	HHs with 02 Member and belongs to Low Income Group
3	HHS3_HHIL	HHs with 03 Member and belongs to Low Income Group
4	HHS4_HHIL	HHs with 04 Member and belongs to Low Income Group
5	HHS5_HHIL	HHs with 05 or more Member and belongs to Low Income Group
6	HHS1_HHIM	HHs with 01 Member and belongs to Medium Income Group
7	HHS2_HHIM	HHs with 02 Member and belongs to Medium Income Group
8	HHS3_HHIM	HHs with 03 Member and belongs to Medium Income Group
9	HHS4_HHIM	HHs with 04 Member and belongs to Medium Income Group
10	HHS5_HHIM	HHs with 05 or more Member and belongs to Medium Income Group
11	HHS1_HHIH	HHs with 01 Member and belongs to High Income Group
12	HHS2_HHIH	HHs with 02 Member and belongs to High Income Group
13	HHS3_HHIH	HHs with 03 Member and belongs to High Income Group
14	HHS4_HHIH	HHs with 04 Member and belongs to High Income Group
15	HHS5_HHIH	HHs with 05 or more Member and belongs to High Income Group

Following fifteen parameters were set in model estimation for level 01 low-income category using the above five categories. Accordingly, forty-five parameters were set for all three income groups under level 01 (see Appendix A).

1. HHS1_HHIL_MB
2. HHS1_HHIL_3W
3. HHS1_HHIL_Oth
4. HHS2_HHIL_MB
5. HHS2_HHIL_3W
6. HHS2_HHIL_Oth
7. HHS3_HHIL_MB
8. HHS3_HHIL_3W
9. HHS3_HHIL_Oth
10. HHS4_HHIL_MB
11. HHS4_HHIL_3W
12. HHS4_HHIL_Oth
13. HHS5_HHIL_MB
14. HHS5_HHIL_3W
15. HHS5_HHIL_Oth

Thus, each data item was assigned to one data item out of those 45 data fields and defined as 1 and otherwise 0. Accordingly, model output was generated, and summary of results is shown in Table 14.

Table 14: Model estimations of level 01 on income categories vs HH members and drivers

Category		Vehicle Ownership Combinations		
		MB	3W	Other
Drivers				
Drivers	*Estimate*	0.6061	0.3739	-0.8367
	Std. Error	0.0522	0.0606	0.1350
	T Ratio	11.6	6.2	-6.2
HHS_HHI Categories				
HHS1_HHIL	*Estimate*	0.000032	-0.000026	0.000065
	Std. Error	0.000015	0.000018	0.000028
	T Ratio	2.2	-1.4	2.3
HHS2_HHIL	*Estimate*	0.000129	0.000059	0.000122
	Std. Error	0.000025	0.000027	0.000050
	T Ratio	5.1	2.2	2.4
HHS3_HHIL	*Estimate*	0.000246	0.000174	0.000235
	Std. Error	0.000037	0.000040	0.000073
	T Ratio	6.6	4.4	3.2
HHS4_HHIL	*Estimate*	0.000393	0.000308	0.000390
	Std. Error	0.000050	0.000053	0.000097
	T Ratio	7.9	5.8	4
HHS5_HHIL	*Estimate*	0.000538	0.000536	0.000578
	Std. Error	0.000069	0.000073	0.000131
	T Ratio	7.8	7.4	4.4
HHS1_HHIM	*Estimate*	-0.000006	-0.000032	-0.000008
	Std. Error	0.000006	0.000011	0.000019
	T Ratio	-1	-2.9	-0.4
HHS2_HHIM	*Estimate*	-0.000022	-0.000061	-0.000011
	Std. Error	0.000009	0.000011	0.000020
	T Ratio	-2.5	-5.4	-0.6
HHS3_HHIM	*Estimate*	-0.000005	-0.000055	0.000003
	Std. Error	0.000013	0.000014	0.000026
	T Ratio	-0.4	-3.9	0.1
HHS4_HHIM	*Estimate*	0.000016	-0.000042	0.000034
	Std. Error	0.000017	0.000018	0.000034
	T Ratio	0.9	-2.3	1
HHS5_HHIM	*Estimate*	0.000037	0.000004	0.000086
	Std. Error	0.000023	0.000024	0.000045
	T Ratio	1.7	0.2	1.9
HHS1_HHIH	*Estimate*	-0.000013		
	Std. Error	0.000005		
	T Ratio	-2.6		

Category		Vehicle Ownership Combinations		
		MB	**3W**	**Other**
HHS2_HHIH	*Estimate*	-0.000032	-0.000045	-0.000011
	Std. Error	0.000006	0.000009	0.000011
	T Ratio	-5.3	-4.9	-1
HHS3_HHIH	*Estimate*	-0.000057	-0.000075	-0.000019
	Std. Error	0.000009	0.000012	0.000017
	T Ratio	-6.6	-6	-1.2
HHS4_HHIH	*Estimate*	-0.000062	-0.000098	-0.000057
	Std. Error	0.000010	0.000014	0.000029
	T Ratio	-6.2	-6.8	-1.9
HHS5_HHIH	*Estimate*	-0.000056	-0.000107	0.000007
	Std. Error	0.000012	0.000019	0.000020
	T Ratio	-4.6	-5.8	0.3

Observations accepted for processing	*13161*
Likelihood with Zero Coefficients	-18245
Likelihood with Constants only	-14487.4
Initial Likelihood	-18245
Final value of Likelihood	-12810.8
"Rho-Squared" w.r.t. Zero	0.2978
"Rho-Squared" w.r.t. Constants	0.1157

There is the highest tendency of owning a car when there is only one vehicle per household is assumed, compared to the other considered vehicle types. Therefore, the model estimation was carried out by figuring the utilities of choosing motorbikes, three-wheelers, and "other" vehicle types compared against preferring a car for a household. However, such decision is vary based on two main concerns, including household income level and the number of household members. Hence, estimations were obtained under above mention 15 categories based on such two criteria, household income and the number of members. Due to the non-availability of data for the variable of HHS1_HHIH under three-wheeler and other vehicle categories, those two sub-variables had to eliminate before the model run.

As can be observed from Table 12, all coefficients of the level 01 model are highly significant. Moreover, if the goodness of fit measures like adjusted rho square of the initial model (where HH members and income are considered without classification) is slightly improved in the second model where the second model fits the dataset much better.

From Table 14, it can be observed that as suspected, the coefficients of three modes compared to owning a car concerning the number of licensed drivers available at a household is varied significantly. The model estimation results inclined that the coefficients are higher for the only MB owning HH groups, which shows that indeed for households in this group, reflects economic standard is a highly important factor in the decision-making process about their private vehicle ownership. The coefficient for only the three-wheelers household group is further positively correlated, but lower than the coefficient of the households owning motorbikes only group, which means that for this group as household members increases, households become more and more inclined to three-wheelers which give higher occupy rate than motorbikes, further economically sustainable. However, the coefficient for other vehicle types only owning alternatives is lower and negatively correlated, which means that this group of households become more and more inclined to own only cars as their personally used vehicles when the number of licensed drivers increased per HH.

In-depth analysis against HH members and the average income of households under 15 categories provides sensible outputs. Accordingly, for all low-income group households, despite their number of household members, positively correlated coefficients were observed for MBs, 3Ws, and other types of vehicles compared to owning a car except 3W only HHs with only one HH member.

Besides, when the income level increase, the tendency of owning a motorbike, a three-wheeler, or other types of vehicle gradually declines, which explain by the negative coefficient values, as summarized in Table 14.

The t-ratios for most of the variables under all three mode categories are greater than 1.96, suggest that the parameters are statistically significantly different from 0 at the 95% confidence level. As can be observed from Table 14, the $\rho 2(0)$ value is low. This may be due to available attributes being insufficient to distinguish between the different choices. However, the goodness of fit measures like adjusted rho square has reduced compared to the rho with respect to zero. Likelihood value was also calculated with zero coefficients and with constants only, which also indicate that model fit better.

Accordingly, utility functions compared to car selection under the first model could be finalized as follows.

VMB = **+ 0.6061** (Number of Licensed Drivers_MB) + **0.00003173** (HHS1_HHIL_MB) + **0.000129** (HHS2_HHIL_MB) + **0.0002459** (HHS3_HHIL_MB) + **0.0003929** (HHS4_HHIL_MB) **0.0005377** (HHS5_HHIL_MB) **-0.000006265 (**HHS1_HHIM_MB) - 0.00002221 **(HHS2_HHIM**_MB) -0.000005038 (HHS3**_HHIM_MB**) + 0.00001569 (HHS4**_HHIM_**MB) + 0.00003742 (HHS5**_HHIM_**MB) -0.00001301 (HHS1_HHIH**_MB)** -0.00003151 (HHS2_HHIH_MB**)** **-0.00005738** (HHS3_HHIH_MB) **- 0.000062 (**HHS4_HHIH_MB) -0.00005591 **(HHS5_**HHIH_MB) **-0.1383 (**Constants_MB)

[Equation 8]

V_{3W} = **+ 0.3739** (Number of Licensed Drivers_3W) **- 0.00002603** (HHS1_HHIL_3W) **+ 0.00005885** (HHS2_HHIL_3W) **+ 0.0001742** (HHS3_HHIL_3W) **+ 0.0003084** (HHS4_HHIL _3W) **+ 0.0005358** (HHS5_HHIL_3W) **- 0.00003203** (HHS1_HHIM_3W) **- 0.00006113** (HHS2_HHIM_3W) **- 0.00005493** (HHS3_HHIM_3W) **- 0.00004159** (HHS4_HHIM_3W) **+ 0.000003816** (HHS5_HHIM_3W **- 0.00004468** (HHS2_HHIH_3W) **- 0.00007495** (HHS3_HHIH_3W) **- 0.00009793** (HHS4_HHIH_3W) **- 0.0001071** (HHS5_HHIH_3W) **- 0.4831**

[Equation 9]

