DETERMINANTS OF VEHICLE CHOICE IN METRO MANILA:
CONSUMER PREFERENCE FOR LOW EMISSION VEHICLES (LEVs)

A Thesis

by

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In Partial Fulfillment

of the Requirements for the Degree

Master of Sustainability Science

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Graduate Program in Sustainability Science

Graduate School of Frontier Sciences

THE UNIVERSITY OF TOKYO

September 2012

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ABSTRACT

The consistent increase in the number of motor vehicles in the last two decades has significantly contributed to the deterioration of air quality in the Philippines. In an urban area like Metro Manila, low emission vehicles (LEVs) present an option to reduce vehicular emission while maintaining the necessary mobility of the people. While the availability of LEVs to consumers is a basic prerequisite, determining the number of potential adopters is crucial as reduction in vehicular emission in urban areas depends on the proportion of new car buyers who opt for less polluting vehicle (Ewing and Sarigollu 1998).

The main objective of this study is to model vehicle choice among owners of personal vehicles (i.e. privately-used) in Metro Manila using discrete choice experiment. By modelling vehicle choice, this study determined if there is preference for LEVs. This study also identified ways to promote LEVs among vehicle owners, assessed the impact of selected LEVs on CO_2 emission, and compared its benefits and costs to gasoline and diesel vehicles.

Conditional logit models were estimated from the choice experiment data. Using the choice model, simulations were undertaken to determine the impacts of various policy scenarios on choice probabilities or market share of each vehicle type. The different vehicles included were gasoline and diesel vehicles (conventional vehicles), LPG Dual-fuel (LPG), hybrid electric (HEV), battery electric (BEV), and plug-in hybrid vehicles (PHEV). A total of 300 vehicle owners in Metro Manila were interviewed for this study using a semi-structured questionnaire that included the choice experiment.

The choice model indicates that diesel vehicles are most preferred by the respondents followed by HEV, gasoline vehicles, BEV and LPG vehicles. Initial market simulation shows that increasing the price of gasoline and diesel vehicles would decrease the share of diesel vehicles only. A combination of incentives, lower emission levels, and decrease in

cost of travel increased the share of HEV to 30% and BEV to 33%, both higher than the share of conventional vehicles. The reduction in emission level of HEV and BEV had the biggest impact on choice probabilities. However, considering that these vehicles cost twice as much as conventional vehicles, only 13% are considered potential adopters of HEV and BEV. Factoring in this price constraint, a second simulation done separately for potential adopters and non-adopters showed a lower share of 3% for HEV and 4% for BEV. A third simulation that considered the available model variants for all vehicle types and the price constraint further reduced the share of HEV to 0.9% and BEV to 1.0%.

Assuming all the respondents use PHEV, analysis showed that their vehicular CO_2 emission would decrease by at least 80%. Further analysis on more realistic scenarios for the whole personal vehicle sector showed that a vehicle share of 20% PHEV plus 10% BEV will result in 8% reduction in CO_2 emission and a share of 30% PHEV plus 20% BEV in 28% reduction in CO_2 emission.

A simple cost analysis for a 10-year period revealed that PHEV and BEV are 47% and 79% more expensive to operate, respectively, compared to conventional vehicles. The 40% fuel savings from BEV and PHEV is not enough to compensate for its high purchase price. Even the potential value of carbon credit from these vehicles is very small (less than Php1,000 per vehicle) to have a significant effect on vehicle price.

Despite the benefits from reduced emission and fuel savings, LEVs particularly HEV/PHEV and BEV remain expensive to most of the Filipino vehicle owners. Its price alone limits the number of potential adopters thereby affecting projected market share. This means that significant price reduction is an important first step in promoting LEVs. This can be done through alternative financing schemes, additional incentives and government support, and removal of customs duties for clean vehicles such as HEV and BEV.

ACKNOWLEDGEMENTS

They say sustainability is not an end state but rather a journey. My pursuit of knowledge on sustainability is likewise a journey - one with many sacrifices and a lot of hard work. And as I carry on, I would like to extend my deepest gratitude to the following that made this part of my journey possible:

To the Graduate Program in Sustainability Science, Graduate School of Frontier Sciences, The University of Tokyo – faculty and staff- for the opportunity to pursue my graduate studies and for all the assistance provided.

To the Ministry of Education, Culture, Sports, Science & Technology (MEXT) in Japan for the scholarship grant that made this graduate study possible.

To my advisor, Professor Yoshida Yoshikuni, for all the advice, the research support, and open-mindedness that allowed me to pursue something relevant and interesting; and to Associate Professor Yarime Masaru for serving as my co-advisor.

To the University of the Philippines Los Banos - Chancellor Rex Victor O. Cruz and former Chancellor Luis Rey I. Velasco; Vice Chancellor for Instruction Oscar B. Zamora and former Vice Chancellor Rita P. Laude for allowing me to go on study leave.

To the my beloved officemates at the UPLB Office of the Vice Chancellor for Instruction – Professor Roly Panopio and Professor Grace De Ocampo; Tita Babes Lim, Tito Danny Santiago, and Ms. Weng Perez for taking on the responsibilities I temporarily left behind; To Tita Letty and Grace Opulencia for assistance in data encoding; To Tita Lucy Mula, Tita Clets Talucod, Rachelle Lopez, Ingo Salcedo, Gary and Rey for the merienda and company during my visits.

ACKNOWLEDGEMENTS (continued)

To all the GPSS Students for all the serious and casual discussions inside and outside of the classroom. Let’s drink to that! – かんぱい！

To I-Views and Ms. Punzalan for the assistance provided in the field interview.

To all the survey respondents who willingly provided the necessary information for my research.

To Victor, Margie, and Mary Mar for the bazaar updates, cooking sessions, and merienda.

To my friends and family for their unwavering love and support.

And most importantly to God Almighty for giving me the wisdom and patience, for keeping my health and sanity, and for protecting my family in my absence.

DEDICATION

This thesis would not be possible without the support and the patience of the two most important persons in my life. I dedicate this achievement to my wonderful wife Zacyl and to our son Ayrton Miguel “Huey” - my source of strength, encouragement and inspiration.

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LIST OF ABBREVIATIONS AND ACRONYMS

AUV	Asian Utility Vehicle
BEV	Battery Electric Vehicle
CDM	Clean Development Mechanism
DENR	Department of Environment and Natural Resources
DOE	Department of Energy
DOTC	Department of Transportation and Communication
EMB	Environmental Management Bureau
EPA	US Environmental Protection Agency
HEV	Hybrid Electric Vehicles
LEV	Low emission vehicles
LPG	Liquefied Petroleum Gas
LTO	Land Transportation Office
MMUTIS	Metro Manila Urban Transportation Integrated Study
MPV	Multi-purpose Vehicle
NESTS	National Environmentally Sustainable Transportation Strategy
NSCB	National Statistical Coordination Board
NSO	National Statistics Office
PHEV	Plug-in Hybrid Electric Vehicle
PNOC	Philippine National Oil Company
UN FCCC	United Nations Framework Convention on Climate Change
WTP	Willingness-to-pay

CHAPTER 1. INTRODUCTION

1.1. Background

The choice of vehicle by individuals or households plays an important role in reducing air pollution. According to Ewing & Sarigollu (1998) the future levels of air pollution from vehicles in urban areas depends on the proportion of new car buyers who opt for less polluting vehicle. Low emission vehicles (LEVs) provide an opportunity for reducing CO_2 emissions from the road transport sector due to lower emission factor of its fuel, its higher fuel economy or both. Under the Clean Development Mechanism Program of UNFCCC for commercial fleets (UNFCCC, 2012), LEVs include but is not limited to the following vehicles:

- Compressed natural gas (CNG) vehicles;
- Electric vehicles
- Liquid petroleum gas (LPG) vehicles;
- Hybrid vehicles (HEVs) with electrical and internal combustion motive systems

In the Philippines, motorization increased consistently over the past decades. From 1981 to 2010, the number of registered vehicles increased six folds from less than 1 million to more than 6.6 million (Land Transportation Office, 2011). From the year 2000 to 2010 alone, the total number of motor vehicles nearly doubled from 3.7 million to 6.6 million. The number of vehicles continues to rise by an average of 6% per year in the last five years.

Despite occupying less than 1% of the country's total land area, Metro Manila is where 29% of the total vehicles in the country are located. The high concentration of vehicles resulted in air pollution which is a heavy burden in any urban area (Van Mierlo et al., 2003) due to the joint presence of a large number of pollution sources (i.e. vehicles) on one hand, and a large number of receptors (i.e. people and buildings) on the other hand. In 2001, the estimated health cost of air pollution (PM_{10}) for Metro Manila alone is US$392 million (World Bank, 2002). A study by the Department of Health in 2004 (as cited by DENR-EMB, 2005) found that "*considerable morbidity and mortality due to respiratory and cardiovascular diseases could have been prevented with better air quality in Metro Manila in 2002* (p. 12)." The Asian Development Bank (2009) further added that non-health impacts is higher for some air pollutants. Non-health impacts include traffic congestion, loss of income and productivity, and damage to ecosystem and infrastructure (World Bank, 2002). Hence, the total cost of air pollution is much higher than what previous studies have estimated.

