PHILIPPINE ENGINEERING JOURNAL
PEJ 2004; **Vol. 25 No. 1**:35–50

Development of a Car Ownership Model in Metro Manila

Caesar P. Rubite[1]*and Noriel Christoper C. Tiglao[2]

[1] *Department of Engineering Sciences*
University of the Philippines Diliman
Quezon City 1101 PHILIPPINES

[2] *National Center for Transportation Studies*
University of the Philippines Diliman
Quezon City 1101 PHILIPPINES

ABSTRACT

The Metro Manila region has been continuously growing swiftly over the past years. This rapid urbanization in the city center has spilled over its periphery, the adjoining municipalities. Accessibility between the outer periphery and the city center becomes very critical especially when people seek employment within the city center. With the lack of efficient transit system on one hand, and improved socioeconomic characteristics of the household on the other, the demand for private cars is expected to increase also. However, the limited supply of road space cannot keep pace with increasing demand. Therefore, it is necessary to manage the growth of car ownership in metropolitan areas. A basic understanding of individual and household attitudes towards car ownership would enable the formulation of effective policies and plans for managing car ownership. Knowledge of car ownership paves the way for a better understanding of the people's behavior which will greatly affect policy formulation and analysis in the future.

The research is concerned with determining the various household characteristics which influence the household's decision to own a car. This decision is modeled as a binary choice incorporating the different household and individual characteristics as explanatory variables. The study used data taken from the Metro Manila Urban Transportation Integration Study Home-Interview Survey (HIS) database. The research revealed that the major factors affecting household decision to own a car are household income and number of working adults

KEY WORDS: Transportation Engineering

1. INTRODUCTION

Car ownership has increased dramatically over the recent years most especially in Metro Manila. According to the Land Transportation Office (LTO), Metro Manila has more than 30% (1.2 million) of all vehicles registered in the country, for the year 2001, more than 65% of which is registered as private vehicle. From 1991 to 2001, the average growth rate of vehicle

*Correspondence to: Department of Engineering Sciences, University of the Philippines Diliman, 304 Melchor Hall Quezon City 1101 PHILIPPINES. email:cprubite@up.edu.ph

Copyright © 2004 Philippine Engineering Journal

Received 29 May 2003
Revised 26 May 2004
Accepted 16 February 2005

registration is approximately 5% annually. Despite the economic slow down which started in 1998, it seems that each household wants to acquire an automobile for certain reasons. The household's decision of owning or not owning a car depends on many factors, some of which may not be well-defined quantitatively. It is generally acknowledged though that the major determinant of this decision is the household's level of income. However, the results of past studies abroad show that models which have income as the sole independent variable will give a considerably poorer explanation of cross-section variation in car ownership choices compared to a multi-variable model which incorporates a number of household and socioeconomic factors.

This study is primarily concerned with the development of an empirical model that relates car ownership at the individual household level, to household and socioeconomic characteristics thought to influence it. More specifically, the model is directed towards explaining the determinants of the household's choice of owning or not owning a car. For this study, a household is defined as a social unit consisting of a person living alone or group of persons who a) sleep in the same housing unit, and b) have a common arrangement in the preparation and consumption of food.

2. SIGNIFICANCE OF THE STUDY

The car plays a very important role in the economies of the industrialized, as well as developing countries, impinging on a whole range of activities. Automobile construction, manufacturing, sub-contracting, dealership and recycling create a considerable impact on the economy of a nation. The car provides planners and engineers the important data for construction, maintenance and management of road network. The balance of trade is very much affected by capital movements associated with the export and import of vehicles and parts, fuel imports and taxes such as fuel taxes constitute a significant source of government revenue.

Given these roles played by the car, knowledge on the different factors that influence car ownership will be useful in policy formulation and analysis. The study attempts to come up with a binary logit model relating the household's probability of owning or not owning a car, with its various household characteristics. Put simply, the study is an initial attempt to use disaggregate modeling approach to investigate car ownership decisions in Metro Manila.

3. SOCIOECONOMIC AND CAR OWNERSHIP PROFILE IN METRO MANILA

This research utilizes the Home-Interview Survey (HIS) database of the Metro Manila Urban Transportation Integration Study (MMUTIS) Project which contained the socioeconomic profile of residents including their trip information. The MMUTIS Project, a two and a half year study begun in 1996, was undertaken by the Department of Transportation and Communications (DOTC) with the cooperation and technical assistance from the Japan International Cooperation Agency (JICA). A random sample of approximately 2.5% (225 thousand households) of the population in Metro Manila, and approximately 0.8% (25 thousand households) of the population in the adjoining areas (i.e. Cavite, Laguna, Bulacan and Rizal Province) were visited and interviewed by field surveyors who collected socioeconomic information pertaining to the household. Field interviews were scheduled to ensure that trip information collected would pertain to a typical weekday of travel. The