Vother = -0.8367 (Number of Licensed Drivers**_Other)** + 0.00006501 (HHS1_HHIL**_Other)** +0.0001221 (HHS2_HHIL_Other) **+0.0002352** (HHS3_HHIL_Other) +0.0003901 **(_**Other) + 0.0005784 (HHS5**_HHIL_**Other) - 0.000008107 (HHS1_HHIM**_Other)** -0.00001097 (HHS2_HHIM_Other) **0.000003119** + (HHS3_HHIM_Other**)** **+** 0.00003383 (HHS4_HHIM_Other**)** **+** 0.00008593 (HHS5_HHIM_Other**)** **(**HHS1_HHIH_Other) -0.00001141 **(HHS2_**HHIH_Other) - 0.00001926 (HHS3**_HHIH_**Other) -0.00005663 (HHS4_HHIH**_Other)** + 0.000006884 (HHS5_HHIH**_Other)** **-2.679 (-0.1383_**Other)

[Equation 10]

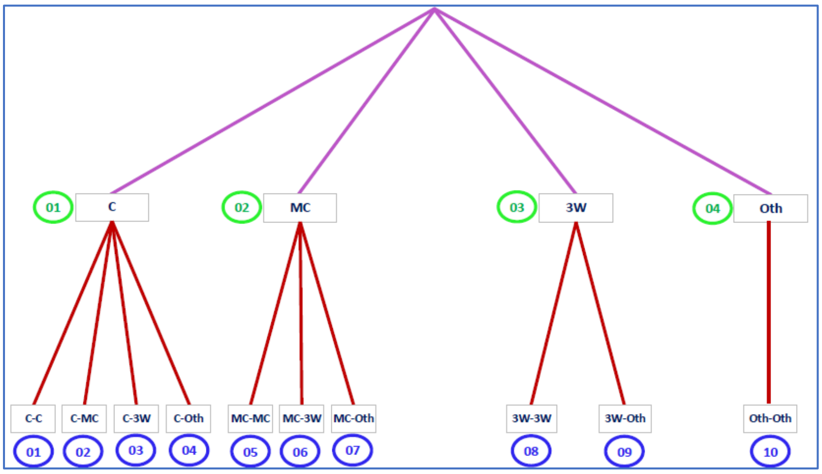
$V_{Car} = 0$

[Equation 11]

5.2.2 Two vehicles ownership model

As discussed in the section 5.1, model development following structure is assumed to be applied for the households owned only two vehicles. As shown in Figure 22, ten vehicle combinations are considered as Car_Car, Car_MB, Car_3W, Car_Oth, MB_MB, MB_3W, MB_Other, 3W_3W, 3W_Other, and Other_Other. When calculating utilities, utility for owning two cars is assumed to be zero, so that all other combination utility values are comparable to it.

Initially, following tree structure is considered in defining "Tree" and "theta" commands in the control file, consequently, different values have assigned for each choice as shown in Figure 25.



Suggested Numbering

Choice C,	C-C: 10
	C-MC: 10
	C-TW: 10
	C-Oth: 10
Choice MC,	MC-MC: 11
	MC-TW: 11
	MC-Oth: 11
Choice TW,	TW-TW: 12
	TW-Oth: 12
Choice Other,	Oth-Oth: 13
Then	C: 14
	MC: 14
	3W: 14
	Oth: 14
Root: 0	

Figure 25: Suggested numbering to be used in setting up commands

However, responds for each choice is considered, Other-Other options is insignificant as the percentage is less than 1% as summarized in the Table 15. Therefore, in the model, Oth-Oth option is omitted and renumbered as follows.

Table 15: Respondent's summary of HHs with two vehicles

Choice ID	Choice Description	Count	% of Choice
1	C-C	314	10.92%
2	C-MC	924	32.13%
3	C-TW	87	3.03%
4	C-Oth	54	1.88%
5	MC-MC	436	15.16%
6	MC-TW	783	27.23%

Choice ID	Choice Description	Count	% of Choice
7	MC-Oth	156	5.42%
8	TW-TW	54	1.88%
9	TW-Oth	48	1.67%
10	Oth-Oth	20	0.70%
Total		**2,876**	**100.00%**

Suggested Altered Numbering

Choice C, C-C: 10
C-MC: 10
C-TW: 10

C-Oth: 10

Choice MC, MC-MC: 11
MC-TW: 11
MC-Oth: 11

Choice TW, TW-TW: 12
TW-Oth: 12

Then C: 13
MC: 13
3W: 13
Oth: 13

Root: 0

The attributes of model that defined as per the finalized settings for the level 02 model, and transformations that define how the model works for the level 02 was demarcated. The utility functions were specified according to the assigned attributes, except for the car, which conserving the utility value zero. ALOGIT model run was done and the model results obtained as coefficients of nest values equal to 01. The model output results describe that considered nest structure is inexistent with the used data. Since the nested logit structure model run does not exist, a single level logit model was tried and as previous, utility for Car-Car was kept as zero and followed the same utility function.

To identify the best fit model attributes of the utility function was introduced stepwise as Car, MC, TW and Other options in four steps. Further, it was observed that warnings have appeared concerning the constants, mentioning that alternatives were not specified and connected to the root. Also, it was further justified where the model was towards a single-level logit structure despite it was expected to be a nested structure model. Similar to the methodology followed when creating the level 01 model, the five basic combined categories made up of the number of household members and household income categories were used. The initially defined ten vehicle choice combinations were applied for level 02, however Car_Car vehicle combination was not considered, whereas utility for that option was considered as zero. And thus, low-income category has been evaluated under 45 parameters, whereas 135 parameters were set for all three income groups under level 02.

1. HHS1_HHIL_C_MB
2. HHS1_HHIL_C_3W
3. HHS1_HHIL_C_Oth
4. HHS1_HHIL_MB_MB
5. HHS1_HHIL_MB_3W
6. HHS1_HHIL_MB_Oth
7. HHS1_HHIL_3W_3W
8. HHS1_HHIL_3W_Oth
9. HHS1_HHIL_Oth_Oth
10. HHS2_HHIL_C_MB
11. HHS2_HHIL_C_3W
12. HHS2_HHIL_C_Oth
13. HHS2_HHIL_MB_MB
14. HHS2_HHIL_MB_3W
15. HHS2_HHIL_MB_Oth
16. HHS2_HHIL_3W_3W
17. HHS2_HHIL_3W_Oth
18. HHS2_HHIL_Oth_Oth
19. HHS3_HHIL_C_MB
20. HHS3_HHIL_C_3W
21. HHS3_HHIL_C_Oth
22. HHS3_HHIL_MB_MB
23. HHS3_HHIL_MB_3W
24. HHS3_HHIL_MB_Oth
25. HHS3_HHIL_3W_3W
26. HHS3_HHIL_3W_Oth
27. HHS3_HHIL_Oth_Oth
28. HHS4_HHIL_C_MB
29. HHS4_HHIL_C_3W
30. HHS4_HHIL_C_Oth
31. HHS4_HHIL_MB_MB
32. HHS4_HHIL_MB_3W
33. HHS4_HHIL_MB_Oth
34. HHS4_HHIL_3W_3W
35. HHS4_HHIL_3W_Oth
36. HHS4_HHIL_Oth_Oth
37. HHS5_HHIL_C_MB
38. HHS5_HHIL_C_3W
39. HHS5_HHIL_C_Oth
40. HHS5_HHIL_MB_MB
41. HHS5_HHIL_MB_3W
42. HHS5_HHIL_MB_Oth
43. HHS5_HHIL_3W_3W
44. HHS5_HHIL_3W_Oth
45. HHS5_HHIL_Oth_Oth

Thus, each data item was assigned to one data item out of those 135 data fields and defined as 1 and otherwise 0. Accordingly, model output was generated, and summary of results is shown in Table 15. However, based on the data availability, some of the parameters were not exist. Therefore, such parameters were eliminated from the model and non-use parameters are highlighted in Table 16. Complete List of Parameters used for the development of level 02 is attached to the report as Appendix B.

Table 16: Summary of used and non-use parameters in level 02 model

Mode Combinations	Income Category	HH Members				
		1	2	3	4	4+
Car -MB	H	130	139	148	157	166
	M	85	94	103	112	121
	L	40	49	58	67	76
Car -3W	H	131	140	149	158	167
	M	86	95	104	113	122
	L	41	50	59	68	77
Car - Other	H	132	141	150	159	168
	M	87	96	105	114	123
	L	42	51	60	69	78
MB - MB	H	133	142	151	160	169
	M	88	97	106	115	124
	L	43	52	61	70	79
MB - 3W	H	134	143	152	161	170
	M	89	98	107	116	125
	L	44	53	62	71	80
MB - Other	H	135	144	153	162	171
	M	90	99	108	117	126
	L	45	54	63	72	81
3W - 3W	H	136	145	154	163	172
	M	91	100	109	118	127
	L	46	55	64	73	82
3W - Other	H	137	146	155	164	173
	M	92	101	110	119	128
	L	47	56	65	74	83
Other - Other	H	138	147	156	165	174
	M	93	102	111	120	129
	L	48	57	66	75	84

Table 17: Model estimations of level 02 on income categories vs HH members and drivers

Category		Vehicle Ownership Combinations								
		CMB	C3W	COth	MBMB	MB3W	MBOth	3W3W	3WOth	OthOth
Drivers										
Drivers	*Estimate*	-0.4177	-0.3633	-1.077	0.6385	-0.2552	-0.7894	0.9884	-0.9416	-2.669
	Std. Error	0.114	0.198	0.263	0.132	0.124	0.177	0.236	0.278	0.744
	T Ratio	-3.7	-1.8	-4.1	4.9	-2.1	-4.5	4.2	-3.4	-3.6
HHS_HHI Categories										
HHS1_HHIL	*Estimate*	0.000028			0.000083		0.000161	0.000245		
	Std. Error	0.000063			0.000075		0.000078	0.000076		
	T Ratio	0.5			1.1		2.1	3.2		
HHS2_HHIL	*Estimate*	0.000140	0.000191	0.000145	0.000176	0.000273	0.000316			
	Std. Error	0.000055	0.000087	0.000096	0.000073	0.000058	0.000089			
	T Ratio	2.5	2.2	1.5	2.4	4.7	3.6			
HHS3_HHIL	*Estimate*	0.000440	0.000530	0.000448	0.000535	0.000707	0.000709	0.000699	0.000683	0.000729
	Std. Error	0.000097	0.000122	0.000129	0.000115	0.000100	0.000135	0.000124	0.000150	0.000187
	T Ratio	4.5	4.4	3.5	4.7	7.1	5.2	5.6	4.6	3.9
HHS4_HHIL	*Estimate*	0.000557	0.000692	0.000446	0.000759	0.000964	0.000972	0.000845	0.000943	0.000798
	Std. Error	0.000106	0.000139	0.000162	0.000133	0.000110	0.000161	0.000145	0.000175	0.000246
	T Ratio	5.3	5	2.7	5.7	8.7	6	5.8	5.4	3.2
HHS5_HHIL	*Estimate*	0.000786	0.001073	0.000582	0.001080	0.001411	0.001457	0.001419	0.001367	0.001383
	Std. Error	0.000166	0.000205	0.000268	0.000200	0.000171	0.000231	0.000200	0.000251	0.000324
	T Ratio	4.7	5.2	2.2	5.4	8.2	6.3	7.1	5.4	4.3
HHS1_HHIM	*Estimate*	0.000010	0.000040							
	Std. Error	0.000016	0.000022							
	T Ratio	0.6	1.8							
HHS2_HHIM	*Estimate*	0.000032	0.000016	0.000037	-0.000014	0.000009	0.000034		0.000067	0.000079