In a country where 65% of air pollution is from mobile sources, mainly attributed to increasing population of cars and motorcycles (DENR-EMB, 2009), LEVs warrant a consideration in the road transport sector. The final report of the Formulation of a National Environmentally Sustainable Transport Strategy for the Philippines (NESTS) identified "*promotion of alternative fuels and vehicles such as AutoLPG, hybrid vehicles and electric vehicles"* as one of the many strategies in achieving its objectives of 1) Reducing energy consumption and associated greenhouse gases and other air pollutants, and 2) Enhancing sustainable mobility through viable markets of environmentally sustainable transportation (EST) goods and services.

However, the NESTS Report likewise acknowledged that as a developing country, the Philippines still struggle with the economic operation of its transportation sector. It further adds that survival and sustainability in the sector is far from being reconciled especially at the local level. Recognizing these potential barriers of sustainable transportation, understanding the stakeholders' (e.g. vehicle owners, transport operators, fleet owners, etc) behaviour towards proposed technological and policy solutions become imperative. This is important since understanding the behavioural responses of individuals to the actions of business and government will always be of interest to a wide spectrum of society (Louviere, Hensher, & Swait, 2000). In addition, it will inform policy makers and make them “confident that the policies they pursue will bring about the desired technological changes at acceptable costs” (Horne, Jaccard, & Tiedemann, 2005).

1.1.1. Alternative fuels in the Philippines

The impact of motor vehicles in the Philippines extends beyond the air pollution it causes. The transport sector accounts for 37.7% of the total energy consumption (NESTS, 2009). Of this percentage, 80% is consumed by road transportation. Because the Philippines imports much of its petroleum products, the rising oil prices that occurred in the past has caused major concern for the government and other stakeholders especially those involved in public transportation. The Republic Act 9367, also known as the Biofuels Act of 2006, was enacted to address issues associated with fuel supply and prices as well as concerns related to the environment, ecological systems and livelihood. Under this law, a minimum of 1% biodiesel blend in all diesel fuels shall be sold within three months of the laws effectivity and 2% biodiesel blend within two years from the law’s effectivity, upon the recommendation of an appropriate agency. For gasoline fuels, a minimum of 5% ethanol blend within two years of the law’s effectivity and 10% ethanol blend within four years is required to be sold by all oil companies (PNOC, 2007). Among the mentioned advantages of biofuels is its relatively cleaner emission especially from use of biodiesel. In addition to economic benefits, biofuel use is expected to result in emission reduction.

To further improve vehicular emission and provide “cost effective” options for the vehicle sector, other alternative fuels and vehicles are being promoted by the national and some local governments, mostly in the public transportation sector. This includes promotion of AutoLPG taxis, electric jeepneys[1] and tricycles (both a common mode of public transportation), and even CNG buses. Among these, LPG has the most extensive adoption with an estimated 30,000 taxis using LPG in Metro Manila (plus an undetermined number of privately-used vehicles and tricyles)

1.1.2. Definition of vehicle and engine types

This research involved various vehicle types differentiated by engine (power system) or by fuel used. The following broadly describes these vehicles.

Gasoline engine – A gasoline engine is an internal combustion engine with spark-ignition (spark plug), designed to run on gasoline and similar volatile fuels (http://en.wikipedia.org/wiki/Petrol_engine) . This engine can run on either regular or premium gasoline. Unleaded gasoline is used in the Philippines.

Diesel engine - A diesel engine (also known as a compression-ignition engine) is an internal combustion engine that uses the heat of compression to initiate ignition to burn the diesel fuel, which is injected into the combustion chamber (http://en.wikipedia.org/wiki/Diesel_engine)

LPG Dual-fuel vehicles (or LPG vehicles) – LPG Dual fuel vehicles are vehicles with engines capable of running on LPG and gasoline. The two fuels are stored in separate tanks and the engine runs on one fuel at a time. These vehicles have the capability to switch back and forth from gasoline to the other fuel, manually or automatically.

Hybrid electric vehicles (or HEVs)– A hybrid gas-electric vehicle (HEV) is a type of vehicle which combines a gasoline engine with an electric propulsion system. The presence

[1] Jeepney is a common mode of public transportation in the Philippines. It originated from US Military vehicles that were modified to transport passengers. It is characterized by having two parallel seating arrangement running lengthwise along its side with passengers facing each other. The entrance is located at the backmost part of the vehicle. Passenger capacity varies depending on the length of the jeepney.

of the electric power train is intended to achieve either better fuel economy than a conventional vehicle, or better performance. (http://en.wikipedia.org/wiki/Hybrid_electric_vehicle)

Batteries for the electric motor are recharged automatically when the brakes are applied when driving the vehicle. Newer models called Plug-in HEV or PHEV can be plugged in electrical sockets to recharge the battery.

Battery electric vehicles (or BEV)- An electric vehicle (EV), also referred to as an electric drive vehicle, uses one or more electric motors or traction motors for propulsion (http://en.wikipedia.org/wiki/Electric_vehicle). Batteries inside the car power the electric motors. These batteries can be recharged from the power outlet and also recharges when brakes are applied during driving.

1.1.3. Hybrid and battery electric vehicles in the Philippines

Various sectors are currently promoting battery electric vehicles in the Philippines. However, adoption of BEV even in high income countries remain low mainly due to limited number of refuelling (recharging) stations, high refuelling (recharging) costs, on-board fuel storage issues, safety and liability concerns, technologies and performances improvements in the competition, and high costs for consumers (Romm, 2006).

There are very few BEV in Metro Manila and in the whole Philippines. According to the Department of Energy (2011), there were 560 units of electric vehicles in 2010 which increased to 623 units in the first half of 2011. While the data is aggregated over different possible types of BEVs (electric jeepneys or e-jeep, e-trikes, e-motorcycles, e-cars, etc), it is clear that adoption is in its very early phase.

Current efforts to further promote the use of BEV are focused mostly in the public transportation sector. These include pilot projects for green routes using electric jeepneys in the City of Makati in Metro Manila. On the other hand, the Asian Development Bank funded a loan project to pilot test electric tricycles (e-trike) where 20 units were used in the City of Mandaluyong also in Metro Manila. As of this writing, there is little evidence of use of BEV for personal transportation except for some internet reports on the use of electric motorcycles and similar mode of transportation.

On the supply side, there are likewise few suppliers of electric vehicles and parts in the country. While Japanese automakers dominate the local auto industry, they have not ventured into electric vehicles in the Philippines. Some of the available BEV in the country is shown in Table 1.

Table 1. Locally available BEV

Company	BEV Products
EVNNOVATIONS (http://www.evnnovations.com/home.php)	dealer of REVAi electric vehicle
LEO Motors (http://www.leomotors.com/)	EV Power Trains Electric Bikes Power Pack Range Extender EV Packaging Services Conversion Solution-Buses and trucks
Eagle Motorcycles (http://www.eaglemotorcycles.net/index.html)	e-Jeepney e-Cars e-Trikes Accesories

Note: This table was generated through internet searches and may not represent an exhaustive listing. It was not validated whether each company is still operating as of this writing.

Hybrid electric vehicles are likewise new in the country having been introduced only in 2007 by Toyota Motor Philippines through the Prius model. Today, few full hybrid Lexus models are also available. While there is no official data from the DOTC or LTO regarding the number of HEV registered in the country, its price of almost double that of a vehicle of similar make and size suggests that few units were sold compared to conventional vehicles.

Newspaper report[2] states an average of two to three units sold per month. The new Prius C model has a lower price but is smaller in size. However, incentives being proposed in congress are expected to further reduce prices and increase HEV's price competitiveness.

1.1.4. Energy mix

BEV remains as one of the options in reducing vehicular CO_2 emissions. It is being promoted due to its zero-tailpipe emission and lower cost per kilometer of travel despite high cost of electricity in the Philippines. One of the advantages of using electricity for transportation in the Philippines is its low CO_2 emission factor (or grid emission factor) compared to gasoline, diesel and LPG. Low grid emission factor is a prerequisite for electric vehicles to contribute to air quality improvement. Otherwise, the emission is just transferred to the location where electricity is generated.

Estimates of the grid emission factor in the Philippines vary according to source. The 2008 estimate of the International Energy Agency (IEA) is 487 g of CO_2 /kWh; Takahashi, Kuriyama and Ninomiya of IGES (2012) estimated it at 494 g of CO_2/kWh; and the Institute of Energy Economics in Japan estimated it at 466 g of CO_2/kWh. Despite the different estimates, there is an indication that the grid emission factor in the Philippines is one of the lowest in Southeast Asia and in the whole Asian Region. The low grid emission factor can be explained by the sources of electricity as shown in Figure 1.