Copyright © 2004 Philippine Engineering Journal

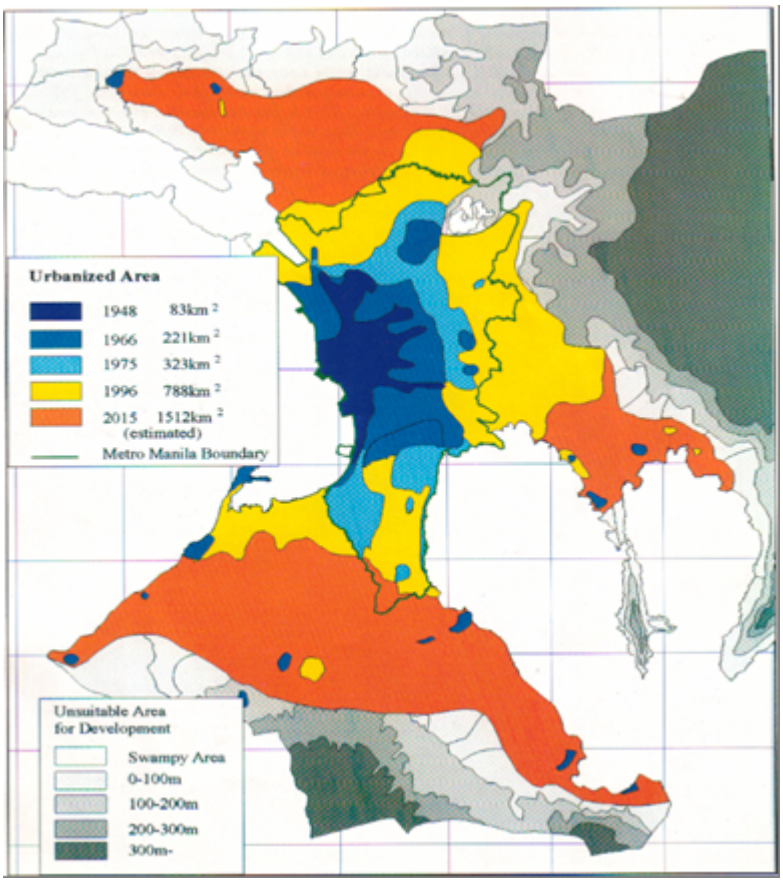

Figure 1. Expansion of Urban Areas, 1948 - 2015 [2]

metropolitan area together with the adjoining areas, comprise the MMUTIS study area.

3.1. Socioeconomic Profile

Metro Manila still dominates as a primate region among all regions of the country despite the different decentralization and regionalization programs and strategies of the government. It remains as the center of administration, business, commerce, industrial, and cultural activities of the island as well as the whole archipelago. From Figure 1, rapid urbanization is now towards the periphery of Metro Manila and it is occurring in a radial direction at a relatively rapid pace. This outward movement of urbanization is an effect of the spill-over development from the city center, the metropolitan region.

3.1.1. Population From Table I, it is evident that population growth rate in Metro Manila is steadily increasing, from 2.9% (1980 to 90), to 3.6% (1990 to 95). However, the population

Copyright © 2004 Philippine Engineering Journal

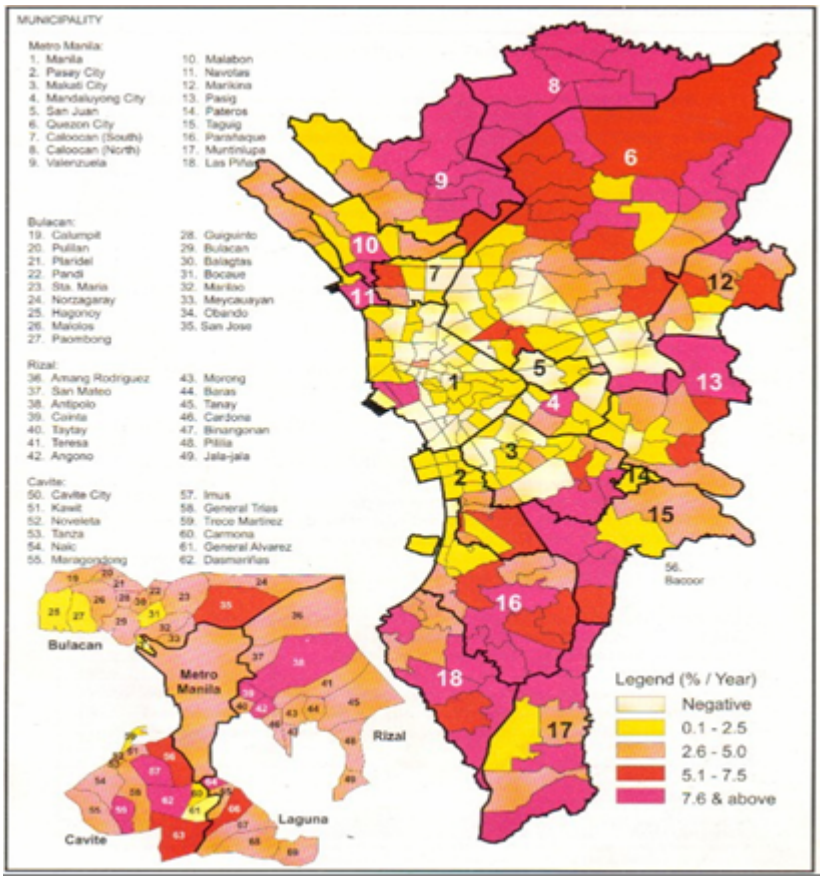

Figure 2. Population Growth, 1980 - 1995

growth rate in the adjoining areas is relatively much higher than that of the city center. This phenomenon is very common in rapidly urbanizing metropolitan area such as Metro Manila. As the city center builds up, people start to move into the fringe areas. One of the primary reasons might be attributed to the fact that land price goes up in the city center such that households prefer to settle into the adjoining areas. Figure 2 shows a graphical presentation of the population growth rate of Metro Manila per city/municipality. Settlement in the adjoining areas is very much evident with the high population growth rate in the region compared to the city center population growth rate

3.1.2. Employment and Student population The labor force in Metro Manila in 1989 was estimated at 3.1 million, increasing at an annual average rate of about 3% in the last three years. This is about 60% of the working age population. From Table II, employed labor force in 1995 is estimated at 3.7 million. By the year 2015, the employed persons are expected to reach 5.8 million. Of the 14.4 million residents of the metropolitan region for the year 1996,

Copyright © 2004 Philippine Engineering Journal

Area	Population: ×1000			Growth Rate:% per year		
	1980	1990	1995	1980-90	1990-95	1980-95
Metro Manila	5,926	7,929	9,454	2.9	3.6	3.1
Adjoining Areas	2,434	3,773	4,914	4.5	5.4	4.8
TOTAL	8,360	11,702	14,368			

Table I. Population of the Study Area

Item	Area	Number: ×1000			Growth Rate: % per year	
		1980	1995	2015	1980-95	1995-2015
Employment at work	Metro Manila	1,784	3.709	5,815	5.0	2.3
	Adjoining Areas	n.a.	1440	3,628	n.a.	4.7
Students at school	Metro Manila	1,547	2,966	4,167	4.7	1.5
	Adjoining Areas	n.a.	4,589	4,8,394	n.a.	5.5

Table II. Employment and Students in the Study Area

5.1 million (or 35%) are employed. This means that for every employed person, approximately three persons are being economically supported.