Category		Vehicle Ownership Combinations								
		CMB	**C3W**	**COth**	**MBMB**	**MB3W**	**MBOth**	**3W3W**	**3WOth**	**OthOth**
	Std. Error	0.000017	0.000039	0.000031	0.000031	0.000025	0.000042		0.000042	0.000049
	T Ratio	1.9	0.4	1.2	-0.4	0.3	0.8		1.6	1.6
HHS3_HHIM	*Estimate*	0.000054	0.000037	0.000053	0.000027	0.000077	0.000129	0.000024	0.000120	0.000136
	Std. Error	0.000018	0.000036	0.000034	0.000028	0.000021	0.000037	0.000056	0.000044	0.000058
	T Ratio	3.1	1	1.6	1	3.7	3.5	0.4	2.8	2.3
HHS4_HHIM	*Estimate*	0.000109	0.000108	0.000110	0.000101	0.000151	0.000222	0.000025	0.000197	0.000108
	Std. Error	0.000023	0.000040	0.000040	0.000036	0.000026	0.000047	0.000074	0.000054	0.000095
	T Ratio	4.8	2.7	2.7	2.8	5.8	4.7	0.3	3.7	1.1
HHS5_HHIM	*Estimate*	0.000153	0.000202	0.000167	0.000187	0.000271	0.000307	0.000287	0.000312	0.000185
	Std. Error	0.000034	0.000053	0.000057	0.000050	0.000037	0.000064	0.000051	0.000071	0.000126
	T Ratio	4.6	3.8	3	3.7	7.4	4.8	5.6	4.4	1.5
HHS1_HHIH	*Estimate*									
	Std. Error									
	T Ratio									
HHS2_HHIH	*Estimate*	-0.000014			-0.000038					
	Std. Error	0.000006			0.000020					
	T Ratio	-2.4			-1.9					
HHS3_HHIH	*Estimate*	-0.000021	- 0.000008	0.000000	-0.000044	- 0.000038	- 0.000021			
	Std. Error	0.000007	0.000014	0.000011	0.000017	0.000017	0.000028			
	T Ratio	-3	-0.6	0	-2.5	-2.3	-0.7			
HHS4_HHIH	*Estimate*	-0.000025	0.000007	0.000013	-0.000072	- 0.000052	- 0.000003		- 0.000005	0.000018
	Std. Error	0.000010	0.000015	0.000015	0.000023	0.000020	0.000025		0.000038	0.000039
	T Ratio	-2.5	0.5	0.9	-3.1	-2.6	-0.1		-0.1	0.5

Category		Vehicle Ownership Combinations								
		CMB	**C3W**	**COth**	**MBMB**	**MB3W**	**MBOth**	**3W3W**	**3WOth**	**OthOth**
HHS5_HHIH	*Estimate*	-0.000032	-0.000009	-0.000005	-0.000066	-0.000025	-0.000013	-0.000025	0.000023	0.000000
	Std. Error	0.000012	0.000022	0.000023	0.000026	0.000016	0.000034	0.000037	0.000024	0.000058
	T Ratio	-2.6	-0.4	-0.2	-2.5	-1.5	-0.4	-0.7	1	0

Observations accepted for processing	*13161*
Likelihood with Zero Coefficients	-6622.23
Likelihood with Constants only	-5069.93
Initial Likelihood	-6622.23
Final value of Likelihood	-4418.36
"Rho-Squared" w.r.t. Zero	0.3328
"Rho-Squared" w.r.t. Constants	0.1285

There is the highest tendency of owning two three-wheelers (3W_3W) and two motorbikes (MB_MB) respectively when there are only two vehicles per household compared to owning two cars, which is assumed, compared to the other considered vehicle combinations when the number of licensed drivers increased per household. All other vehicle combinations, Car_MB, Car_3W, Car_Oth, MB_3W, MB_Other, 3W_Other, and Other_Other are negatively correlated compared to owning two cars when the number of licensed drivers increased per household.

It seems that vehicle ownership decision for level 02, owning only two vehicles also vary based on two main concerns, including household income level and the number of household members, and concerning that factor, estimations were obtained under aforementioned 15 categories based on such two criteria, household income and the number of members.

In-depth analysis against HH members and the average income of households under 15 categories provides sensible outputs. Accordingly, for all low-income group households, despite their number of household members, positively correlated coefficients were observed for all available vehicle type compared to owning two cars. Besides, when the income level increase, the tendency of owning two cars compared to other vehicle combinations is gradually increasing, which is highly elaborated with high income category, as summarized in Table 17.

The t-ratios for most of the variables under all nine mode combinations are greater than 1.96, suggest that the parameters are statistically significantly different from 0 at the 95% confidence level. T values with respect to the number of drivers in a household are greater than 1.96. As can be observed from Table 17, the ρ2(0) value is low. This may be due to available attributes being insufficient to distinguish between the different choices. However, the goodness of fit measures like adjusted rho square has reduced compared to the rho with respect to zero. Likelihood value was also calculated with zero coefficients and with constants only, which also indicate that model fit better. Accordingly, utility functions compared to car selection under the first model could be finalized as follows.

V_{CMB}= **- 0.4177** (Drivers_CMB) **+ 0.00002819** (HHS1_HHIL_CMB) **+ 0.0001399** (HHS2_HHIL_CMB) **+ 0.0004396** (HHS3_HHIL_CMB) **+ 0.0005574** (HHS4_HHIL_CMB) **+ 0.0007861** (HHS5_HHIL_CMB) **+ 0.00001001** (HHS1_HHIM_CMB) **+ 0.00003188** (HHS2_HHIM_CMB) **+ 0.00005439** (HHS3_HHIM_CMB) **+ 0.0001094** (HHS4_HHIM_CMB) **+ 0.0001534** (HHS5_HHIM_CMB) **- 0.00001369** (HHS2_HHIH_CMB) **- 0.00002137** (HHS3_HHIH_CMB) **- 0.00002451** (HHS4_HHIH_CMB) **- 0.00003195** (HHS5_HHIH_CMB) **- 0.6843**

[Equation 12]

V_{C3W}= **- 0.3633** (Drivers_C3W) **+ 0.0001912** (HHS2_HHIL_C3W) **+ 0.0005299** (HHS3_HHIL_C3W) **+ 0.0006923** (HHS4_HHIL_C3W) **+ 0.001073** (HHS5_HHIL_C3W) **+ 0.00003961** (HHS1_HHIM_C3W) **+ 0.00001557** (HHS2_HHIM_C3W) **+ 0.00003666** (Estimate_C3W) **+ 0.0001082** (HHS4_HHIM_C3W) **+ 0.0002018** (HHS5_HHIM_C3W) **- 0.000008486** (HHS3_HHIH_C3W) **+ 0.000007115** (HHS4_HHIH_C3W) **- 0.000008763** (HHS5_HHIH_C3W) **-2.216**

[Equation 13]

V_{COth} = **-1.077** (Drivers_COth) **+ 0.000145** (HHS2_HHIL_COth) **+ 0.0004483** (HHS3_HHIL_COth) **+ 0.0004462** (HHS4_HHIL_COth) **+ 0.0005818** (HHS5_HHIL_COth) **+ 0.00003695** (HHS2_HHIM_COth) **+ 0.00005339** (HHS2_HHIM_COth) **+ 0.00011** (HHS4_HHIM_COth) **+ 0.0001673** (HHS5_HHIM_COth) **+ 0.000000258** (HHS3_HHIH_COth) **+ 0.00001262** (HHS4_HHIH_COth) **- 0.000004537** (HHS5_HHIH_COth) **- 1.945**

[Equation 14]

V_{MBMB}= **+ 0.6385** (Drivers_MBMB) **+ 0.0000827** (HHS1_HHIL_MBMB) **+ 0.0001755** (HHS2_HHIL_MBMB) **+ 0.0005345** (HHS3_HHIL_MBMB) **+ 0.0007586** (HHS4_HHIL_MBMB) **+ 0.00108** (HHS5_HHIL_MBMB) **- 0.00001356** (HHS2_HHIM_MBMB) **+ 0.00002701** (HHS3_HHIM_MBMB) **+ 0.0001012** (HHS4_HHIM_MBMB) **+ 0.0001865** (HHS5_HHIM_MBMB) **- 0.00003802** (HHS2_HHIH_MBMB) **- 0.00004423** (HHS3_HHIH_MBMB) **- 0.0000716** (HHS4_HHIH_MBMB) **-0.00006554** (HHS5_HHIH_MBMB) **- 1.28**

[Equation 15]

V_{MBOth}= **- 0.7894** (Drivers_MBOth) **+ 0.0001607** (HHS1_HHIL_MBOth) **+ 0.0003156** (HHS2_HHIL_MBOth) **+ 0.0007085** (HHS3_HHIL_MBOth) **+ 0.000972** (HHS4_HHIL_MBOth) **+ 0.001457** (HHS5_HHIL_MBOth) **+ 0.00003416** (HHS2_HHIM_MBOth) **+ 0.0001286**

(HHS3_HHIM_MBOth) **+ 0.0002217** (HHS4_HHIM_MBOth) **+ 0.0003071** (HHS5_HHIM_MBOth) **- 0.00002074** (HHS3_HHIH_MBOth) **- 0.000003289** (HHS4_HHIH_MBOth) **- 0.00001307** (HHS5_HHIH_MBOth) **- 2.626**

[Equation 16]