[2] http://business.inquirer.net/14097/hybrid-vehicles-too-tempting-too-costly (accessed 19 July 2012)

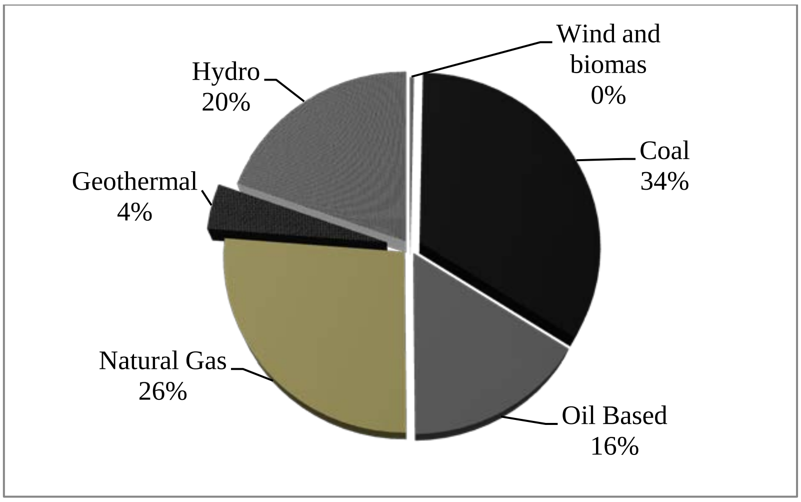

Figure 1. Energy capacity mix (dependable) in Luzon, Philippines, 2010 (Source: DOE 2010 http://www.doe.gov.ph/)

While coal form a large part of the energy mix, there is also energy from renewable sources such as hydro power plants (20%) and geothermal energy (4%) which has practically no CO_2 emission and also from natural gas (26%) which produces lower emission compared to burning coal and oil (EPA, ____). There is a potential to further reduce grid emission factor either by expanding geothermal energy or increasing the efficiency of coal power plants through technology transfer or both.

1.2. Objectives

The main objective of this study is to model vehicle choice among owners of personal vehicles (i.e privately-used). By modelling vehicle choice, this study provided information about consumers' vehicle preference that can be useful to transportation planners and policy makers in relation to the promotion of LEVs. In doing this, the study attempted to answer the following research questions:

- Do vehicle owners in Metro Manila have preference for LEVs?
- Is it beneficial to own LEVs from an individual and society's perspective?

To address the research questions, this study specifically:

a) Identified the factors that affect vehicle choice of consumers;

b) Determined if vehicle owners have preference for LEVs over conventional fossil fuel vehicles;

c) Identified course of action that would increase market share of LEVs; and

d) Estimated potential impact of LEVs on vehicular CO_2 emissions.

1.3. Theoretical Framework of Choice

The behavioural theory underlying discrete choice experiments is discrete choice theory, based on random utility theory or RUT (Ewing & Sarigollu, 1998). According to the RUT, the indirect utility function (U) of an individual can be decomposed into two parts: a deterministic element (V), which is typically specified as a linear index of the attributes (X) of the different alternatives in a choice set, and a stochastic element (*e*). The deterministic elements are factors that can be observed by the researcher while the stochastic elements are unobservable factors that affect choices.

Various goods (vehicles in this case) have different attributes. Given a task of choosing one alternative from a set of goods, consumer theory states that an individual will choose the alternative that maximizes their utility given their income and other constraints. In a choice set *C* with *J* number of alternatives, an individual will choose alternative *a* over other alternatives in the choice set *C* if the utility gained from alternative *a* is the highest among all alternatives. This can be expressed as:

$$U_a > U_j \qquad (1)$$

where U_a is the utility of the alternative *a* . U_j refers to the utility of any other alternative in choice set *C*. Using the RUT, the utility of an individual can be expressed as:

$$U_a = V_a + e_a = \beta X_a + e_a \qquad \text{for alternative } a \qquad (2)$$

$$U_j = V_j + e_j = \beta X_j + e_j \qquad \text{for other alternatives in the choice set}$$

where β is the vector of the preference parameters associated with attributes *X*. Substituting (2) to (1) will yield:

$$V_a + e_a > V_j + e_j \qquad (3)$$

$$(V_a - V_j) + e_a - e_j > 0$$

But since there is a stochastic (unknown) component in the equation, we can only describe the probability of choosing alternative *a*. That is:

$$\text{Prob}(U_a > U_j) = \text{Prob}\,[(V_a - V_j) + e_a - e_j > 0] \qquad (4)$$

For (4) hold true, assumptions on the distribution of the unknown component *e* should be made. Assuming an independently and identically distributed with an extreme-value (Gumbel) distribution, the equation can be specified as a conditional logit model (Mcfadden, 1973) with the form:

$$\text{Prob}\,(a \mid C = a,b,c,\ldots J) = \exp(V_a) / \textstyle\sum_{j=a}^{J} \exp(V_j) \qquad (5)$$

$$= \exp(\beta X_a) / \textstyle\sum_{j=a}^{J} \exp(\beta X_j) \qquad (6)$$

Explanatory variables *X* (e.g. vehicle attributes) assume different values in each alternative and the probabilities depends on the difference in the value of the characteristics or attributes across alternatives (Hoffman & Duncan, 1988). Conditional logit model is appropriate when choices among a set of goods are made based on their attributes or characteristics (Wooldridge, 2001).

A closely-related probabilistic choice model is the multinomial logit model or MNL. It has the form:

$$\text{Prob}\ (a \mid C = a,b,c,\ldots,J\ ) = \exp(\ \alpha_j Z)/ \sum_{j=a}^{J} \exp\ (\alpha_j Z)$$

In MNL, the explanatory variables Z are the individuals' characteristics and are constant across alternatives. The probability depends on the difference in coefficients across alternatives (Hoffman & Duncan, 1988). The number of estimated coefficients for MNL increases proportionally with the number of possible outcomes (i.e. alternatives). Each possible outcome has its own set of coefficients for each explanatory variable. The total number of coefficients estimated in MNL is equal to $(J - 1)*K$ where J is number of possible outcomes with K number of explanatory variables. The term $(J - 1)$ is a result of one alternative outcome being set as the base outcome.

Marginal willingness-to-pay (WTP) or implicit prices for various vehicle attributes can be computed from either type of choice model. It is the ratio of the coefficient of one attribute and the coefficient of the monetary attribute. This is consistent with utility maximization as long as a status quo or "will not buy" option is included (Hanley, Mourato, & Wright, 2001).

1.4. Review of Related Literature

1.4.1. Applications of choice experiment on vehicle choice modelling

Stated preference methods, particularly discrete choice experiments, have been extensively used in transportation research specifically in vehicle choice (see Bunch, Bradley, Golob, & Occhiuzzo (1993); Choo & Mokhtarian (2004); Ahn, Jeong, & Kim (2008); Ewing & Sarigollu (2000); and Potoglou & Kanaroglou (2007) among others) and also recently in valuation of the natural resource environment (Adamowicz, Louviere, & Williams, 1994). Disaggregate *models* (household or individual level model) estimated from stated preference data offer additional precision due to increase in number of explanatory variables (Ben-Akiva & Lerman, 1985) compared to *aggregate models* whose data are aggregated over a particular geographical region. However, aggregate measures will be of similar importance in research at some point (Train, 2003) such as in estimating market shares of various goods or services and analyzing the effects of different policies that may affect consumers' demand for various goods and services.

In absence of market data, choice experiments are useful in estimating preference for new products. It has been applied extensively to LEVs for marketing or policy purposes. In California, USA, Bunch et al., (1993) studied the effect of vehicle attributes on demand for clean-fuel vehicles compared to conventional vehicles while allowing the use of the model to evaluate various scenarios regarding alternative-fuel vehicles and fuel supply. Ewing & Sarigollu (1998) and Ewing & Sarigollu (2000) used commuting time and cost associated with LEVs in addition to vehicle attributes to determine if government interventions in Canada can increase adoption of this kind of vehicles. Also in Canada, Potoglou & Kanaroglou (2007) included neighbourhood characteristics as a factor that might influence choice for cleaner vehicles in urban setting. While Kuwano, Zhang, & Fujiwara (2005) focused on vehicle taxes to investigate its impacts on adoption of low-emission passenger cars in local cities in Japan. In the Philippines, majority of choice modelling in the field of transportation is on mode choices.

1.4.2. Potential adoption of low emission vehicles

Despite the benefits associated with the use of LEVs and alternative fuel vehicles (AFVs), it is faced with adoption challenges. Romm (2006) mentioned two central problems: market disadvantage and lack of cost-effectiveness. Market disadvantage necessitates government support and subsidies. Lack of cost-effectiveness emanates from stiff competition from conventional vehicles which has increased its fuel economy and lowered its tailpipe emission at levels not even thought possible a few decades back.