Table II also reveals that student population in the adjoining areas is much higher than that of Metro Manila. The growth rate per year (from 1995 to 2015) in the adjoining areas is likewise very much higher than that in the metropolis. However, higher level education enrolment and employment opportunities still concentrate in Metro Manila.

3.1.3. Household Income The average household income in Metro Manila was PhP 11,760 for the year 1996. In the adjoining areas, it was estimated at PhP 9,740. The household income distribution is presented in Figure reffigure3. Around 8.7% of households are considered below the poverty line of PhP 6,520 per month.

3.1.4. Car Ownership For the period 1981 to 2001, car registrations have been increasing at an average rate of 4.4% annually. Car registration reached 738,641 units in the year 2001 and has a modal share of around 19%. Metro Manila has the highest number of car registration with about 460 thousand units. From 1980 to 1996, the percentage of car-owning households jumped from 10% to 20%. Moreover, average household annual income for all income classes increased from PhP173,500 to approximately PhP300,000, with an average growth rate of 9% per year from 1994 to 2000. A very strong determinant of car ownership is the household income. As income level goes up, car-owning rate of households also goes up. Figure 4 reveals the car-ownership structure in Metro Manila for the year 1996. The graph shows that 19% of the households own at least one car. Households owning more than one car accounts for only 3% compared with the 15% owning only one car. Multi-car ownership is still low in Metro Manila.