$\mathbf{V_{3W3W}}$= **+ 0.9884** (Drivers_3W3W) **+ 0.0002449** (HHS1_HHIL_3W3W) **+ 0.0006985** (HHS3_HHIL_3W3W) **+ 0.000845** (HHS4_HHIL_3W3W) **+ 0.001419** (HHS5_HHIL_3W3W) **+ 0.00002443** (Estimate_3W3W) **+ 0.00002465** (HHS4_HHIM_3W3W) **+ 0.0002873** (HHS5_HHIM_3W3W) **- 0.00002461** (HHS5_HHIH_3W3W) **- 4.626**

[Equation 17]

$\mathbf{V_{3WOth}}$= **- 0.9416** (Drivers_3WOth) **+ 0.0006828** (HHS3_HHIL_3WOth) **+ 0.000943** (HHS4_HHIL_3WOth) **+ 0.001367** (HHS5_HHIL_3WOth) **+ 0.00006653** (HHS2_HHIM_3WOth) (HHS3_HHIM _3WOth) **+ 0.0001965** (HHS4_HHIM_3WOth) **+ 0.0003122** (HHS5_HHIM_3WOth) **- 0.000004836** (HHS4_HHIH_3WOth) **+ 0.00002331** (HHS5_HHIH_3WOth)

[Equation 18]

$\mathbf{V_{OthOth}}$= **- 2.669** (Drivers_OthOth) **+ 0.0007286** (HHS3_HHIL_OthOth) **+ 0.0007982** (HHS4_HHIL_OthOth) **+ 0.001383** (HHS5_HHIL_OthOth) **+ 0.00007911** (HHS2_HHIM_OthOth) **+ 0.0001357** (HHS3_HHIM_OthOth) **+ 0.0001083** (HHS4_HHIM_OthOth) **+ 0.0001854** (HHS5_HHIM_OthOth) **+ 0.00001832** (HHS4_HHIH_OthOth) **+ 0.0000002477** (HHS5_HHIH_OthOth) **-3.726**

[Equation 19]

$\mathbf{V_{CC}} = 0$

[Equation 20]

5.2.3 Three or more vehicles ownership model

As shown in Figure 23, twenty vehicle combinations are considered as follows.

1. Car_Car_Car
2. Car_Car_MB
3. Car_Car_3W
4. Car_Car_Other
5. Car_MB_MB
6. Car_MB_3W
7. Car_MB_Other
8. Car_3W_3W
9. Car_3W_Other
10. Car_Other_Other
11. MB_MB_MB
12. MB_MB_3W
13. MB_MB_Other
14. MB_3W_3W
15. MB_3W_Other
16. MB_Other_Other
17. 3W_3W_3W
18. 3W_3W_Other
19. 3W_Other_Other
20. Other_Other_Other

Since the level 02 model was realized as a single level logit model instead of being a nested logit model, the level 03 model was also analyzed as a single level logit model. Similar to the level 01 and level 02 models, the five basic combined categories made up of the number of household members and household income categories were used.

The initially defined twenty vehicle choice combinations were applied for level 03, however, the utility of the Car_Car_Car option is considered as a constant where model outputs are generated compared to it. And thus, the low-income category has been evaluated under 95 parameters, whereas 285 parameters were set for all three income groups under level 03. Complete List of Parameters used for the development of level 02 is attached to the report as Appendix C.

Thus, each data item was assigned to one data item out of those 285 data fields and defined as 1 and otherwise 0. Accordingly, model output was generated, and summary of results is shown in Table 19. However, based on the data availability, some of the parameters were not exist. Therefore, such parameters were eliminated from the model and non-use parameters are highlighted in Table 18.

Table 18: Summary of used and non-use parameters in level 03 model

Mode Combinations	Income Category	HH Members				
		1	2	3	4	4+
CCMB	H	40	249	268	287	306
	M	230	154	173	192	211
	L	135	59	78	97	116
CC3W	H	41	250	269	288	307
	M	88.5	155	174	193	212
	L	79.3	60	79	98	117
CCOth	H	42	251	270	289	308
	M	232	156	175	194	213
	L	137	61	80	99	118
CMBMB	H	43	252	271	290	309
	M	233	157	176	195	214
	L	138	62	81	100	119
CMB3W	H	44	253	272	291	310
	M	234	158	177	196	215
	L	139	63	82	101	120
CMBOth	H	45	254	273	292	311
	M	235	159	178	197	216
	L	140	64	83	102	121
C3W3W	H	46	255	274	293	312
	M	236	160	179	198	217
	L	141	65	84	103	122
C3WOth	H	47	256	275	294	313
	M	237	161	180	199	218

Mode Combinations	Income Category	HH Members				
		1	2	3	4	4+
	L	142	66	85	104	123
COthOth	H	48	257	276	295	314
	M	238	162	181	200	219
	L	143	67	86	105	124
MBMBMB	H	49	258	277	296	315
	M	239	163	182	201	220
	L	144	68	87	106	125
MBMB3W	H	50	259	278	297	316
	M	240	164	183	202	221
	L	145	69	88	107	126
MBMBOth	H	51	260	279	298	317
	M	241	165	184	203	222
	L	146	70	89	108	127
MB3W3W	H	52	261	280	299	318
	M	242	166	185	204	223
	L	147	71	90	109	128
MB3WOth	H	53	262	281	300	319
	M	243	167	186	205	224
	L	148	72	91	110	129
MBOthOth	H	54	263	282	301	320
	M	244	168	187	206	225
	L	149	73	92	111	130
3W3W3W	H	55	264	283	302	321
	M	245	169	188	207	226
	L	150	74	93	112	131
3W3WOth	H	56	265	284	303	322
	M	246	170	189	208	227
	L	151	75	94	113	132
3WOthOth	H	57	266	285	304	323
	M	247	171	190	209	228
	L	152	76	95	114	133
OthOthOth	H	58	267	286	305	324
	M	248	172	191	210	229
	L	153	77	96	115	134

Table 19: Model estimations of level 03 on income categories vs HH members and drivers

Category		Vehicle Ownership Combinations																		
		CCMB	CC3W	CCOth	CMBMB	CMB3W	CMBOth	C3W3W	C3WOth	COthOth	MBMBMB	MBMB3W	MBMBOth	MB3W3W	MB3WOth	MBOthOth	3W3W3W	3W3WOth	3WOthOth	OthOthOth
Drivers																				
Drivers	Estimate	-0.03024		-0.5444	0.3373	-0.3216	-0.9597	-0.002451			1.094	0.3998	-0.2737	0.4997	-1.245	-2.107	1.96	1.289	-0.5516	-0.3999
	Std. Error	0.27		0.549	0.229	0.29	0.351	0.873			0.332	0.276	0.566	0.442	0.483	0.771	0.9	1.15	0.815	0.684
	T Ratio	-0.1		-1	1.5	-1.1	-2.7	0			3.3	1.5	-0.5	1.1	-2.6	-2.7	2.2	1.1	-0.7	-0.6
HHS_HHI Categories																				
HHS1_HHIL	Estimate																			
	Std. Error																			
	T Ratio																			
HHS2_HHIL	Estimate																			
	Std. Error																			
	T Ratio																			
HHS3_HHIL	Estimate	0.000235				0.000326	0.000268					0.000618	0.000487		0.000683					
	Std. Error	0.000162				0.000162	0.000146					0.000148	0.000172		0.000204					
	T Ratio	1.5				2	1.8					4.2	2.8		3.4					
HHS4_HHIL	Estimate	0.000130			0.000207	0.000320	0.000123				0.000578	0.000744			0.000865					
	Std. Error	0.000199			0.000162	0.000191	0.000192				0.000187	0.000169			0.000247					
	T Ratio	0.7			1.3	1.7	0.6				3.1	4.4			3.5					
HHS5_HHIL	Estimate	0.00007358			0.000317	0.000469					0.000222	0.000896			0.001064	0.000665				
	Std. Error	0.000226			0.000166	0.000211					0.000288	0.000189			0.000307	0.000252				
	T Ratio	0.3			1.9	2.2					0.8	4.8			3.5	2.6				
HHS1_HHIM	Estimate																			
	Std. Error																			
	T Ratio																			
HHS2_HHIM	Estimate																			
	Std. Error																			
	T Ratio																			
HHS3_HHIM	Estimate	0.000006215			-0.0000115	0.00001869						0.00007119								
	Std. Error	0.0000441			0.0000392	0.0000488						0.0000476								
	T Ratio	0.1			-0.3	0.4						1.5								
HHS4_HHIM	Estimate	0.0001996			0.0001283	0.0001414	0.0001065					0.0001850			0.0003127	0.0002262				
	Std. Error	0.000057			0.0000577	0.0000694	0.0000644					0.0000700			0.0000882	0.0000740				
	T Ratio	3.5			2.2	2	1.7					2.6			3.5	3.1				
HHS5_HHIM	Estimate	0.000001421		0.000086	0.000017	0.000107					0.000136	0.000151		0.000070	0.000192	0.000111				
	Std. Error	0.0000604		0.000083	0.000051	0.000065					0.000061	0.000063		0.000076	0.000112	0.000086				
	T Ratio	0		1	0.3	1.7					2.3	2.4		0.9	1.7	1.3				
HHS1_HHIH	Estimate																			
	Std. Error																			
	T Ratio																			
HHS2_HHIH	Estimate																			
	Std. Error																			
	T Ratio																			
HHS3_HHIH	Estimate				-0.00002815	-0.00001024							0.00000799							
	Std. Error				0.0000194	0.0000165							0.0000122							
	T Ratio				-1.5	-0.6							0.7							
HHS4_HHIH	Estimate	0.000003237		0.00001454	-0.00002943	-0.000005669	0.000009469					0.000004132								
	Std. Error	0.0000128		0.0000182	0.0000184	0.0000201	0.0000121					0.0000182								
	T Ratio	0.3		0.8	-1.6	-0.3	0.8					0.2								
HHS5_HHIH	Estimate	-0.00001008			-0.000008075	-0.00004052	-0.00001739			0.00002519	-0.00000006									
	Std. Error	0.0000216			0.0000173	0.0000422	0.0000239			0.0000211	0.0000276									
	T Ratio	-0.5			-0.5	-1	-0.7			1.2	0									

Observations accepted for processing	*13161*
Likelihood with Zero Coefficients	-1120.4
Likelihood with Constants only	-912.511
Initial Likelihood	-1120.4

Final value of Likelihood	-832.818
"Rho-Squared" w.r.t. Zero	0.2567
"Rho-Squared" w.r.t. Constants	0.0873

There is the highest tendency of owning three three-wheelers (3W_3W_3W), two three-wheelers and one other type of vehicle (3W_3W_Other) and three motorbikes (MB_MB_MB) respectively when there are 3 or more vehicles per household compared to owning three cars, which is assumed, compared to the other considered vehicle combinations when the number of licensed drivers increased per household. In addition, Car_MB_MB and MB_MB_3W vehicle combination options are also positively correlated compared to owning three or more cars when the number of licensed drivers in a household increase. All other vehicle combinations are negatively correlated compared to owning three or more cars when the number of licensed drivers increased per household.