However, despite these disadvantages, numerous studies suggest acceptance and even adoption of LEVs. In Canada, choice simulation by Ewing & Sarigollu (1998) revealed as high as 55% share by AFVs in one scenario and as high as 50% share for BEV in another. In a follow up study, Ewing & Sarigollu (2000) included attitudinal factors and their simulation provided almost the same result with regards to AFV and BEV. In South Korea, while gasoline vehicles are still the primary choice, AFV offers a viable alternative to conventional vehicles (Ahn et al., 2008). As high as 60% share of LEVs for personal cars was estimated in local Japanese cities (Kuwano et al., 2005). Although Rubite & Tiglao (2004) modelled vehicle ownership in Metro Manila, no further literature related to vehicle choice was found for the Philippines.

CHAPTER 2. METHODOLOGY

2.1. Design of Choice Experiment

The main methodology employed in this study is choice experiment. It is an attribute-based stated preference method where respondents are directly asked about their preferred goods or services (e.g. consumer or environmental good). It is used in estimating the level of preference for and economic values of changes in quality or characteristics of a good.

Compared to contingent valuation method (CVM), a popular stated preference method where a single situation is usually presented to survey respondents, choice experiment uses several alternatives or options for the respondents to choose from. The alternatives (in this study refers to the vehicle choices) are contained in a *choice set* from which respondents are made to select one. This design closely resembles the real world decision-making condition, thus reducing the biases associated with CVM (Kragt & Bennett, 2010). Ewing & Sarigollu (1998) added that for the same reason, choice experiments are often preferred to preference ranking experiments, another stated choice method.

Choice experiment requires carefully designed choice sets. In their paper about conducting discrete choice experiments in developing countries, Mangham, Hanson, & McPake (2009) provided three general steps in designing a choice experiment (Table 2). In addition to the paper of Mangham et al., (2009), the procedure discussed by Bunch, Louviere, & Anderson (1996) was included to describe the process of making the actual choice set.

The first three methods of choice set generation are categorized as object-based design strategy. The rest are attribute based design strategies. The latter is described as a two-stage process. First, a starting design such as an orthogonal main effects plan (OMEP) which represents the first alternative in the choice sets is generated. The second step is to create the other alternatives based on the attributes of the first option. (Since discussion of the various methods are outside the scope of this study, readers are referred to Bunch et al, 1996 for details).

Table 2. General steps in designing choice experiments

Step	Details
1.Identifying the attributes	Literature reviews (published and gray) Primary data (surveys or focus group discussions) Relevance to the study
2.Assigning attribute levels	Range of values respondents might expect to experience
3.Designing the choice sets	a. Starting design • Full factorial • Fractional factorial • Orthogonal arrays b. Choice set generation (Bunch et al 1996) • All pairs (complete enumeration) • 2^J block assignment • Balanced incomplete block design (BIBD) • L^{IK} Method • Foldover • Shifted Designs (pairs, triples, quadruples)

2.1.1. Vehicle attributes and attribute levels

For this study, relevant vehicle attributes were identified using literature reviews. All attributes are considered generic (unlabeled) as opposed to alternative specific (labelled). Attribute levels were first established arbitrarily. The identification of attribute and attribute levels depends on the purpose of this study and relevance to the concerned population. Since most of the studies reviewed were conducted in developed countries, there was a possibility that the attributes and corresponding levels initially identified were irrelevant. To validate these attributes and attribute levels, an informal non-probabilistic online survey was conducted. The result of this survey confirms the appropriateness of the vehicle attributes and attributes levels initially identified.

The vehicle attributes and the attribute levels used are presented in Table 3. These attributes are either monetary, non-monetary and environmental as used by Bunch et al. (1993) and Potoglou & Kanaroglou (2007) in their similar studies. No vehicle performance attributes (e.g. engine power, acceleration time, etc) was included in this design.

Table 3. Vehicle attributes and attribute levels used in choice experiment design

Attributes	Levels	Variable Name	Description of Attribute
Fuel / Engine Type (*ENGINE*)	• Gasoline • Diesel • LPG-Gasoline dual-fuel • Hybrid electric • Battery electric	*GAS* *DIESEL* *LPG* *HEV* *BEV*	Type of motor installed in the vehicle
Purchase Price in Php'000 (*PPRICE*)	• Less than Php700 • Php700 to Php1,000 • More than Php1,000	*LessP700* *P700to1m* *MoreP1m*	Purchase price of the vehicle
Range of full tank or charge (*RANGE*)	• 200km • 450km • More than 450km	*r200km* *r450km* *Over450km*	Number of kilometers travelled by a full tank of fuel or full battery charge for electric vehicles.
Cost of driving 100 kilometers of travel in Php (*C100KM*)	• Php400 • Php600	*C400-km* *C600-km*	Fuel or electricity expenses incurred in travelling 100 kilometers
Parking / registration incentive / tax incentive (*INCNTV*)	• WITH Incentive • NO Incentive	*WITH_incntv* *NO_incntv*	Presence or absence of incentives
Emission Level (*EMIS*)	• Same as present day passenger car • At least 80% or less of present day passenger car	*Emis100* *Emis80*	The level of emission relative to present day brand new car.

For the purchase price, an initial list was obtained from the website of major automotive manufacturers in the Philippines. The various prices were then categorized as shown in the previous table to show boundaries for low, medium, and high vehicle prices. Cost of driving 100 kilometers was estimated using the assumed fuel economy of 10 km/liter and the average fuel price. The base fuel used was gasoline since this is the fuel used in most private vehicles. Fuel/engine type are those existing in the country including the newer hybrid-electric and battery electric vehicles. Range of travel in one full tank or full charge of battery is based on the range of an average car with a fuel tank capacity of 45 liters and the current potential maximum range of BEVs (200km) and HEV (more than 450kms). Incentives are list of hypothetical but realistic incentives that may be given to a vehicle buyer. Emission is the level of emission (in percent) relative to present day vehicle.

Some of the important considerations for stated preference surveys are the framing of the questions and relevance and comprehensibility of the attributes used. These aim to address some of the biases resulting from misunderstanding the questions or the choices. For the choice experiment, the aim is to make the attribute levels as meaningful, understandable and readily absorbed by the respondents (Ewing & Sarigollu, 2000). For example, instead of using emission level in terms of CO_2/km which may be difficult to fully understand without prior knowledge of its nature or implication, percent reduction or relative emission level was used.

2.1.2. Designing the choice sets

Given the number of attributes and attribute levels, there are 5x3x3x2x2x2 $=5x3^2x2^3$ =360 possible combination of attribute levels (called *profiles*) that can be created. Each profile describes one alternative. This full factorial design is orthogonal and all main effects can be estimated and are uncorrelated – desired characteristics of a choice experiment design. However, with $[p*(p-1)/2] = 64{,}620$ (p is the total number of profiles) total possible number of choice sets with two alternatives that can be created, it is necessary to reduce the number of choice sets for practical reasons. A fraction of the full factorial design was used.

For this choice experiment design, only the main effects were considered for estimation. Main effects designs tend to be simpler and results in smaller number of alternatives required in making the design. While higher order interactions may be better, main effects design is enough to explain the choices made by the respondents. According to Louviere et al. (2000):

- Main effects typically account for 70 to 90 per cent of explained variance,
- Two-way interactions typically account for 5 to 15 per cent of explained variance, and
- Higher-order interactions account for the remaining explained variance.

(a) Starting design

For this study, the procedure described by Bunch et al. (1996) was followed. The first step is to create a starting design. Ideally, an orthogonal design is used as the starting design. However, since no orthogonal array is available, a near orthogonal and efficient design was sought using the statistical software called R (http://cran.r-project.org/index.html). R statistical software was used by employing the AlgDesign Package.[3] R is a free software with comparable capabilities and many available statistical packages.

First, a full factorial design was generated using the *gen.factorial* command. An efficient design with a desired number of profiles was generated from the full factorial design using the *optFederov* command. Efficiency of a design is measured with respect to a particular statistical criterion. For this study, the D-efficiency criterion was used (see

[3] http://cran.r-project.org/web/packages/AlgDesign/index.html

AlgDesign Manual).[4] The goal is to increase efficiency to decrease bias in estimated parameters.

Since the *optFederov* command searches for an optimal design, an orthogonal main effects plan (OMEP) will be generated if it exists. If an OMEP does not exist for the specific number of attributes and its levels, the algorithm will search for the design with the highest efficiency given the specified number of profiles. For this study, a design with 30 profiles yielded the highest efficiency (97%). The starting design is shown in second column of Table 4. This starting design has very low correlation among attributes (Table 5).

(b) Generating the Choice Sets

The 30 profiles created in the starting design will serve as the first vehicle option in the choice experiment. To complete a choice set, a second alternative was created from each of the profile in the starting design. This was done using the *shifting method*. *Shifting* involves adding 1 to the attribute level of the initial design using modulo arithmetic based on the number of levels of the attribute concerned. This method maintains the orthogonality of the starting design.

Each number in the design was replaced with the corresponding vehicle characteristics to produce the actual description of each vehicle. The coding and the final choice set design are also shown in Table 4. Thirty choice sets with two vehicle options each plus an option not to choose was the final design. The number of alternatives per choice set was limited to two to reduce cognitive difficulty in answering the choice experiment.