Copyright © 2004 Philippine Engineering Journal

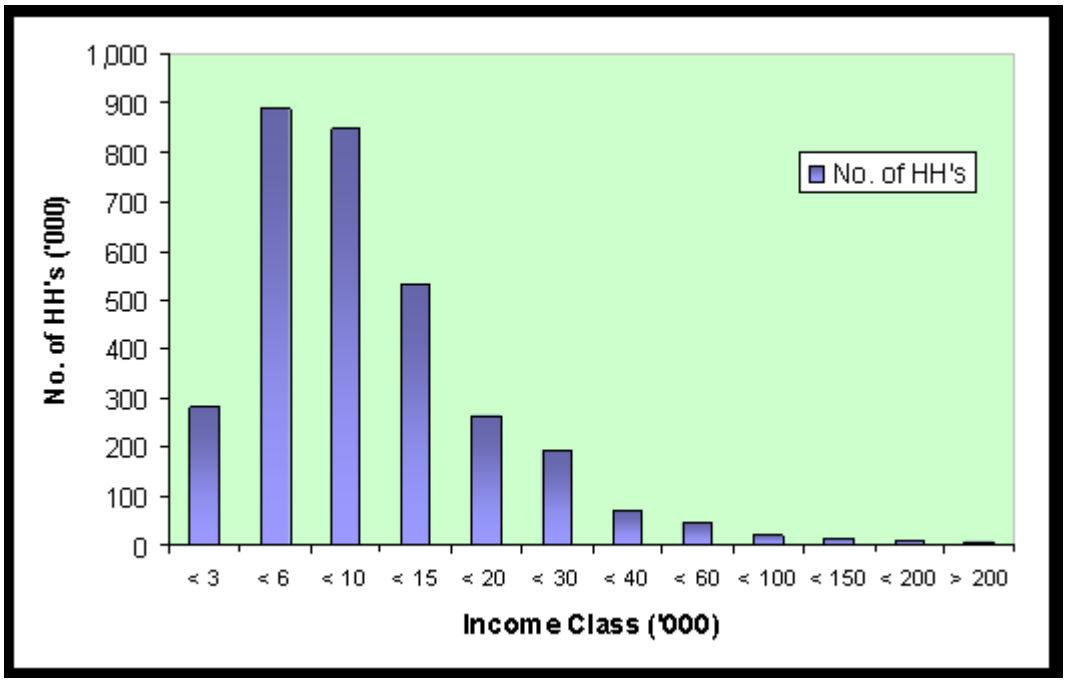

Figure 3. Distribution of Households by Income Level

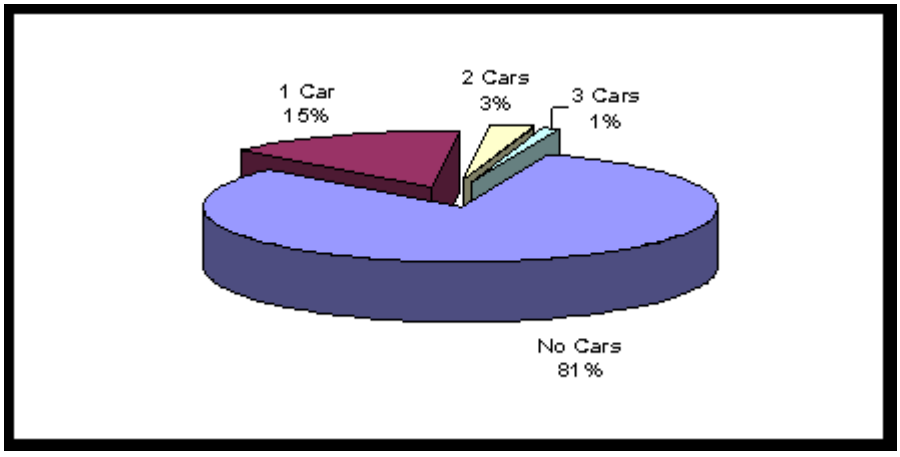

Figure 4. Car Ownership, 1996

Copyright © 2004 Philippine Engineering Journal

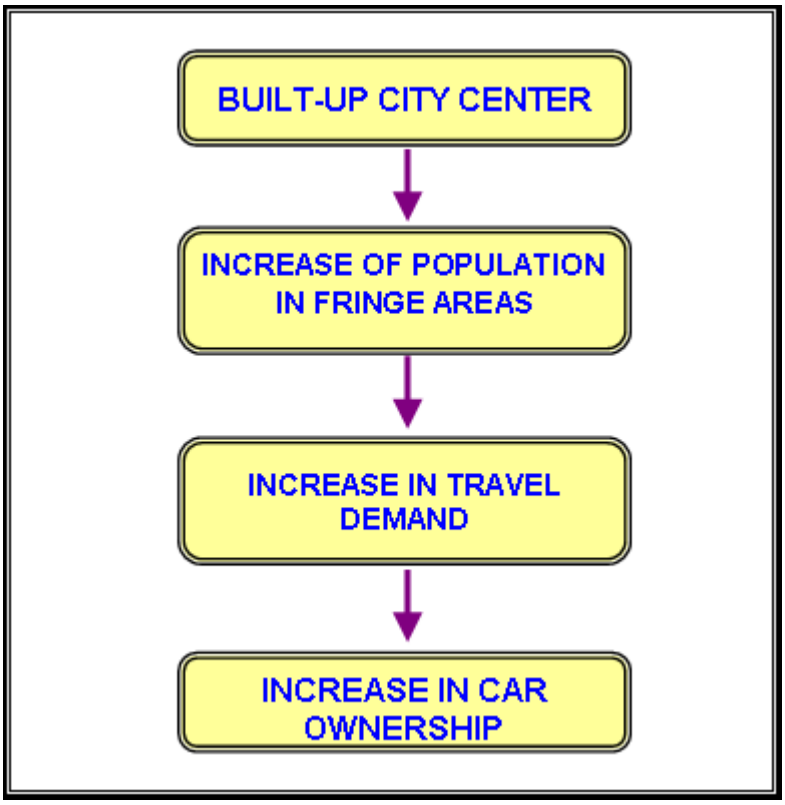

Figure 5. Factors leading to increase in Car Ownership

3.2. Rapid Urbanization of Metro Manila and the Adjoining Areas

Development in the metropolis and its periphery that leads to increase in car ownership can be described by Figure 5. Given all the information from the preceding sections about Metro Manila, as well as its adjoining areas, the following cause-and-effect phenomena can be developed. With a built-up city center, coupled with a relatively high population growth rate, there is a rapid increase in population in the fringe areas. The population growth rates are significant in the periphery of Metro Manila. One of the primary reasons is the high land price at or within the city center. Settlement at the outskirts of Metro Manila continues to increase, primarily in order to gain better access to the center of employment and commerce. It is evident that the city center is still the center of employment for the households living in the adjoining areas. As population continues to increase, travel demand likewise increases. More people correspond to more travelers or trip-makers. Accessibility between the outer periphery and the city center becomes very critical especially when people still seek employment within the city center. With a lack of efficient transit system, and with an improvement in the socioeconomic characteristics of the households, preference over cars or car ownership will also increase.

Copyright © 2004 Philippine Engineering Journal

4. CAR-OWNERSHIP MODELLING

The scope of this study comprises the households within Metro Manila covered by the Metro Manila Urban Transportation Integration Study (MMUTIS) Home-Interview Survey (HIS), including zones that are outside the Metropolitan area (i.e., Bulacan, Laguna, Cavite and Rizal Province) which were part of the MMUTIS study area. A sample of 1,459 households was randomly selected from the MMUTIS HIS database. Zones that are outside the Metro Manila area were included in the analysis. These are the areas surrounding or bounding Metro Manila (i.e., Bulacan, Laguna, Cavite and Rizal Province) which were part of the MMUTIS study area.

There are many factors affecting Car Ownership. Generally speaking, these factors can be divided into three main types. These are:

1. Household characteristics (e.g. income, number of members, age, etc.)
2. Relative location of the household
3. Cost and Service level (e.g. purchase price, repairs, fuel costs, etc.)

These factors affect the household's decision to own a car or not, including the use of its car. This study will be dealing with the first type or the factors relating to the household characteristics.

The second type of factor, relative location of the household, pertains to locational factors that affect car ownership. There is a relatively higher percentage of car-owning households in most urban areas as opposed to rural areas. Level of car ownership as well as car use is likewise linked to the supply of public transport services. The third type of factor pertains to costs and prices related to car ownership as well as car usage. Factors such as fuel prices, public transport fares, maintenance and spare parts costs, purchase price and other fixed cost are but a few issues that can be regarded.

Generally speaking, car ownership can be viewed as a long term decision of the household. Car ownership is decided by the household jointly on a long term basis depending on the factors enumerated above. Households opting not to own a car are called transport captives for they do not have a choice but to take the public transportation mode.

This study deals with predicting the probability of the household's choice of owning a car or not as a function of the household's and house head's characteristics (e.g. income, household size, number of working adults, sex, age, occupation type, etc.). The result will be a binary choice of whether to own 0 cars, or 1+ (one or more) cars. Figure 6 illustrates the conceptual framework of the study.

The decision unit or decision maker will be the household given a binary choice set of owning 0 or owning 1+ cars. The choice of ownership level depends upon the household characteristics. These characteristics will make up the set of explanatory variables. In order to arrive at a decision, the theoretical framework to generate the discrete choice will be that of Random Utility Theory.