It seems that vehicle ownership decision for level 03, owning three or more vehicles also vary based on two main concerns, including household income level and the number of household members, and concerning that factor, estimations were obtained under aforementioned 15 categories based on such two criteria, household income and the number of members.

In-depth analysis against HH members and the average income of households under 15 categories provides sensible outputs. Accordingly, for all low-income group households, despite their number of household members, positively correlated coefficients were observed for all available vehicle type compared to owning three or more cars.

Besides, when the income level increase, the tendency of owning three cars compared to other vehicle combinations is gradually increasing, which is highly elaborated with high income category, as summarized in Table 19.

The t-ratios for 5 mode combinations are greater than 1.96, suggest that the parameters are statistically significantly different from 0 at the 95% confidence level with respect to the number of licensed drivers in a household. However, rest of the active 11 variables are less than 1.96, suggest that the parameters are not statistically significantly different from 0 at the 95% confidence level with respect to the number of licensed drivers in a household. As can be observed from Table 19, the $\rho2(0)$ value is low. This may be due to available attributes being insufficient to distinguish between the different choices. However, the goodness of fit measures like adjusted rho square has reduced compared to the rho with respect to zero. Likelihood value was also calculated with zero coefficients and with constants only, which also indicate that model fit better.

Accordingly, utility functions compared to car selection under the first model could be finalized as follows.

$\mathbf{V_{CCMB}}$= **-** 0.03024 (Drivers_CCMB) + **0.0002349** (HHS3_HHIL_CCMB) **+ 0.0001301** (HHS4_HHIL_CCMB) **+ 0.00007358** (HHS5_HHIL_CCMB) **+ 0.000006215** (HHS3_HHIM_CCMB) **+ 0.0001996** (HHS4_HHIM_CCMB) **+ 0.000001421**

[Equation 21]

$\mathbf{V_{CCOth}}$ = **- 0.5444** (Drivers_CCOth) **+ 0.00008643** (HHS5_HHIM_CCOth) **+ 0.00001454** (HHS4_HHIH_CCOth) **- 0.9882**

[Equation 22]

$\mathbf{V_{CMBMB}}$ = **+ 0.3373** (Drivers_CMBMB) **+ 0.0002073** (HHS4_HHIL_CMBMB) **+ 0.000317** (HHS5_HHIL_CMBMB) **-0.0000115** (HHS3_HHIM_CMBMB) **+ 0.0001283** (HHS4_HHIM_CMBMB) **+ 0.00001717** (HHS5_HHIM_CMBMB) **- 0.00002815** (HHS3_HHIH_CMBMB) **- 0.00002943** (HHS4_HHIH_CMBMB) **- 0.000008075** (HHS5_HHIH_CMBMB) **+ 0.7531**

[Equation 23]

$\mathbf{V_{CMB3W}}$= **- 0.3216** (Drivers_CMB3W) **+ 0.0003261** (HHS3_HHIL_CMB3W) **+ 0.0003198** (HHS4_HHIL_CMB3W) **+ 0.000469** (HHS5_HHIL_CMB3W) + **0.00001869** (HHS3_HHIM_CMB3W) **+ 0.0001414** (HHS4_HHIM_CMB3W) **+ 0.0001067** (HHS5_HHIM_CMB3W) **- 0.00001024** (HHS3_HHIH_CMB3W) **- 0.000005669** (HHS4_HHIH_CMB3W) **- 0.00004052** (HHS5_HHIH_CMB3W) **+ 0.2382**

[Equation 24]

$\mathbf{V_{CMBOth}}$= **- 0.9597** (Drivers_CMBOth) **+ 0.0002684** (HHS3_HHIL_CMBOth) **+ 0.0001227** (HHS4_HHIL_CMBOth) **+ 0.0001065** (HHS4_HHIM_CMBOth) **+ 0.000009469** (HHS4_HHIH_CMBOth) **- 0.00001739** (HHS5_HHIH_CMBOth) **+ 0.8367**

[Equation 25]

$\mathbf{V_{C3W3W}}$= **- 0.002451** (Drivers_C3W3W) **-2.349**

[Equation 26]

$\mathbf{V_{C3WOth}}$= **- 1.946**

[Equation 27]

$V_{COthOth}$= **+ 0.00002519** (HHS5_HHIH_COthOth) **- 1.664**

[Equation 28]

V_{MBMBMB}= **+ 1.094** (Drivers_MBMBMB) **+ 0.0005781** (HHS4_HHIL_MBMBMB) **+ 0.0002219** (HHS5_HHIL_MBMBMB) **+ 0.0001361** (HHS5_HHIM_MBMBMB) **- 0.00000006295** (HHS5_HHIH_MBMBMB) **- 2.21**

[Equation 29]

V_{MBMB3W}= **+ 0.3998** (Drivers_MBMB3W) **+ 0.0006179** (HHS3_HHIL_MBMB3W) **+ 0.0007436** (HHS4_HHIL_MBMB3W) **+ 0.0008957** (HHS5_HHIL_MBMB3W) **+ 0.00007119** (HHS3_HHIM_MBMB3W) **+ 0.000185** (HHS4_HHIM_MBMB3W) **+ 0.0001512** (HHS5_HHIM_MBMB3W) **+ 0.000004132** (HHS4_HHIH_MBMB3W) **- 1.373**

[Equation 30]

$V_{MBMBOth}$ = **- 0.2737** (Drivers_MBMBOth) **+ 0.0004871** (HHS3_HHIL_MBMBOth) **+ 0.00000799** (HHS3_HHIH_MBMBOth) **- 1.26**

[Equation 31]

V_{MB3W3W}= **+ 0.4997** (Drivers_MB3W3W) **+ 0.00007012** (HHS5_HHIM_MB3W3W) **- 1.747**

[Equation 32]

$V_{MB3WOth}$= **- 1.245** (Drivers_MB3WOth **+ 0.000683** (HHS3_HHIL_MB3WOth) **+ 0.0008651** (HHS4_HHIL_MB3WOth) **+ 0.001064** (HHS5_HHIL_MB3WOth **+ 0.0003127** (HHS4_HHIM_MB3WOth) + **0.0001917** (HHS5_HHIM_MB3WOth) **- 1.859**

[Equation 33]

$V_{MBOthOth}$= **- 2.107** (Drivers_MBOthOth) **+ 0.0006649** (HHS5_HHIL_MBOthOth) **+ 0.0002262** (HHS4_HHIM_MBOthOth) **+ 0.0001113** (HHS5_HHIM_MBOthOth) **- 0.6429**

[Equation 34]

V_{3W3W3W}= **+ 1.96** (Drivers_3W3W3W) **- 5.784**

[Equation 35]

$V_{3W3WOth}$ = **+ 1.289** (Drivers_3W3WOth) **- 4.965**

[Equation 36]

$\mathbf{V_{3WOthOth}} = \mathbf{-\ 0.5516}$ (Drivers_3WOthOth) $\mathbf{-\ 1.49}$

[Equation 37]

$\mathbf{V_{OthOthOth}} = \mathbf{-\ 0.3999}$ (Drivers_OthOthOth) $\mathbf{-\ 1.31}$

[Equation 38]

$\mathbf{V_{CCC}} = 0$

[Equation 39]

6 CONCLUSION AND RECOMMENDATIONS

Personal vehicle type ownership models for the Western Province of Sri Lanka are presented in this study. The research objective is to learn about the attributes and factors that lead to the varying ownership of different types of vehicles in a household. Therefore, three important features were identified as showing a significant influence on the possession of several vehicles in a household. Some of them split into groups. These characteristics were the average household income, the number of licensed drivers belonging to a household, and the number of household members. There, the number of household members implies the direct transport demand generated aspect of the people that are mostly taken into consideration than the age variation of the family members, gender of family members, and the social status of household members. All these features were separately evaluated as part of the development of the level 01 model, which targeted households with a single car, the highest preference of vehicle ownership with the dataset used that was counted, as 13,161. The estimation of coefficients of utility equation was done by ALOGIT software.

The Model development was done employing three levels; single-vehicle own households, two-vehicle own households as well as three or more vehicles own households distinctly. There, the level 01 model was developed assuming that there is a single-level logit model, under-considered four vehicle types, cars, motorcycles, three-wheelers, and all other personal use vehicle types. The utility functions for the level 01 model were developed initially, assuming that the car is the most prioritized mode among them. Hence utility functions were developed compared to the car where the utility of the car is depicted as zero. There, to eradicate obtaining average coefficient values, different categories were created based on the number of households against the three income groups defined as high, medium, and low. Accordingly, 03 separate utility functions were derived. The model outputs received from the level 01 model were rational and comprehensible, which implies that when the number of household members and income level increases, there is an increased tendency in owning cars compared other three personal use vehicle types. The households with low income and the number of household members are less, the tendency for obtaining a motorbike is high. Furthermore, the households with low income and number of household members are high, the tendency for obtaining a three-wheeler is high.

Initially, it was assumed that the second and third level models are followed the nested logit model structure where if the first type of vehicle ownership known, succeeding layers could derive from it. However, once the model is carried out with a nested logit model, all the nested coefficients become one, which implies that there was no nested structure; instead, it is undeviating linked to the root. Accordingly, the control file was re-prepared as a single level logit model while following the same assumptions and methods used in the development of the level 01 model. There also, subcategories were used against the number of household members and income levels, thus realizing that high-income group households showed a higher tendency for owning two cars, which was defined as the based utility value. Moreover, that low-income group households with low household members tend to own motorbikes and also when the household members are high, the tendency for owning a three-wheeler is high, compared to owning two cars. Medium income category households are also provided expedient and sensible outputs against the number of household members, which vary where most of them were varying between motorbikes and three-wheelers ownership against the owning two cars.