[4] http://cran.r- project.org/web/packages/AlgDesign/AlgDesign.pdf

Table 4. Choice set design

Choice Set	Starting Design (Alternative 1)	Shifted Design (Alternative 2)	Design codes
1	521111	132222	Engine Type (1st column)
2	112111	223222	1-Gasoline
3	322111	433222	2-Diesel
4	432111	513222	3-LPG-Gas Dual Fuel
5	533111	111222	4-Hybrid Gas-Electric (HEV)
6	231211	312122	5-Electric (BEV)
7	331211	412122	
8	211121	322212	Price (2nd column)
9	123121	231212	1-Less than Php700,000
10	411221	522112	2-Php700,000 to Php1 million
11	512221	123112	3-More than 1 million
12	422221	533112	
13	213221	321112	Range (3rd column)
14	123221	231112	1-More than 450kms
15	333221	411112	2-450kms
16	111112	222221	3-Less than 200kms
17	413112	521221	
18	223112	331221	Cost of 100kms of travel (4th column)
19	131212	212121	1- Php400
20	512212	123121	2- Php600
21	222212	333121	
22	313212	421121	Incentive (5th column)
23	423212	531121	1-WITH Incentive
24	321122	432211	2-NO Incentive
25	431122	512211	
26	312122	423211	Emission relative to present day car
27	232122	313211	1-Same as present day passenger car
28	533122	111211	2-80% or less of present day passenger car
29	521222	132111	
30	132222	213111	

Table 5. Correlation matrix of starting design

	ENG	PRICE	RANGE	C100km	INCNTV	EMIS
ENG	1.000					
PRICE	0.000	1.000				
RANGE	0.000	-0.050	1.000			
C100km	0.000	0.000	0.000	1.000		
INCNTV	0.000	0.000	0.000	0.067	1.000	
EMIS	0.000	0.000	0.000	-0.067	-0.067	1.000

(c) Evaluating the choice set

To further test the efficiency of the choice sets, the design was evaluated using the desired properties of efficient designs - level balance, orthogonality, minimal overlap, and utility balance (Huber & Zwerina, 1996).

The choice set achieved level balance (Table 6) and no overlap (i.e. no the same attribute level appeared in the same choice set). Orthogonality cannot be achieved since the starting design is only near orthogonal but nonetheless it was best suited considering the number of desired choice sets. Utility balance was not considered since *a priori* values of the parameter coefficients are unknown or there is no basis for a good estimate of its values.

Table 6. Level balance of the starting design and the shifted pair

Attribute Levels	Number of Appearance in the Design					
	ENG	PRICE	RANGE	C100km	INCNTV	EMIS
1	6	10	10	15	15	15
2	6	10	10	15	15	15
3	6	10	10			
4	6					
5	6					

2.1.3. Employing the choice experiment

The 30 choice sets were still too many for a single respondent to evaluate. To address this, the choice sets were randomly assigned into 3 blocks with 10 choice sets each. As a result, three versions of the questionnaire were produced with the choice experiment as the only difference among the versions. Each block was answered by an equal number of respondents.

Furthermore, the ordering of the attributes in each choice set was randomized to prevent "learning" which might result in biased choices by the respondents. Another consideration was the existence of dominant alternatives. Dominant alternatives are those that have all attribute levels considered superior to the attribute levels of the other alternative in the same choice set. In this study, few semi-dominant alternatives emerged but were nonetheless included in the choices. An example of a choice set is shown in Figure 2.

CHOICE SET 1 of 10

If these were your final vehicle choices, which one would you choose?

FEATURES	Vehicle K	Vehicle A
No. of kilometers in a full tank or full charge	More than 450 kilometers	Less than 200 kilometers
Level of emission	Same as present day vehicle	At least 20% LESS than present day vehicle
Fuel cost of travelling 100 kilometers	Php600	Php400
Purchase price	Less than Php700,000	Between Php700,000 to 1million
Engine	Hybrid Gas-Electric	Electric
Incentives (vehicle registration, parking, and tax)	NO incentive	WITH incentive
I WILL BUY VEHICLE	☐ K	☐ A
☐ I WILL NOT BUY EITHER OF THE VEHICLES		

Figure 2. An example of a choice experiment used in the survey

2.2. Questionnaire Design

The questionnaire was designed for face-to-face interview format. Questions were made self-explanatory, easy to understand, and self-answerable. In case of terminologies and parts of the questionnaire incomprehensible to layman, additional information was provided to the respondents. In addition to the choice experiments, the questionnaire has other parts that addressed the data needs of the study. These are:

- Characteristics of the most often used vehicle
- Vehicle usage and travel behavior
- Knowledge on vehicles (including LEVs)

- Future vehicle choices (including the choice experiment)
- Views on technology and the environment
- Respondent information (socio-economic and demographics)

2.3. Study Area, Relevant Population and Sampling

Metro Manila is the National Capital Region of the Philippines. It is located in the southern part of Luzon Island bounded by Manila Bay to the west and Laguna de Bay to the east (Figure 3). It has a land area of 639 square kilometers, less than 1% of the country's total land area. Nonetheless, Metro Manila is home to almost 12 million people (National Statistics Office, 2012) making it one of the most densely populated urban areas in the world.

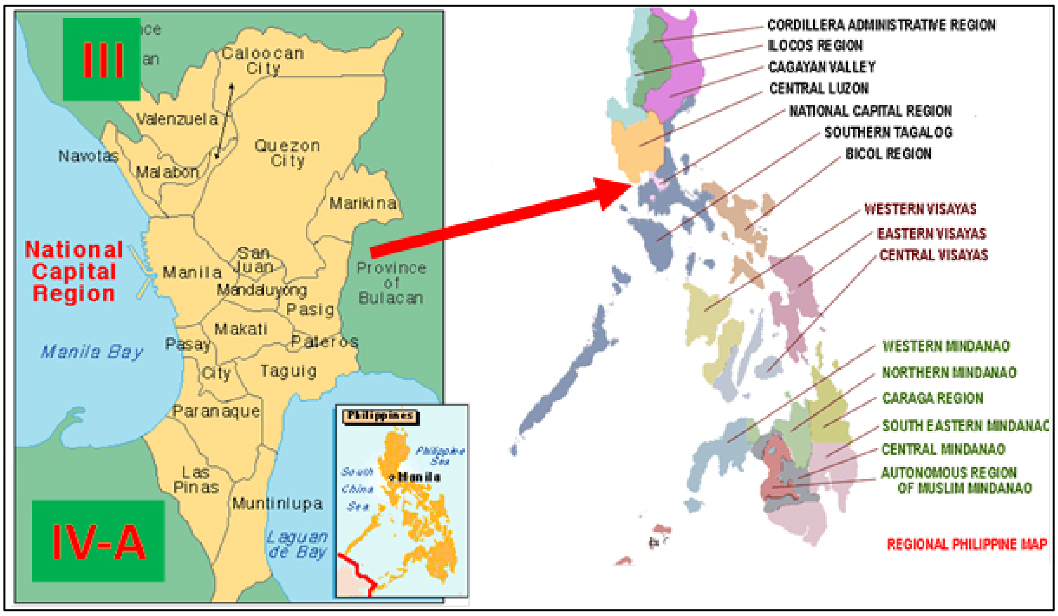

Figure 3. Map of Metro Manila, Philippines
(sources: http://www.retireinthephilippines.info/wp-content/uploads/2011/09/metro-manila-map.gif
http://bahay.ph/img/map.gif)

Metro Manila is composed of 16 cities and one municipality. As the major center of commerce and economic activity in the Philippines, it contributes at least 32% of the country’s gross domestic product (NSCB, 2007). Metro Manila also has 29% of the 6.6 million vehicles in the country. The high concentration of vehicles and people in this region resulted in air pollution with its adverse impacts on human health.

The respondents of this study were owners of personal privately-used vehicles excluding two- and three-wheeled motorcycles. In case of multiple vehicle holdings, the target vehicle for the survey was the vehicle used most often for personal commuting. It was assumed that this sector of vehicle owners have the financial capability and flexibility in terms of vehicle choices. This is important since LEVs included in the choice experiment are considered more expensive than conventional vehicles.

In the absence of complete and accurate listing of the relevant population, random sampling was not an option. For this survey, specific areas in Metro Manila where there is a large concentration of vehicles were targeted. These areas include central business districts and mall parking lots. Respondents were then randomly selected on spot to be interviewed.

A survey company was hired for the fieldwork. Meeting and regular communications were made to ensure full understanding of the survey questionnaire. The face-to-face interviews were undertaken from September to November of 2011. Considering time and costs constraints, the number of respondents was limited to 300 vehicle owners.