4.1. Data

The data used for this research were taken from the Home-Interview Survey (HIS) database [3] of the Metro Manila Urban Transportation Integration Study (MMUTIS) Project [1] which contained the socioeconomic profile of residents including their trip information. The Home-

Copyright © 2004 Philippine Engineering Journal

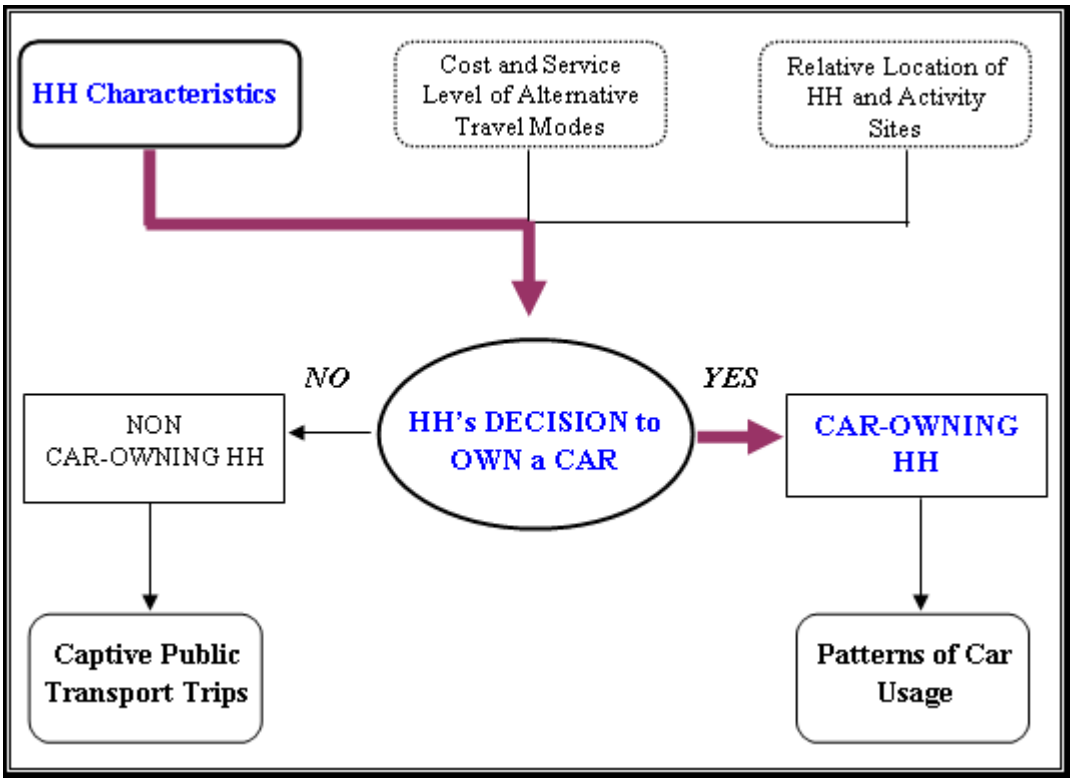

Figure 6. Conceptual Framework

Interview Survey was conducted on the final quarter of the year 1996. A random sample of approximately 2.5% (225 thousand samples) of the population in Metro Manila, and approximately 0.8% (25 thousand samples) of the population in the adjoining areas (e.g. Cavite, Laguna, Bulacan and Rizal Province) were visited and interviewed by field surveyors who collected socioeconomic information pertaining to the household. They also recorded all trips taken by all members of the household (over 4 years old) during the entire day.

The Home-Interview Survey (HIS) master file of the MMUTIS Database contained three (3) types of record. Record type 1 defined the Household Attributes, where the different household characteristics were described. Record type 2 contained the Personal Attributes or the characteristics of each member of the household. All Trip Information of each household member were defined in Record type 3. A total of 1,459 households, randomly selected from the HIS master file, were picked and analyzed by this study.

The master file containing all the three records was summarized into files of household records. In order to do this, computer programs were written both for the extraction of the data from Form 1, and the matching of these randomly selected households with its corresponding Forms 2 and 3. Sub-programs and Excel spreadsheets were also written for summarizing the extracted samples into household records designed to be used as input to the GAUSS platform.

Copyright © 2004 Philippine Engineering Journal

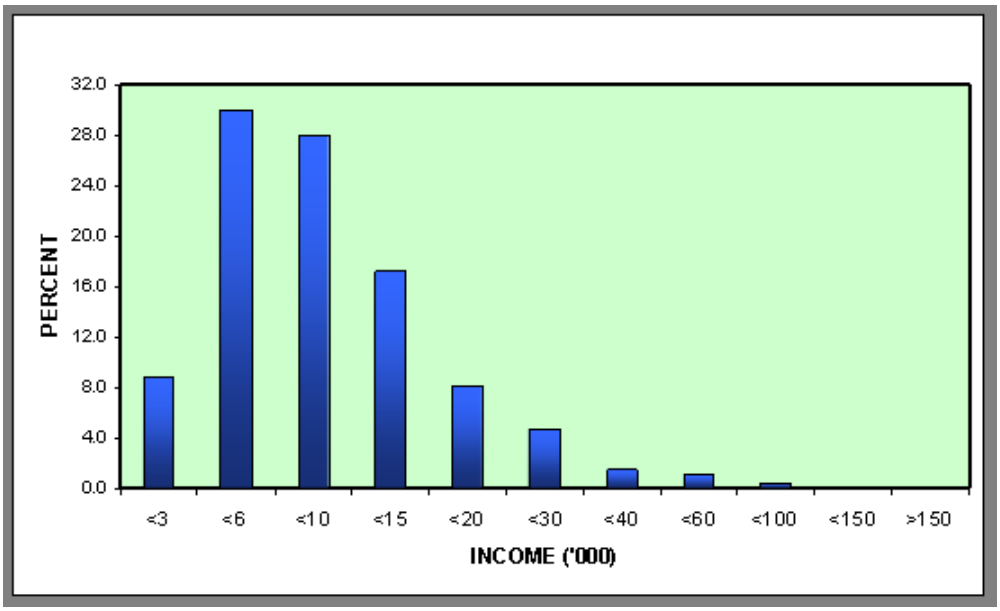

Figure 7. Income Distribution of the Sample

4.1.1. Sample Statistics The samples taken from the MMUTIS master file contains 1,459 households, 16% of which are car owners (at least 1 car). Figure 7 shows the income distribution of the sample. Mean household monthly income level of the sample falls at 3.2 (between PhP 6,000-8,000), while that of car-owning households at 3.9 (between PhP 8,000-10,000). The mean sample household size is at 4.3 members per household, approximately 2 of whom are working adults in the household.