As the level 02 model is followed by the single-level logit model, the level 03 model for three or more vehicle own households was developed. There also, subcategories were used against the number of household members and income levels, thus realizing that high-income group households showed a higher tendency for owning three cars, which was defined as the based utility value, making it zero. Moreover, those low-income group households with low household members tend to own three motorbikes while when the household members are high, the tendency for owning three three-wheelers is high compared to owning three cars. Similar, behavior was observed from medium-income category households as in the level 02 model. However, the level 03 model is not supported for all defined 285 categories as the sample distribution among those was minimal and negligible. Therefore, to develop the level 03 model, data population is required to enhance significantly to capture more households with different choice options.

The three models developed for illustration purposes can be applied to test several policy scenarios. Availability of personal use vehicles and the type of personal vehicle ownership are major factors in travel behavior and play an important role in predicting travel demand. The main objective of this research is to assist urban planners and traffic-related designers to address planning and traffic issues so that these models can be used to improve the capability of modeling systems because the vehicle type characteristic influences the travel decision in the western province of Sri Lanka.

As this research focuses on the status of vehicle ownership in the western province of Sri Lanka, it is truly important to pay attention to the safety aspect in an urban context. Considering the huge existing traffic situation, problems related to public transportation in the study area, and due to the economic condition, low and middle-income families are highly inclined to own and use motorcycles and three-wheeled vehicles. However, as a result, road accidents have gradually increased in the urban context of the western province. It is therefore recommended that the use of three-wheelers and motorcycles be regulated as much as possible, especially in city centres. There have been several proposals to impose tariffs based on the entry of low-passenger vehicles into Colombo as well as restricting entry of three-wheelers and motorbikes entirely. However, these measures cannot be implemented yet because they require appropriate solutions for the parties affected by such measures, as transportation in a country must ensure inclusiveness for every citizen. Therefore, the development of public transport networks while ensuring reliability and comfort is an essential requirement to be taken well in advance.

On the other hand, as a result of this research, it has been observed that when the household income increases and the number of licensed drivers in the household increases, the ownership of cars, vans and SUVs increases exponentially. This trend has had negative effects on urban traffic conditions, especially in the metropolitan area of Colombo. Hence, effective measures are needed to adapt, reduce and control vehicle entrances. This can achieve by providing adequate parking facilities for each main corridor entering vital city centres and operating well-defined luxury transportation services to respective offices and other demanded places of travel in major cities.

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APPENDICES

Appendix A: Parameters used in level 01 model

Income Category	ID	Parameter ID	Parameter Code	Inclusion in the Final Model [Yes = 1, No =0]
Low Income	1	40	HHS1_HHIL_MB	1
	2	41	HHS1_HHIL_3W	1
	3	42	HHS1_HHIL_Oth	1
	4	43	HHS2_HHIL_MB	1
	5	44	HHS2_HHIL_3W	1
	6	45	HHS2_HHIL_Oth	1
	7	46	HHS3_HHIL_MB	1
	8	47	HHS3_HHIL_3W	1
	9	48	HHS3_HHIL_Oth	1
	10	49	HHS4_HHIL_MB	1
	11	50	HHS4_HHIL_3W	1
	12	51	HHS4_HHIL_Oth	1
	13	52	HHS5_HHIL_MB	1
	14	53	HHS5_HHIL_3W	1
	15	54	HHS5_HHIL_Oth	1
Medium Income	16	55	HHS1_HHIM_MB	1
	17	56	HHS1_HHIM_3W	1
	18	57	HHS1_HHIM_Oth	1
	19	58	HHS2_HHIM_MB	1
	20	59	HHS2_HHIM_3W	1
	21	60	HHS2_HHIM_Oth	1
	22	61	HHS3_HHIM_MB	1
	23	62	HHS3_HHIM_3W	1
	24	63	HHS3_HHIM_Oth	1
	25	64	HHS4_HHIM_MB	1
	26	65	HHS4_HHIM_3W	1
	27	66	HHS4_HHIM_Oth	1
	28	67	HHS5_HHIM_MB	1
	29	68	HHS5_HHIM_3W	1
	30	69	HHS5_HHIM_Oth	1
Low Income	31	70	HHS1_HHIH_MB	1
	32	-71	HHS1_HHIH_3W	0
	33	-72	HHS1_HHIH_Oth	0
	34	73	HHS2_HHIH_MB	1
	35	74	HHS2_HHIH_3W	1
	36	75	HHS2_HHIH_Oth	1
	37	76	HHS3_HHIH_MB	1
	38	77	HHS3_HHIH_3W	1

Income Category	ID	Parameter ID	Parameter Code	Inclusion in the Final Model [Yes = 1, No =0]
	39	78	HHS3_HHIH_Oth	1
	40	79	HHS4_HHIH_MB	1
	41	80	HHS4_HHIH_3W	1
	42	81	HHS4_HHIH_Oth	1
	43	82	HHS5_HHIH_MB	1
	44	83	HHS5_HHIH_3W	1
	45	84	HHS5_HHIH_Oth	1

Appendix B: Parameters used in level 02 model

Income Category	ID	Parameter Code	Parameter_ID	Inclusion in the Final Model [Yes = 1, No =0]
Low Income	1	40	HHS1_HHIL_C_MB	1
	2	-41	HHS1_HHIL_C_3W	0
	3	-42	HHS1_HHIL_C_Oth	0
	4	43	HHS1_HHIL_MB_MB	1
	5	-44	HHS1_HHIL_MB_3W	0
	6	45	HHS1_HHIL_MB_Oth	1
	7	46	HHS1_HHIL_3W_3W	1
	8	-47	HHS1_HHIL_3W_Oth	0
	9	-48	HHS1_HHIL_Oth_Oth	0
	10	49	HHS2_HHIL_C_MB	1
	11	50	HHS2_HHIL_C_3W	1
	12	51	HHS2_HHIL_C_Oth	1
	13	52	HHS2_HHIL_MB_MB	1
	14	53	HHS2_HHIL_MB_3W	1
	15	54	HHS2_HHIL_MB_Oth	1
	16	-55	HHS2_HHIL_3W_3W	0
	17	-56	HHS2_HHIL_3W_Oth	0
	18	-57	HHS2_HHIL_Oth_Oth	0
	19	58	HHS3_HHIL_C_MB	1
	20	59	HHS3_HHIL_C_3W	1
	21	60	HHS3_HHIL_C_Oth	1
	22	61	HHS3_HHIL_MB_MB	1
	23	62	HHS3_HHIL_MB_3W	1
	24	63	HHS3_HHIL_MB_Oth	1
	25	64	HHS3_HHIL_3W_3W	1
	26	65	HHS3_HHIL_3W_Oth	1
	27	66	HHS3_HHIL_Oth_Oth	1
	28	67	HHS4_HHIL_C_MB	1
	29	68	HHS4_HHIL_C_3W	1
	30	69	HHS4_HHIL_C_Oth	1
	31	70	HHS4_HHIL_MB_MB	1
	32	71	HHS4_HHIL_MB_3W	1
	33	72	HHS4_HHIL_MB_Oth	1
	34	73	HHS4_HHIL_3W_3W	1
	35	74	HHS4_HHIL_3W_Oth	1
	36	75	HHS4_HHIL_Oth_Oth	1
	37	76	HHS5_HHIL_C_MB	1
	38	77	HHS5_HHIL_C_3W	1
	39	78	HHS5_HHIL_C_Oth	1
	40	79	HHS5_HHIL_MB_MB	1

Income Category	ID	Parameter Code	Parameter_ID	Inclusion in the Final Model [Yes = 1, No =0]
	41	80	HHS5_HHIL_MB_3W	1
	42	81	HHS5_HHIL_MB_Oth	1
	43	82	HHS5_HHIL_3W_3W	1
	44	83	HHS5_HHIL_3W_Oth	1
	45	84	HHS5_HHIL_Oth_Oth	1
Medium Income	46	85	HHS1_HHIM_C_MB	1
	47	86	HHS1_HHIM_C_3W	1
	48	-87	HHS1_HHIM_C_Oth	0
	49	-88	HHS1_HHIM_MB_MB	0
	50	-89	HHS1_HHIM_MB_3W	0
	51	-90	HHS1_HHIM_MB_Oth	0
	52	-91	HHS1_HHIM_3W_3W	0
	53	-92	HHS1_HHIM_3W_Oth	0
	54	-93	HHS1_HHIM_Oth_Oth	0
	55	94	HHS2_HHIM_C_MB	1
	56	95	HHS2_HHIM_C_3W	1
	57	96	HHS2_HHIM_C_Oth	1
	58	97	HHS2_HHIM_MB_MB	1
	59	98	HHS2_HHIM_MB_3W	1
	60	99	HHS2_HHIM_MB_Oth	1
	61	-100	HHS2_HHIM_3W_3W	0
	62	101	HHS2_HHIM_3W_Oth	1
	63	102	HHS2_HHIM_Oth_Oth	1
	64	103	HHS3_HHIM_C_MB	1
	65	104	HHS3_HHIM_C_3W	1
	66	105	HHS3_HHIM_C_Oth	1
	67	106	HHS3_HHIM_MB_MB	1
	68	107	HHS3_HHIM_MB_3W	1
	69	108	HHS3_HHIM_MB_Oth	1
	70	109	HHS3_HHIM_3W_3W	1
	71	110	HHS3_HHIM_3W_Oth	1
	72	111	HHS3_HHIM_Oth_Oth	1
	73	112	HHS4_HHIM_C_MB	1
	74	113	HHS4_HHIM_C_3W	1
	75	114	HHS4_HHIM_C_Oth	1
	76	115	HHS4_HHIM_MB_MB	1
	77	116	HHS4_HHIM_MB_3W	1
	78	117	HHS4_HHIM_MB_Oth	1
	79	118	HHS4_HHIM_3W_3W	1
	80	119	HHS4_HHIM_3W_Oth	1
	81	120	HHS4_HHIM_Oth_Oth	1