2.4. Data Analysis

2.4.1. Choice modelling

Data from the choice experiment was fitted into a conditional logit model. Several choice models were estimated and compared to determine the best fitted model. The basic utility specification is as follows:

$$
\begin{aligned}
\text{Utility (U)} = {} & GAS*\beta_{GAS} + DIESEL*\beta_{DIESEL} + LPG*\beta_{LPG} + HEV*\beta_{HEV} + BEV*\beta_{BEV} \\
& + LessP700*\beta_{LessP700} + P700to1m*\beta_{P700to1m} + MoreP1m*\beta_{MoreP1m} \\
& + r2ookm*\beta_{r200km} + r450km*\beta_{r450km} + Over450km*\beta_{Over450km} \\
& + C400km*\beta_{C400km} + C600km*\beta_{C600km} \\
& + WITH\_incntv*\beta_{WITH\_incntv} + NO\_incntv*\beta_{NO\_incntv} \\
& + Emis100*\beta_{Emis100} + Emis80*\beta_{Emis80} \\
& + NONE*\beta_{NONE}
\end{aligned}
$$

In this model, all variables are categorical and dummy-coded. Minor modifications in the utility specification were done when selected explanatory variables were treated as quantitative.

2.4.2. Market simulation

Choice simulations were done on different vehicle types to estimate potential market share. The first simulation involves straightforward application of the choice model. Eleven (11) scenarios characterized by changing vehicle characteristics were used in Simulation 1. For Simulation 2, the constraint imposed by the price of HEV and BEV was included in the computation of probabilities. Then for Simulation 3, a scale parameter in the form of the number of available model variants for each vehicle type was added. The details of each simulation are discussed in the corresponding section of the simulation results.

2.4.3. Emission models

Emission is a function of different factors. As used by the Metro Manila Urban Transportation Integration Study (1999):

Air pollutant emissions = f (travel distance, travel speed, idling, emission factors, wind speed, wind direction)

While Subida, Velas, & MacNamara (2004) used the following emission model:

Emissions = f (travel distance, travel speed, emission factors)

This study used only travel distance and emission factors in estimating the CO_2 emission.

Emission = f (Emission Factor, Travel Distance)

The potential CO_2 reduction was separately estimated for diesel and gasoline vehicles to account for the difference in the emission factor of each fuel type.

2.4.4. Estimating the potential CO_2 reduction

As previously mentioned, emission and emission reductions were estimated using travel distance and emission factor. Other factors such as driving conditions and driving behaviour are difficult to quantify and were not considered in the emission model. Estimating the CO_2 emission was straightforward for gasoline, diesel, LPG and even HEV vehicles. For BEV, the grid emission factor was used to estimate the CO_2 emission per kilometer of travel.

For PHEV, estimation of emission required several steps. First, the fraction of daily travel that can be made in *blended mode*[5] and in gasoline engine only mode was computed from the daily travel data of each respondent. The daily estimates are then translated into annual vehicle kilometers travelled. Using the appropriate emission factors, annual CO_2 emissions and reductions were computed.

[5]Blended mode refers to simultaneous operation of the electric motor and gasoline engine in PHEVs.

(a) Vehicle kilometers travelled

The daily travel of each respondent was taken from the survey. The distance travelled by PHEV was decomposed based on an assumed range of the blended mode. The blended mode range used was 17, 30, 40, 50 and 60 kilometers. A sample computation at 17km blended mode range of PHEV is shown below:

Respondent 1 (Monday)

Total daily travel	– 15km
Blended mode travel	– 15km
Gasoline only	- 0km

Respondent 1 (Saturday)

Total daily travel	- 75km
Blended mode travel	- 17km
Gasoline only	- 58km

The estimates were made for all respondents using a simple spreadsheet. The daily estimates were forecasted into annual values using the frequency of use by each day of the week. Long distance travels were also considered in estimating the annual travel. In case respondents travel long distances on a daily basis (e.g. more than 100kms per day), it was counter checked to avoid double counting that would result in overestimation of the travel distance

.

(b) Emission Factors

To estimate the CO_2 emission from the annual vehicle travel, two types of emission factors were used. These were:

- Grid emission factor –the amount of CO_2 emitted per unit of electricity produced. This depends on the source of electricity. This was converted into a factor that measures the amount of CO_2 emitted per kilometer of travel of the BEV or PHEV.

- Fuel emission factor – the amount of CO_2 emitted per kilometer travelled by gasoline or diesel vehicles (in g or kg of CO_2 per kilometer travel). The values of the emission factors used for this study are shown in Table 7.

Table 7. Emission factors of different fuel types

Fuel Type	Vehicle Type	Emission Factor (in g CO_2 / km)
Gasoline	Cars	399
	Utility/Jeepney	456
	Motorcycles/Tricycles	186
Diesel	Cars	537
	Utility/Jeepney	559
	Buses	1249
Electricity*		71

Source: ADB 2002 as cited by IES (except for electricity which is based on the researcher's own estimate

*Assumed 7 kilometers/kWh at grid emission factor of 495 g CO_2/kWh (Takahashi, 2011)

Emission factor for PHEV was computed assuming a Parallel or Blended Type PHEV. This type uses the electric motor and gasoline engine simultaneously until the battery is drained after which the only the gasoline engine functions until such time the battery is recharged. Because of this, there are separate emission factor for blended mode and gasoline engine only mode (Table 8). (For description of PHEVs, see 5.3.1. Plug-in hybrid vehicle: Description and characteristics, p. 67).

Table 8. Emission factor and range of PHEV

Running Mode	Range	grams CO2 per kilometer
Electric and Gasoline (Blended Mode)	17.7 kilometers	100.24
Gasoline Only	529.0 kilometers	110.79
Total	851.7 kilometers	n.a

*Based on US EPA rating of the 2012 Plug-in Toyota Prius

2.5. Scope and Limitation

This study acknowledges the fact that the transportation sector is broad with many sub-sectors under its umbrella. The focus for this particular research is privately-used or personal vehicles. As defined in this research, these are vehicles not used for public conveyance. Furthermore, even though motorcycles have taken majority share of the total vehicles in the country, it was excluded as it belongs to a completely different vehicle type compared to four-wheeled vehicles and has a different market niche.

This research leans heavily on statistical analysis. However, due to time, logistical, and financial limitations, the sample size was limited to 300, with non-random sampling that were justified based on previous studies done by other researchers. As such, some findings here are interpreted with caution. Generalizations may refer only to the respondents unless the method of analysis allows for the whole relevant population. Findings refer only to Metro Manila and cannot be readily extended to other parts of the Philippines due to absence of analysis that will permit such interpretation.

Only the demand side of LEVs was studied here. Considering that the LEVs included in this study are commercially available, it is assumed that supply will react accordingly to changes in demand.

Lastly, this is not an attempt to promote any specific model or brand of a vehicle. Specific brands and models were mentioned in the succeeding text but it is by no means an endorsement. It is just a statement of facts to provide necessary background information for the analyses. Other analytical and methodological limitations are mentioned in their respective chapters and sub-chapters.

CHAPTER 3. RESPONDENT CHARACTERISTICS

3.1. Distribution of Respondents by City/Municipality

Most of the respondents came from the cities in Metro Manila with major economic activity (i.e. with big central business districts) such as the cities of Pasig, Makati and Mandaluyong (Table 9). Quezon City, on the other hand, is the largest city in Metro Manila in terms of land area and population.

Table 9. Distribution of respondents by city/municipality

City	Number	Percent
Pasig	91	30.3
Quezon	67	22.3
Makati	40	13.3
Mandaluyong	23	7.7
Manila	18	6.0
Marikina	17	5.7
Parañaque	13	4.3
Taguig	11	3.7
Muntinlupa	7	2.3
Las Piñas	4	1.3
Pasay	3	1.0
San Juan	3	1.0
Caloocan	2	0.7
Pateros	1	0.3
Total	300	100

3.2. Socio-economic Characteristics

The socio-economic characteristics of the respondents are summarized in Table 10. Mean age of respondents is 36.8 years. Sixty one percent of the respondents are male. More than half (59%) are employees while 34% are self-employed or have their own busines. The remaining 7% who reported no occupation are retired individuals and graduate students.

Table 10. Socio-economic characteristics of respondents

Characteristics	Description
Age (mean, in yrs)	36.8
Sex	
Female	39%
Male	61%
Occupation (% of n)	
Employed	59%
Self-employed/Businessman	34%
None	7%
Household (mean)	
Size	5.2
No. of members with income	2.8
No. of members studying	1.3
Monthly household income (% of n)	
Php15,001 to 30,000	6%
Php30,001 to 75,000	25%
Php75,001 to 100,000	18%
Over Php100,000	51%
Number of vehicles (per household)	
Mean	1.9
Mode	1
Median	1

US$ 1 = Php 43.29

Average household size for this sample is 5.2, close to Metro Manila average of 5. However, this is almost a one-person increase from the average household size of 4.3 reported by Rubite & Tiglao (2004) in their paper on car ownership modelling in Metro Manila using the 1996 data from the MMUTIS. The same can be said to the number of income earners which is 2.8 per household for this study and “approximately 2” for MMUTIS.