Figure 8 reveals that around 22% of the household heads' employment are related to wholesale/retail trade, repair of vehicles, motorcycles, personal and household goods, 11% under transport, storage and communications, and 10% are into manufacturing. From Figure 9, it is shown that majority of the household heads, around 24%, belong to category one (government officials, corporate executives, managers, supervisors), 11.5% fall under category 5 (service, shop, market workers), 14% under category 9 (laborers/unskilled workers), and 10% under category 8 (plant/machine operators). The two categories with the highest frequency, from Figure 9, are 1 and 9, accounting for almost 40% of the total sample. Note the disparity in the personal, as well as household income, of the two aforementioned categories (1 and 9).

4.2. Result of Analyses

4.2.1. Factors Affecting Car Ownership This section relates car ownership with various characteristics of the household and the household head. In most cases, a household consists of persons who are related by kinship ties, like parents and their children. In some instances, several generations of familial ties are represented in one household while, still in others, even more distant relatives are members of the household. Household helpers, boarders, and non-

Copyright © 2004 Philippine Engineering Journal

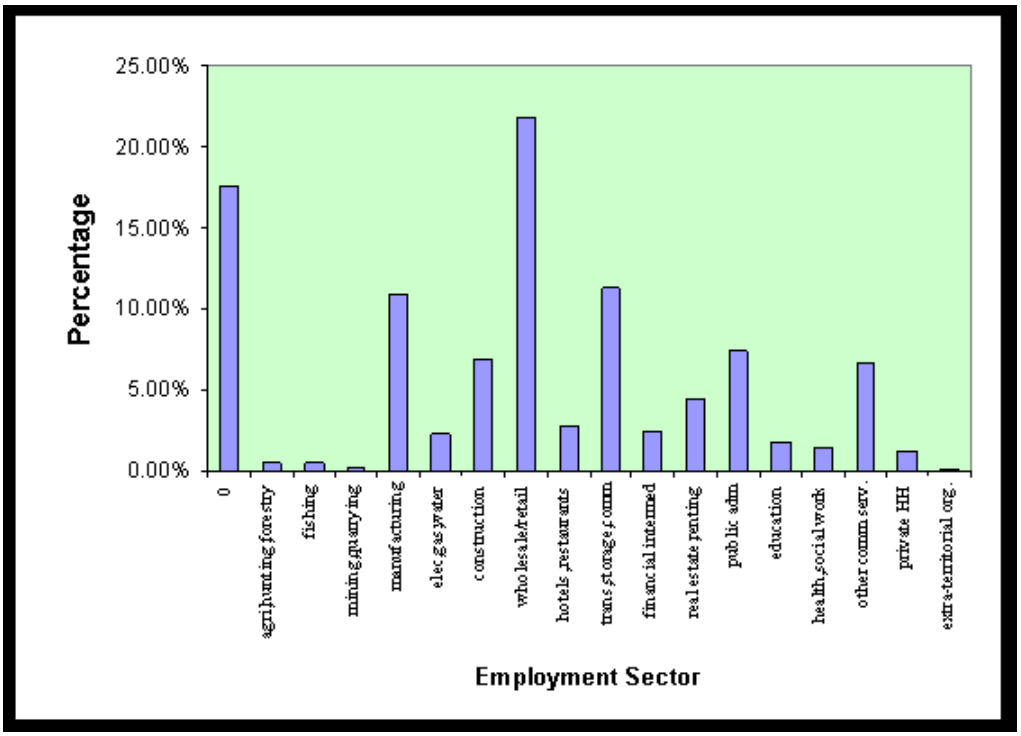

Figure 8. Sample Distribution by Employment Sector

relatives are considered as members of the household provided they sleep in the same housing unit and have common arrangement for the preparation and consumption of food and do not usually go home to their family at least once a week. The household head refers to the person responsible for the care and organization of the household. He or she usually provides the chief source of income for the household. In this study, the head of the household is defined as the highest income earner in the household. Household heads are coded as member 1 in the MMUTIS Home-Interview Survey master file.

The purpose of this section is to identify which among the available explanatory variables in the data set can be used to predict whether or not a household will own a car. The number of households owning more than one car in Metro Manila is relatively small compared with those owning at least one car. Therefore, car ownership is defined as a binary decision variable which takes a value of zero if the household does not own a car, and takes a value of one if the household owns one or more cars.