Income Category	ID	Parameter Code	Parameter_ID	Inclusion in the Final Model [Yes = 1, No =0]
	82	121	HHS5_HHIM_C_MB	1
	83	122	HHS5_HHIM_C_3W	1
	84	123	HHS5_HHIM_C_Oth	1
	85	124	HHS5_HHIM_MB_MB	1
	86	125	HS5_HHIM_MB_3W	1
	87	126	HHS5_HHIM_MB_Oth	1
	88	127	HHS5_HHIM_3W_3W	1
	89	128	HHS5_HHIM_3W_Oth	1
	90	129	HHS5_HHIM_Oth_Oth	1
High Income	91	-130	HHS1_HHIH_C_MB	0
	92	-131	HHS1_HHIH_C_3W	0
	93	-132	HHS1_HHIH_C_Oth	0
	94	-133	HHS1_HHIH_MB_MB	0
	95	-134	HHS1_HHIH_MB_3W	0
	96	-135	HHS1_HHIH_MB_Oth	0
	97	-136	HHS1_HHIH_3W_3W	0
	98	-137	HHS1_HHIH_3W_Oth	0
	99	-138	HHS1_HHIH_Oth_Oth	0
	100	139	HHS2_HHIH_C_MB	1
	101	-140	HHS2_HHIH_C_3W	0
	102	-141	HHS2_HHIH_C_Oth	0
	103	142	HHS2_HHIH_MB_MB	1
	104	-143	HHS2_HHIH_MB_3W	0
	105	-144	HHS2_HHIH_MB_Oth	0
	106	-145	HHS2_HHIH_3W_3W	0
	107	-146	HHS2_HHIH_3W_Oth	0
	108	-147	HHS2_HHIH_Oth_Oth	0
	109	148	HHS3_HHIH_C_MB	1
	110	149	HHS3_HHIH_C_3W	1
	111	150	HHS3_HHIH_C_Oth	1
	112	151	HHS3_HHIH_MB_MB	1
	113	152	HHS3_HHIH_MB_3W	1
	114	153	HHS3_HHIH_MB_Oth	1
	115	-154	HHS3_HHIH_3W_3W	0
	116	-155	HHS3_HHIH_3W_Oth	0
	117	-156	HHS3_HHIH_Oth_Oth	0
	118	157	HHS4_HHIH_C_MB	1
	119	158	HHS4_HHIH_C_3W	1
	120	159	HHS4_HHIH_C_Oth	1
	121	160	HHS4_HHIH_MB_MB	1
	122	161	HHS4_HHIH_MB_3W	1

Income Category	ID	Parameter Code	Parameter_ID	Inclusion in the Final Model [Yes = 1, No =0]
	123	162	HHS4_HHIH_MB_Oth	1
	124	-163	HHS4_HHIH_3W_3W	0
	125	164	HHS4_HHIH_3W_Oth	1
	126	165	HHS4_HHIH_Oth_Oth	1
	127	166	HHS5_HHIH_C_MB	1
	128	167	HHS5_HHIH_C_3W	1
	129	168	HHS5_HHIH_C_Oth	1
	130	169	HHS5_HHIH_MB_MB	1
	131	170	HHS5_HHIH_MB_3W	1
	132	171	HHS5_HHIH_MB_Oth	1
	133	172	HHS5_HHIH_3W_3W	1
	134	173	HHS5_HHIH_3W_Oth	1
	135	174	HHS5_HHIH_Oth_Oth	1

Appendix C: Parameters used in level 03 model

Income Category	ID	Parameter Code	Parameter_ID	Inclusion in the Final Model [Yes = 1, No =0]
Low Income	1	-40	HHS1_HHIL_CCMB	0
	2	-41	HHS1_HHIL_CC3W	0
	3	-42	HHS1_HHIL_CCOth	0
	4	-43	HHS1_HHIL_CMBMB	0
	5	-44	HHS1_HHIL_CMB3W	0
	6	-45	HHS1_HHIL_CMBOth	0
	7	-46	HHS1_HHIL_C3W3W	0
	8	-47	HHS1_HHIL_C3WOth	0
	9	-48	HHS1_HHIL_COthOth	0
	10	-49	HHS1_HHIL_MBMBMB	0
	11	-50	HHS1_HHIL_MBMB3W	0
	12	-51	HHS1_HHIL_MBMBOth	0
	13	-52	HHS1_HHIL_MB3W3W	0
	14	-53	HHS1_HHIL_MB3WOth	0
	15	-54	HHS1_HHIL_MBOthOth	0
	16	-55	HHS1_HHIL_3W3W3W	0
	17	-56	HHS1_HHIL_3W3WOth	0
	18	-57	HHS1_HHIL_3WOthOth	0
	19	-58	HHS1_HHIL_OthOthOth	0
	20	-59	HHS2_HHIL_CCMB	0
	21	-60	HHS2_HHIL_CC3W	0
	22	-61	HHS2_HHIL_CCOth	0
	23	-62	HHS2_HHIL_CMBMB	0
	24	-63	HHS2_HHIL_CMB3W	0
	25	-64	HHS2_HHIL_CMBOth	0
	26	-65	HHS2_HHIL_C3W3W	0
	27	-66	HHS2_HHIL_C3WOth	0
	28	-67	HHS2_HHIL_COthOth	0
	29	-68	HHS2_HHIL_MBMBMB	0
	30	-69	HHS2_HHIL_MBMB3W	0
	31	-70	HHS2_HHIL_MBMBOth	0
	32	-71	HHS2_HHIL_MB3W3W	0
	33	-72	HHS2_HHIL_MB3WOth	0
	34	-73	HHS2_HHIL_MBOthOth	0
	35	-74	HHS2_HHIL_3W3W3W	0
	36	-75	HHS2_HHIL_3W3WOth	0
	37	-76	HHS2_HHIL_3WOthOth	0
	38	-77	HHS2_HHIL_OthOthOth	0
	39	78	HHS3_HHIL_CCMB	1
	40	-79	HHS3_HHIL_CC3W	0

Income Category	ID	Parameter Code	Parameter_ID	Inclusion in the Final Model [Yes = 1, No =0]
	41	-80	HHS3_HHIL_CCOth	0
	42	-81	HHS3_HHIL_CMBMB	0
	43	82	HHS3_HHIL_CMB3W	1
	44	83	HHS3_HHIL_CMBOth	1
	45	-84	HHS3_HHIL_C3W3W	0
	46	-85	HHS3_HHIL_C3WOth	0
	47	-86	HHS3_HHIL_COthOth	0
	48	-87	HHS3_HHIL_MBMBMB	0
	49	88	HHS3_HHIL_MBMB3W	1
	50	89	HHS3_HHIL_MBMBOth	1
	51	-90	HHS3_HHIL_MB3W3W	0
	52	91	HHS3_HHIL_MB3WOth	1
	53	-92	HHS3_HHIL_MBOthOth	0
	54	-93	HHS3_HHIL_3W3W3W	0
	55	-94	HHS3_HHIL_3W3WOth	0
	56	-95	HHS3_HHIL_3WOthOth	0
	57	-96	HHS3_HHIL_OthOthOth	0
	58	97	HHS4_HHIL_CCMB	1
	59	-98	HHS4_HHIL_CC3W	0
	60	-99	HHS4_HHIL_CCOth	0
	61	100	HHS4_HHIL_CMBMB	1
	62	101	HHS4_HHIL_CMB3W	1
	63	102	HHS4_HHIL_CMBOth	1
	64	-103	HHS4_HHIL_C3W3W	0
	65	-104	HHS4_HHIL_C3WOth	0
	66	-105	HHS4_HHIL_COthOth	0
	67	106	HHS4_HHIL_MBMBMB	1
	68	107	HHS4_HHIL_MBMB3W	1
	69	-108	HHS4_HHIL_MBMBOth	0
	70	-109	HHS4_HHIL_MB3W3W	0
	71	110	HHS4_HHIL_MB3WOth	1
	72	-111	HHS4_HHIL_MBOthOth	0
	73	-112	HHS4_HHIL_3W3W3W	0
	74	-113	HHS4_HHIL_3W3WOth	0
	75	-114	HHS4_HHIL_3WOthOth	0
	76	-115	HHS4_HHIL_OthOthOth	0
	77	116	HHS5_HHIL_CCMB	1
	78	-117	HHS5_HHIL_CC3W	0
	79	-118	HHS5_HHIL_CCOth	0
	80	119	HHS5_HHIL_CMBMB	1
	81	120	HHS5_HHIL_CMB3W	1
	82	-121	HHS5_HHIL_CMBOth	0

Income Category	ID	Parameter Code	Parameter_ID	Inclusion in the Final Model [Yes = 1, No =0]
	83	-122	HHS5_HHIL_C3W3W	0
	84	-123	HHS5_HHIL_C3WOth	0
	85	-124	HHS5_HHIL_COthOth	0
	86	125	HHS5_HHIL_MBMBMB	1
	87	126	HHS5_HHIL_MBMB3W	1
	88	-127	HHS5_HHIL_MBMBOth	0
	89	-128	HHS5_HHIL_MB3W3W	0
	90	129	HHS5_HHIL_MB3WOth	1
	91	130	HHS5_HHIL_MBOthOth	1
	92	-131	HHS5_HHIL_3W3W3W	0
	93	-132	HHS5_HHIL_3W3WOth	0
	94	-133	HHS5_HHIL_3WOthOth	0
	95	-134	HHS5_HHIL_OthOthOth	0
Medium Income	96	-135	HHS1_HHIM_CCMB	0
	97	-136	HHS1_HHIM_CC3W	0
	98	-137	HHS1_HHIM_CCOth	0
	99	-138	HHS1_HHIM_CMBMB	0
	100	-139	HHS1_HHIM_CMB3W	0
	101	-140	HHS1_HHIM_CMBOth	0
	102	-141	HHS1_HHIM_C3W3W	0
	103	-142	HHS1_HHIM_C3WOth	0
	104	-143	HHS1_HHIM_COthOth	0
	105	-144	HHS1_HHIM_MBMBMB	0
	106	-145	HHS1_HHIM_MBMB3W	0
	107	-146	HHS1_HHIM_MBMBOth	0
	108	-147	HHS1_HHIM_MB3W3W	0
	109	-148	HHS1_HHIM_MB3WOth	0
	110	-149	HHS1_HHIM_MBOthOth	0
	111	-150	HHS1_HHIM_3W3W3W	0
	112	-151	HHS1_HHIM_3W3WOth	0
	113	-152	HHS1_HHIM_3WOthOth	0
	114	-153	HHS1_HHIM_OthOthOth	0
	115	-154	HHS2_HHIM_CCMB	0
	116	-155	HHS2_HHIM_CC3W	0
	117	-156	HHS2_HHIM_CCOth	0
	118	-157	HHS2_HHIM_CMBMB	0
	119	-158	HHS2_HHIM_CMB3W	0
	120	-159	HHS2_HHIM_CMBOth	0
	121	-160	HHS2_HHIM_C3W3W	0
	122	-161	HHS2_HHIM_C3WOth	0
	123	-162	HHS2_HHIM_COthOth	0
	124	-163	HHS2_HHIM_MBMBMB	0