The multiple income earners per household are reflected in the high monthly household income of the respondents. As shown in the previous table, 51% reported a household monthly income of at least Php100,000 which is more than three times of the Metro Manila average of Php30,000 per month for all households (National Statistics Office-NCR, 2011). This is expected since the target respondents are vehicle owners who were assumed to have considerable amount of income. However, this can also be a result of the non-random sampling process employed in this survey. Nevertheless, the over-sampled segment of the population is rather desirable with regards to cleaner technology according to Potoglou and Kanaroglou (2007).

The average number of vehicles owned is 1.9 per household. But majority of the household own only a single vehicle as indicated by the mode and median. Most of the respondents are well-educated with 77% having attended a college or university (Figure 4). Some have a post-graduate degree (6%) or graduate units earned (2%).

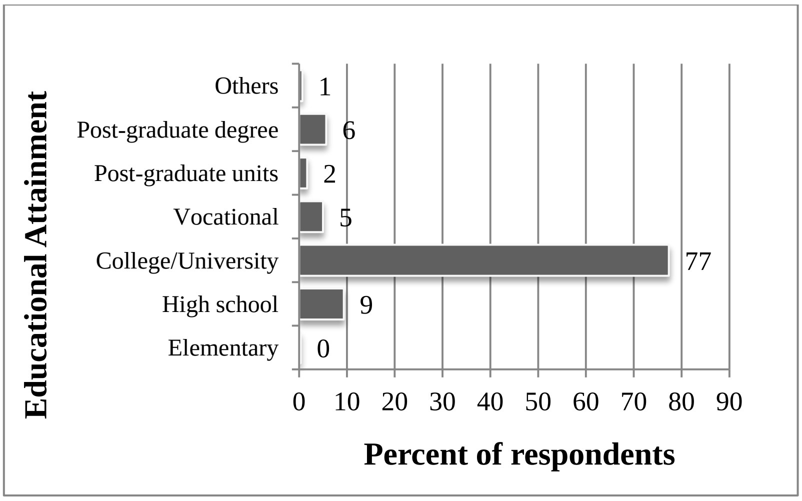

Figure 4. Distribution of respondents by educational attainment

3.3. Vehicle Characteristics

The mean age of the reported vehicles is 8.8 years (Table 11). More than one-third (69%) of the vehicles use gasoline fuel and the rest (31%) use diesel. Data for 2005 from the Land Transportation Office reported the same figures for Metro Manila while on the national level the distribution is 72% gasoline and 28% diesel for all types of vehicles. However, considering only the personal cars (i.e. cars and SUVs), the same LTO data reported 84% of the vehicles using gasoline and the rest diesel.

Table 11. Characteristics of respondents' vehicle

Characteristics	Description
Vehicle age (mean, in years)	8.8
Mean acquisition cost (in Php)	579,007
Fuel Type	
Gasoline	69%
Diesel	31%
Condition when bought	
New	52%
Second hand	48%
Acquisition cost	
Less than Php700,000	65%
Php700,000 to 1million	20%
Over Php1 million	15%
Engine size in liters	
0 to 1.99	61.3%
2 to 2.99	35.3%
More than 3	3.3%

US$ 1 = Php 43.29

The percentage of vehicles bought brand new and second hand is 52% and 48%, respectively. As expected, more vehicles were bought at lower prices. Sixty five percent of the vehicles were bought at less than Php700,000 - most of which are second hand vehicles. Vehicles bought above Php700,000 are mostly brand new vehicles. The mean acquisition cost for all vehicles is Php579,007.

Car financing differs significantly based on the condition of the vehicles bought. Seventy one percent of vehicles bought as new were financed through loans payable in monthly instalments while 88% of used vehicle are bought by cash due to its lower price.

Compact/sub-compact sedans form half of the reported vehicles as shown in Figure 5. This is followed by Asian utility vehicles (18%) and vans (13%) - multi-purpose vehicles that offer bigger space than sedans. Sports utility vehicles (SUV) have also increased its share over the years. Among the vehicles of the respondents, 6% are full-sized SUV and 4% are compact SUV.

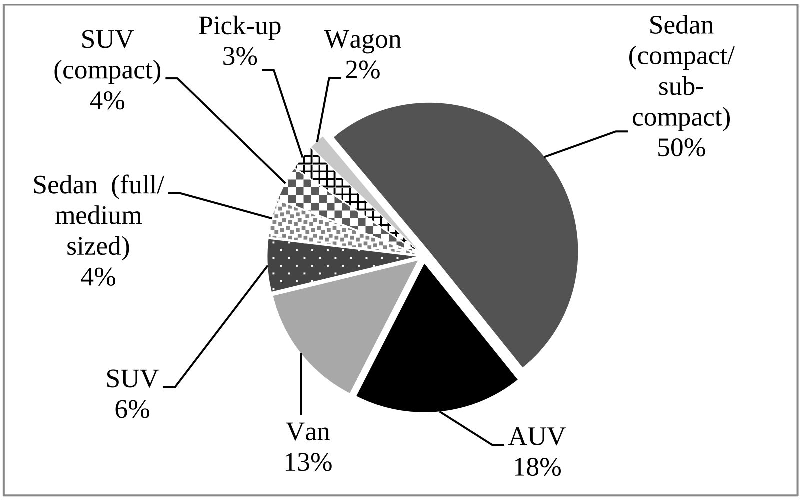

Figure 5. Distribution of vehicles by class/size

Engine size reflects the vehicle and fuel type. Smaller engines with displacement of less than 2.0 liters compose 63% of the reported vehicles. This particular engine size is common to sedans and small vehicles with gasoline engines. On the other hand, large vehicles usually have diesel engines with bigger displacement.

3.4. Travel Characteristics

The respondents' daily travel is generally short with a mean of 18.7 kilometers. Excluded were long distance trips of at least 100 kilometers unless such distance are the regular daily travel of the respondent. The average annual travel is 7,727 kilometers. The figures for daily and annual travel were given as separate estimates. It is acknowledged that accuracy of the self-reported estimates varies and depends on the respondents' computational and recall ability. However, the daily and annual travel of each respondent was compared to determine consistency of the reported figures.

The amount of long distance travel made annually is shown in Table 12. For this study, long distance travel refers not only to distance but also to non-regularity of such travel. Therefore, if the long distance travel pattern of a respondent reflects daily occurrence (e.g. Monday to Friday), it is excluded in the computation of the mean number of long trips and was considered as daily travel as previously mentioned. On the other hand, if such trips were made regularly once or twice a week, it was classified as long distance.

Table 12. Average number of annual long distance travel

Travel distance	Mean	n
100 to 200kms	11.7	135
200 to 300kms	4.2	56
300 to 400 kms	3.0	39
Over 400kms	2.5	51

The result shows that all respondents travelled at least 100 kilometers in a single trip in the past year. The distance of 100 to 200 kilometers was made by 135 of 300 respondents. Such travel distances were made an average of 11.7 times a year. Longer distances of 200 to 300 kilometers were reported by 56 respondents, 300 to 400 kilometers by 39, and over 400 kilometres by 51 respondents.

The primary uses of the vehicle are for going to work (55%), for business-related trips (25%), bringing the children to school (3%) and others (17%). Most of the respondents (79%) reported using public transportation on a regular basis in addition to the regular use of their vehicle.

3.5. Vehicle Purchasing Behaviour

3.5.1. Sources of information

The actual purchase of a consumer good is usually preceded by various decision-making processes. First is to decide whether to buy or not. If the decision maker decides to buy, the rest of the process involves mostly of gathering information about the vehicle, the financing options, and even about the previous vehicle owner (for second hand vehicles). It is therefore critical, that there are reliable sources of information that will help consumers make an informed choice.

Information from various sources was assessed by the respondents by a simple rating procedure. The result shows that the information from almost all potential sources is deemed useful or very useful (Table 13). The information and communication sector – Press (59%), Advertisements (56%) and Internet (50%) - received consistently high assessment as source of useful information. Personal experience (60% very useful) and inter-personal source (54%) also proved to be a source of useful information about vehicles. The government received a mixed assessment with 42% and 10% of respondents saying the information is useful and very useful, respectively. However, 25% said the information from the government is not useful and 23% has not heard of any information from them thus there is no basis for assessment.

Table 13. Respondents' assessment of vehicle information from various sources

Source	Assessment of information (in percent response)			
	Very useful	Useful	Not Useful	Not applicable
Government	10	42	25	23
Press	22	59	17	2
Testimonies	37	54	9	0
Internet	33	50	13	4
Advertisements	27	56	16	1
Experience	60	36	3	1
Consumer Reports	25	58	15	2

In terms of consultation regarding vehicle purchases, respondents consult their spouses (32%), friends (26%), car sales agent (4%) children (1%), and others (12%). Twenty-five percent do not consult anyone regarding this matter.

3.5.2. Environment and vehicle purchase

The respondents' concern for the environment when buying or choosing a vehicle was determined. Sixty two percent (62%) of the respondents said that they consider the environment when buying a vehicle with air pollution and smoke (emission) as the most mentioned environmental impact. Eighty three percent (83%) believe that their current vehicle is environment friendly. This self-assessment is very encouraging, although it can also be misleading due to the tendency of respondents to provide answers that will make themselves or the researcher "feel good". The choice model in the latter part will show how much they are concerned with environmental impact of vehicle use, specifically with emissions.