The variables used in this study can be divided into two categories namely, household factors and household head factors. They are as follows:

HOUSEHOLD FACTORS

Copyright © 2004 Philippine Engineering Journal

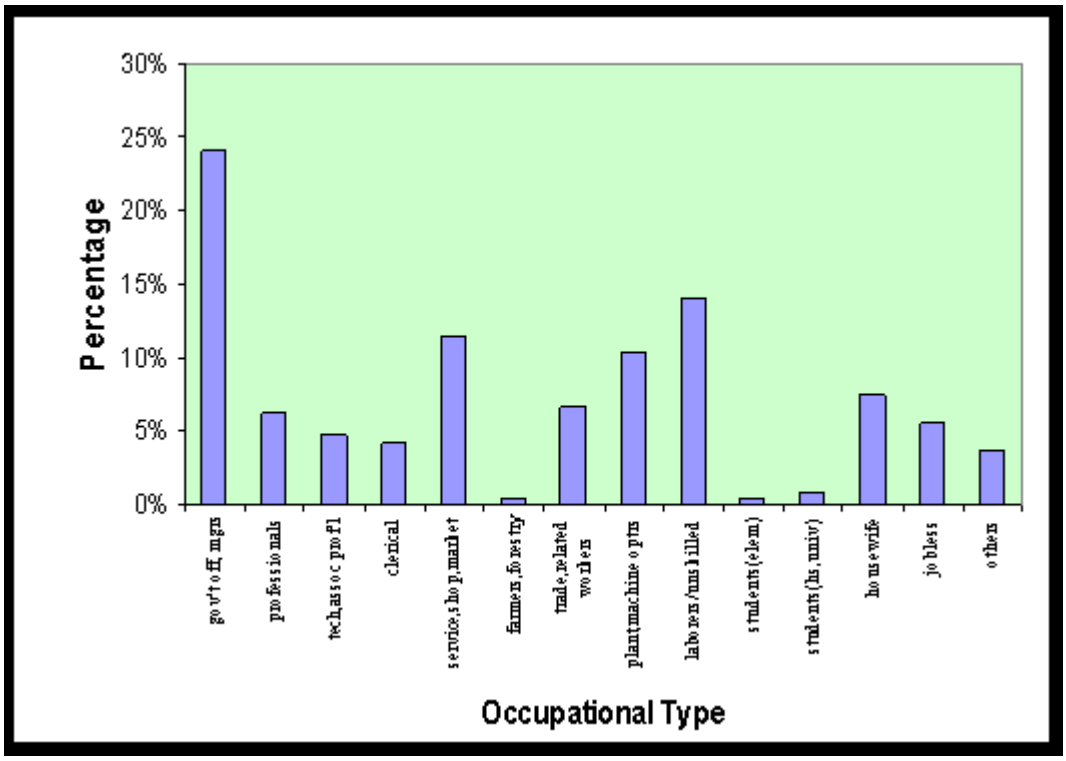

Figure 9. Sample Distribution by Occupational Type

Parameter	Description
HHinc	Household income
HHsize	Household size
Hchild	Number of members under 14
Nwork	Number of working adults
Lic	Number of adults with driver's license

HOUSEHOLD HEAD FACTORS

Parameter	Description
Age	Age of Household Head
Occp	Occupation type of head 1-Officials; 2-Profesionals & Technicians; 3-Clerical & Service Workers; 4-Farmers, Trades, Machine Operators, Laborers; 5-Student, housewife, jobless, others.

Copyright © 2004 Philippine Engineering Journal

The above-listed parameters are individually tested for statistical significance and examined as to the extent of their effect in explaining car ownership. An attempt of adding a spatial variable such as parameter EDSA-in, was included in the model specification for this study. This parameter is a dummy variable, which will take a value of 1, if household is 'within' or inside EDSA (circumferential road 4), and 0 if outside C4. A logit analysis of car ownership versus these factors is done and evaluated on the basis of how well they can explain car ownership, using the GAUSS System. The first task therefore is to convert all data into GAUSS format prior to any program execution.

4.2.2. Discrete Choice Analysis A discrete choice model describes a particular choice situation, which is, for this study, to own or not to own a car. It is based on a theoretical framework called the random utility theory. The models are based on observed choices made by individual termed as the decision-maker. The use of this framework will enable more realistic models when compared to other estimation methods such as least squares method. In general, discrete choice models postulate that "the probability of individuals choosing a given option is a function of their socioeconomic characteristics and the relative attractiveness of the option." The model is specified by different explanatory variables (listed above), known as the attributes of the decision-maker. The decision-maker, for this research, is the household.

The models in the analysis are specified using the logistic regression. The mathematical calculations were provided by the maxlik (maximum likelihood) procedure of GAUSS, which is a very powerful tool for statistical calculations. The procedure fits linear logistic regression models for binary or ordinal response data by the maximum likelihood method.

5. *GAUSS* SYSTEM

GAUSS is a matrix programming language, well-suited to econometric as well as statistical applications, that has become a very useful tool for present modelers. It is designed to operate with and on matrices for its basic operations. This platform is appropriate for a wider range of applications than standard econometric packages because it is a general programming language. It is a very efficient tool for matrix manipulation. Subprograms and functions are available to the user and so the user is able to change and/or modify them. For this study, the procedure MAXLIK of GAUSS was utilized for the modeling exercise.

6. MODEL RESULTS

6.1. Model specification

The modeling process consists of an iterative process of forcing into the model, one by one, in combination, or both, the different variables in order to come up with the best model. Two (2) models will be presented here for comparison. The first model, referred to as Model 1 specifies eight (8) variables namely: HHinc, Employ, Age, Nchild, Nwork, HHsize, Occp and Edsa-in as the explanatory variables. The second model, Model 2, makes use of three (3) variables which are: HHinc, Nwork, and Edsa-in as the independent variables.

Car ownership was defined as a binary choice of owning or not owning a car. Households with

Copyright © 2004 Philippine Engineering Journal

Variable	Parameter Estimate	Standard Error	t-stat	Prob> χ^2
Const	-2.107	0.533	-3.811	0.000
HHinc	0.130	0.049	2.633	0.004
Employ	0.091	0.112	0.814	0.208
Age	-0.014	0.007	-1.888	0.030
NChild	0.008	0.093	0.083	0.467
Nwork	0.454	0.096	4.722	0.000
HHsize	-0.007	0.065	-0.133	0.455
Occp	-0.093	0.069	-1.343	0.090
Edsa-in	-0.330	0.175	-1.881	0.030

Table III. Model 1 Estimation Results

more than one car were "lumped" together in order to define the binary choices or response values of 0 or 1+ cars owned. The response value for non-car-owning households will take the value of '0', while those that own at least one car takes the value of '1'. Therefore, this results into a binary choice of either '0' or '1'.