Income Category	ID	Parameter Code	Parameter_ID	Inclusion in the Final Model [Yes = 1, No =0]
	125	-164	HHS2_HHIM_MBMB3W	0
	126	-165	HHS2_HHIM_MBMBOth	0
	127	-166	HHS2_HHIM_MB3W3W	0
	128	-167	HHS2_HHIM_MB3WOth	0
	129	-168	HHS2_HHIM_MBOthOth	0
	130	-169	HHS2_HHIM_3W3W3W	0
	131	-170	HHS2_HHIM_3W3WOth	0
	132	-171	HHS2_HHIM_3WOthOth	0
	133	-172	HHS2_HHIM_OthOthOth	0
	134	173	HHS3_HHIM_CCMB	1
	135	-174	HHS3_HHIM_CC3W	0
	136	-175	HHS3_HHIM_CCOth	0
	137	176	HHS3_HHIM_CMBMB	1
	138	177	HHS3_HHIM_CMB3W	1
	139	-178	HHS3_HHIM_CMBOth	0
	140	-179	HHS3_HHIM_C3W3W	0
	141	-180	HHS3_HHIM_C3WOth	0
	142	-181	HHS3_HHIM_COthOth	0
	143	-182	HHS3_HHIM_MBMBMB	0
	144	183	HHS3_HHIM_MBMB3W	1
	145	-184	HHS3_HHIM_MBMBOth	0
	146	-185	HHS3_HHIM_MB3W3W	0
	147	-186	HHS3_HHIM_MB3WOth	0
	148	-187	HHS3_HHIM_MBOthOth	0
	149	-188	HHS3_HHIM_3W3W3W	0
	150	-189	HHS3_HHIM_3W3WOth	0
	151	-190	HHS3_HHIM_3WOthOth	0
	152	-191	HHS3_HHIM_OthOthOth	0
	153	192	HHS4_HHIM_CCMB	1
	154	-193	HHS4_HHIM_CC3W	0
	155	-194	HHS4_HHIM_CCOth	0
	156	195	HHS4_HHIM_CMBMB	1
	157	196	HHS4_HHIM_CMB3W	1
	158	197	HHS4_HHIM_CMBOth	1
	159	-198	HHS4_HHIM_C3W3W	0
	160	-199	HHS4_HHIM_C3WOth	0
	161	-200	HHS4_HHIM_COthOth	0
	162	-201	HHS4_HHIM_MBMBMB	0
	163	202	HHS4_HHIM_MBMB3W	1
	164	-203	HHS4_HHIM_MBMBOth	0
	165	-204	HHS4_HHIM_MB3W3W	0
	166	205	HHS4_HHIM_MB3WOth	1

Income Category	ID	Parameter Code	Parameter_ID	Inclusion in the Final Model [Yes = 1, No =0]
	167	206	HHS4_HHIM_MBOthOth	1
	168	-207	HHS4_HHIM_3W3W3W	0
	169	-208	HHS4_HHIM_3W3WOth	0
	170	-209	HHS4_HHIM_3WOthOth	0
	171	-210	HHS4_HHIM_OthOthOth	0
	172	211	HHS5_HHIM_CCMB	1
	173	-212	HHS5_HHIM_CC3W	0
	174	213	HHS5_HHIM_CCOth	1
	175	214	HHS5_HHIM_CMBMB	1
	176	215	HHS5_HHIM_CMB3W	1
	177	-216	HHS5_HHIM_CMBOth	0
	178	-217	HHS5_HHIM_C3W3W	0
	179	-218	HHS5_HHIM_C3WOth	0
	180	-219	HHS5_HHIM_COthOth	0
	181	220	HHS5_HHIM_MBMBMB	1
	182	221	HHS5_HHIM_MBMB3W	1
	183	-222	HHS5_HHIM_MBMBOth	0
	184	223	HHS5_HHIM_MB3W3W	1
	185	224	HHS5_HHIM_MB3WOth	1
	186	225	HHS5_HHIM_MBOthOth	1
	187	-226	HHS5_HHIM_3W3W3W	0
	188	-227	HHS5_HHIM_3W3WOth	0
	189	-228	HHS5_HHIM_3WOthOth	0
	190	-229	HHS5_HHIM_OthOthOth	0
High Income	191	-230	HHS1_HHIH_CCMB	0
	192	-231	HHS1_HHIH_CC3W	0
	193	-232	HHS1_HHIH_CCOth	0
	194	-233	HHS1_HHIH_CMBMB	0
	195	-234	HHS1_HHIH_CMB3W	0
	196	-235	HHS1_HHIH_CMBOth	0
	197	-236	HHS1_HHIH_C3W3W	0
	198	-237	HHS1_HHIH_C3WOth	0
	199	-238	HHS1_HHIH_COthOth	0
	200	-239	HHS1_HHIH_MBMBMB	0
	201	-240	HHS1_HHIH_MBMB3W	0
	202	-241	HHS1_HHIH_MBMBOth	0
	203	-242	HHS1_HHIH_MB3W3W	0
	204	-243	HHS1_HHIH_MB3WOth	0
	205	-244	HHS1_HHIH_MBOthOth	0
	206	-245	HHS1_HHIH_3W3W3W	0
	207	-246	HHS1_HHIH_3W3WOth	0
	208	-247	HHS1_HHIH_3WOthOth	0

Income Category	ID	Parameter Code	Parameter_ID	Inclusion in the Final Model [Yes = 1, No =0]
	209	-248	HHS1_HHIH_OthOthOth	0
	210	-249	HHS2_HHIH_CCMB	0
	211	-250	HHS2_HHIH_CC3W	0
	212	-251	HHS2_HHIH_CCOth	0
	213	-252	HHS2_HHIH_CMBMB	0
	214	-253	HHS2_HHIH_CMB3W	0
	215	-254	HHS2_HHIH_CMBOth	0
	216	-255	HHS2_HHIH_C3W3W	0
	217	-256	HHS2_HHIH_C3WOth	0
	218	-257	HHS2_HHIH_COthOth	0
	219	-258	HHS2_HHIH_MBMBMB	0
	220	-259	HHS2_HHIH_MBMB3W	0
	221	-260	HHS2_HHIH_MBMBOth	0
	222	-261	HHS2_HHIH_MB3W3W	0
	223	-262	HHS2_HHIH_MB3WOth	0
	224	-263	HHS2_HHIH_MBOthOth	0
	225	-264	HHS2_HHIH_3W3W3W	0
	226	-265	HHS2_HHIH_3W3WOth	0
	227	-266	HHS2_HHIH_3WOthOth	0
	228	-267	HHS2_HHIH_OthOthOth	0
	229	-268	HHS3_HHIH_CCMB	0
	230	-269	HHS3_HHIH_CC3W	0
	231	-270	HHS3_HHIH_CCOth	0
	232	271	HHS3_HHIH_CMBMB	1
	233	272	HHS3_HHIH_CMB3W	1
	234	-273	HHS3_HHIH_CMBOth	0
	235	-274	HHS3_HHIH_C3W3W	0
	236	-275	HHS3_HHIH_C3WOth	0
	237	-276	HHS3_HHIH_COthOth	0
	238	-277	HHS3_HHIH_MBMBMB	0
	239	-278	HHS3_HHIH_MBMB3W	0
	240	279	HHS3_HHIH_MBMBOth	1
	241	-280	HHS3_HHIH_MB3W3W	0
	242	-281	HHS3_HHIH_MB3WOth	0
	243	-282	HHS3_HHIH_MBOthOth	0
	244	-283	HHS3_HHIH_3W3W3W	0
	245	-284	HHS3_HHIH_3W3WOth	0
	246	-285	HHS3_HHIH_3WOthOth	0
	247	-286	HHS3_HHIH_OthOthOth	0
	248	287	HHS4_HHIH_CCMB	1
	249	-288	HHS4_HHIH_CC3W	0
	250	289	HHS4_HHIH_CCOth	1

Income Category	ID	Parameter Code	Parameter_ID	Inclusion in the Final Model [Yes = 1, No =0]
	251	290	HHS4_HHIH_CMBMB	1
	252	291	HHS4_HHIH_CMB3W	1
	253	292	HHS4_HHIH_CMBOth	1
	254	-293	HHS4_HHIH_C3W3W	0
	255	-294	HHS4_HHIH_C3WOth	0
	256	-295	HHS4_HHIH_COthOth	0
	257	-296	HHS4_HHIH_MBMBMB	0
	258	297	HHS4_HHIH_MBMB3W	1
	259	-298	HHS4_HHIH_MBMBOth	0
	260	-299	HHS4_HHIH_MB3W3W	0
	261	-300	HHS4_HHIH_MB3WOth	0
	262	-301	HHS4_HHIH_MBOthOth	0
	263	-302	HHS4_HHIH_3W3W3W	0
	264	-303	HHS4_HHIH_3W3WOth	0
	265	-304	HHS4_HHIH_3WOthOth	0
	266	-305	HHS4_HHIH_OthOthOth	0
	267	306	HHS5_HHIH_CCMB	1
	268	-307	HHS5_HHIH_CC3W	0
	269	-308	HHS5_HHIH_CCOth	0
	270	309	HHS5_HHIH_CMBMB	1
	271	310	HHS5_HHIH_CMB3W	1
	272	311	HHS5_HHIH_CMBOth	1
	273	-312	HHS5_HHIH_C3W3W	0
	274	-313	HHS5_HHIH_C3WOth	0
	275	314	HHS5_HHIH_COthOth	1
	276	315	HHS5_HHIH_MBMBMB	1
	277	-316	HHS5_HHIH_MBMB3W	0
	278	-317	HHS5_HHIH_MBMBOth	0
	279	-318	HHS5_HHIH_MB3W3W	0
	280	-319	HHS5_HHIH_MB3WOth	0
	281	-320	HHS5_HHIH_MBOthOth	0
	282	-321	HHS5_HHIH_3W3W3W	0
	283	-322	HHS5_HHIH_3W3WOth	0
	284	-323	HHS5_HHIH_3WOthOth	0
	285	-324	HHS5_HHIH_OthOthOth	0