6.2. Summary of Findings

Tables III and IV show the estimation results of the two models. Model 1 specifies eight explanatory variables as shown in Table III. This model takes into account almost all of the household and household head characteristics in order to explain car ownership. From this tabulation, the relative values of the parameter estimates, standard error of estimate, t-statistics, and probability for each variable can be compared.

Among the explanatory variables, HHinc (household income), Nwork (number of working adults), and Edsa-in (dummy variable) reveal a relatively higher significance level with a prob-value of around 0.0001, with the exception of the dummy variable, as compared with the other variables. With this, Model 2 was specified using the abovementioned variables. Undoubtedly, household income still plays a major role in determining the probability of a household owning at least one car. As household income level increases, so is its probability of owning a car as shown in its positive parameter estimate. It is also interesting to note the negative correlation between household income and the number of working adults which means that increase in the number of workers in a household does not correspond to an increase in income level of the household.

Note that the variable representing the number of household members with driver's license was not included in the model specification for the main reason that it is not intuitively correct to say that the number of licensed drivers affects car ownership. It is more reasonable to argue that car ownership affects the number of licensed drivers most especially for the case of the Philippines, wherein driver's license is relatively easier to acquire as compared to other more advanced countries.

The other factor which may be important but a little less so than household income is the occupation type of the household head which favors car ownership for government officials, managers and supervisors.

Copyright © 2004 Philippine Engineering Journal

Variable	Parameter Estimate	Standard Error	t-stat	Prob> χ^2
Constant	-2.617	0.1095	-12.494	0.000
HHinc	0.1366	0.0409	3.268	0.000
Nwork	0.3876	0.717	5.331	0.000
Edsa-in	-0.2827	0.1458	-1.823	0.034

Table IV. Model 2 Estimation Results

7. CONCLUSION AND FUTURE TASKS

Among the explanatory variables presented in this research, household income (HHinc) and the number of working adults (Nwork) in the household significantly explains car-ownership behavior in Metro Manila. This can be observed from the values of parameter estimate, standard error of estimate, t-statistics, prob > chi square values shown in Tables III and IV. Looking at the parameter estimate of the variable Age, younger household heads has a more tendency of owning a car as shown in Table III. This can be attributed to the fact that younger people demand greater mobility compared to older ones and a car can very well provide this. With regard to the dummy variable Edsa-in, households located within C-4 (EDSA) prefer not to own a car. One reason can be the relatively better accessibility provided by this corridor to workplaces, that is, better public transport within the central business district (CBD), or proximity to employment centers. Moreover, higher-level occupational type (Occp) influences positively car-ownership, which means better paying jobs increases the probability of car-ownership. Therefore between the two models, the second model is preferred over the first one on the basis of relatively better values with respect to parameter estimate, standard error, t-statistics, and prob > chi-square.

Thus, using Model 2 specification, the probability of a household to own a car can be expressed as:

$$\text{Prob}(own) = \frac{e^{\text{logit}(P)}}{1 + e^{\text{logit}(P)}}$$

where

$$\begin{aligned}\text{logit}(P) = &-2.617 + 0.1366 \cdot HHinc + 0.3876 \cdot Nwork \\ &- (0.2827 \cdot Edsa - in)\end{aligned}$$

This research covered the household's car ownership decision as a function of the Household characteristics. There are other factors such as the Price Effects and Geographical Factors, which affect the household's car ownership decision that needs further exploration. These factors are equally important for the development of more comprehensive models in the future, models that can be utilized for policy simulation, such as the Uniform Vehicle Volume Reduction Program (UVVRP) or any other Transportation Demand Management (TDM) measures for future implementation.

Copyright © 2004 Philippine Engineering Journal

The different household characteristics included in the model can be generated for all the 265 zones of Metro Manila. The HIS database contains such information. As mentioned from the previous chapter, the samples for this research were randomly selected from the MMUTIS database. Together with the car ownership data for each zone, all the needed data may be extracted and tabulated from the database, with the aid of computer programs. Expansion factors for each household have been incorporated in the database. The final output of the model is a probability, a value ranging from zero to one. The mean probability can be tabulated per zone, on the basic assumption of homogeneity on a per zone basis. This method is called the classification method, a very practical method in approximating by finite number of relatively homogenous classes,

$$P_{jQ} = \sum f_j\,(X_c)\,Q_c/Q$$

where X_c is the mean of the variable set vector for subgroup c and Q_c/Q the proportion of individuals in the subgroup. The value may then be compared with the actual information of the car owning household per zone. This methodology can be considered as a future task for this research.

REFERENCES

1. MMUTIS Study Team, *A Factbook of Metro Manila's Transportation and Traffic Situation*. December 1997; Department of Transportation and Communication, Republic of the Philippines.
2. MMUTIS Study Team, *Metro Manila Urban Transportation Integration Study: Final Report*. March 1999; Department of Transportation and Communication, Republic of the Philippines.
3. De Ortuzar, J. D. and Willumsen, L. G. *Modeling Transport*(2nd ed.) John Wiley & Sons; 1994.
4. Ben-Akiva, Moshe and Lerman, Steven R., *Discrete Choice Analysis: Theory and Application to Travel Demand.* MIT Press, 1985.
5. SAS Institute Inc., *SAS/STAT User's Guide, Version 6*4th ed.
6. Tanner, J.C., *Car Ownership Trends and Forecasts*, Transport and Road Research 799. Crowthorne. 1977.
7. Tardiff T.J., *Vehicle Choice Models: Review of Previous Studies and Directions for Further Research.* Transportation Research. vol.14A, 327-335, 1980.
8. National Census and Statistics Office,
9. Family Income and Expenditure Survey, 1994/1997/2000.

Copyright © 2004 Philippine Engineering Journal