3.6. Views on Low Emission Vehicles

Seventy seven percent (77%) of the respondents believe that environment-friendly vehicles are already available in the market. However, when asked about LEVs, only 38% know what LEVs specifically are, while 44% have heard about it but do not know the details and 18% do not know anything about LEVs. Of all the respondents who know LEVs, 60% (or 23% of all respondents) said they will buy an LEV in the next 5 to 10 years, 34% said they may consider buying one, and 6% said they will not buy an LEV.

Using common vehicle characteristics, the respondents' opinions on LEVs relative to conventional gasoline or diesel vehicles were sought to determine some level of awareness or familiarity or misconceptions about LEVs. As shown in Table 14, the respondents are almost equally divided on opinion about reliability with 34% saying LEVs are as reliable as conventional vehicles and 31% saying LEVs are less reliable. More respondents said that LEVs have less range (42%), less engine power (46%), less speed (42%) but costs more (53%) than conventional vehicles. While opinion on cost is fairly accurate, those on range, engine power and speed reflect some unfamiliarity on different kinds of LEVs.

Table 14. Respondents' opinion on LEVs compared to ordinary vehicle

Attribute	Percent response			
	1-Less	2-Same	3-More	4-Do not know
Reliability	31	34	13	22
Range (in kms)	**42**	29	11	19
Engine power	**46**	26	9	19
Price	11	15	**53**	21
Speed	**42**	30	9	19

Not all LEVs are created equal so proper information for the consumers is critical for its successful diffusion. For example, BEVs are known to have limited range on a full charge of battery but on the other hand, HEVs have extended range.

3.7. Preference for Next Vehicle Purchase

The respondent's willingness to pay for the next vehicle purchase is shown in Table 15 and their preferred vehicle size or body type in Table 16.

Table 15. Respondents' WTP for next vehicle purchase by vehicle condition

Amount	Condition (%)		ALL
	New	Used	
Less than Php700,000	8.3	13.7	22.0
Php700,000 to 1millio	52.7	0.3	53.0
Over Php1million	25.0	0.0	25.0
Total	86.0	14.0	100.0

Table 16. Respondents' preferred next vehicle by body type and condition

Next vehicle size/class	Condition (%)	
	New	Used
SUV	3.7	25.7
Van	5.0	19.7
Pick-up	2.0	11.3
Full/medium car	0.7	11.0
AUV	0.7	7.3
Compact SUV	0.7	6.0
Sub/Compact	1.3	4.0
Others	0.0	1.0
TOTAL	14.0	86.0

More than half of the respondents (53%) are willing to spend up to Php1 million pesos for their next vehicle purchase. The mean willingness to pay for next vehicle is Php970,390.The respondents prefer larger vehicles than small cars as their next vehicle. Twenty nine percent (29%) of the respondents prefer an SUV followed by van (25%), pick-up trucks (11%) and full-sized sedans (11%) as their next vehicle.

CHAPTER 4. VEHICLE CHOICE MODEL

4.1. Base Models

Two conditional logit choice models were initially estimated using Stata statistical software. An additional package, SPost, was used for the post-estimation commands. In Choice Model 1, all the explanatory variables were dummy-coded. In Choice Model 2, the variables cost of 100 kilometers travel (*C100KM*) and emission level compared to current day vehicle (*EMIS*) were treated as quantitative variables. The two models were compared and one was used in the succeeding analyses.

For dummy-coded attributes, one of the variables was set as the base variable. All estimated parameters are interpreted relative to these base variables. Quantitative variables *C100km* and *EMIS* did not require a base variable. The base variables used for each attribute were:

Vehicle attribute	Base variable
Purchase price	- More than Php1,000 (in Php'000)
Range	- 200kms
Incentive	- NO incentive

Regression results are shown in Table 17 for Choice Model 1 and Table 18 for Choice Model 2. Results show that both models are practically the same in terms of model fit. Both models also showed an improvement from the null model in terms of log-likelihood (-3295.8 to -2582.1). This means that both models are better than the model containing only the intercept.

For both models, all coefficients are highly significant at 95% significance level except for the range variable *Over450km* in Choice Model 1. The signs of the coefficients met theoretical expectations except for the range variable *r450km* which is negative relative to the base variable of *r200km*. This implies that the longer range is less preferred than the shorter one which is opposite of the logical expectation.

Table 17. Choice Model 1

Variables	Coef.	Std. Err	z	P>|z|	P>|z| [95% Conf. Interval]	
DIESEL	0.211	0.076	2.79	0.005	0.063	0.359
LPG	-0.367	0.093	-3.97	0.000	-0.549	-0.186
HEV	0.200	0.091	2.21	0.027	0.023	0.378
BEV	-0.264	0.077	-3.45	0.001	-0.414	-0.114
LessP700	0.258	0.056	4.59	0.000	0.148	0.368
P700to1m	0.233	0.056	4.16	0.000	0.123	0.343
Over450km	0.077	0.056	1.36	0.173	-0.034	0.187
r450kms	-0.235	0.056	-4.22	0.000	-0.345	-0.126
C600-km	-0.193	0.040	-4.85	0.000	-0.272	-0.115
WITH_incntv	0.243	0.040	6.1	0.000	0.165	0.322
Emis100	-0.220	0.040	-5.5	0.000	-0.298	-0.141
NONE	-1.797	0.106	-17.02	0.000	-2.004	-1.590

Number of obs	=	9000	Pseudo R2	=	0.2166
LR chi2(12)	=	1427.51	Log likelihood	=	-2582.0818
Prob > chi2	=	0.0000			

The coefficients in both models indicate that an increase in cost of 100km travel and emission level each decreases the probability of a vehicle being chosen. On the other hand, lower price and the presence of an incentive, each increases probability.

Since both models are practically the same, Choice Model 2 was used for further analyses. The presence of the quantitative explanatory variables in Choice Model 2 gave flexibility in estimating choice probabilities of the vehicle. This proved useful in analyzing various policy scenarios.

Table 18. Choice Model 2

Variables	Coef.	Std. Err	z	P>|z|	P>|z| [95% Conf. Interval]	
DIESEL	0.211	0.076	2.79	0.005	0.063	0.359
LPG	-0.367	0.093	-3.97	0.000	-0.549	-0.186
HEV	0.200	0.091	2.21	0.027	0.023	0.378
BEV	-0.264	0.077	-3.45	0.001	-0.414	-0.114
LessP700	0.258	0.056	4.59	0.000	0.148	0.368
P700to1m	0.233	0.056	4.16	0.000	0.123	0.343
Over450km	0.077	0.056	1.36	0.173	-0.034	0.187
r450kms	-0.235	0.056	-4.22	0.000	-0.345	-0.126
WITH_incntv	0.243	0.040	6.10	0.000	0.165	0.322
C100KM	-0.001	0.000	-4.85	0.000	-0.001	-0.001
EMIS	-0.011	0.002	-5.50	0.000	-0.015	-0.007
NONE	-3.062	0.226	-13.57	0.000	-3.504	-2.620

Number of obs	= 9000	Pseudo R2	= 0.2166
LR chi2(12)	= 1427.51	Log likelihood	= -2582.0818
Prob > chi2	= 0.0000		

4.2. Interpretation of the Regression Coefficients

This section provides a simplistic interpretation of the regression results. Comparison is made among variables within each vehicle attribute (i.e. within different types of engines or different purchase prices, etc.) holding values of other attributes at their mean values. The comparison was made in terms of the changes in odds ratio relative to the base variables.

The coefficients, odds ratio (e^b) and the corresponding percentage change in odds is shown in Table 19. Results show that vehicles with diesel and HEV engines increases the odds of a vehicle being chosen by 23.5% and 22.2%, respectively, relative to vehicles with gasoline engine (base). For diesel vehicles, it can be explained by lower price of diesel fuel and its reputation for better fuel economy compared to gasoline engines. For HEV, despite being new in the market, having cleaner emissions and higher fuel economy explains the respondents' preference.

Table 19. Factor and percent change in odds of variables (Choice Model 2)

Variable		Coef (β)	z	P>Z	e^β	%
DIESEL	|	0.211	2.787	0.005	1.23	23.5
LPG	|	-0.367	-3.970	0.000	0.69	-30.8
HEV	|	0.200	2.212	0.027	1.22	22.2
EV	|	-0.264	-3.452	0.001	0.77	-23.2
LessP700	|	0.258	4.591	0.000	1.29	29.4
P700to1m	|	0.233	4.159	0.000	1.26	26.2
Over450km	|	0.077	1.363	0.173	1.08	8.0
r450kms	|	-0.235	-4.220	0.000	0.79	-21.0
WITH_incntv	|	0.243	6.097	0.000	1.28	27.6
C100KM	|	-0.001	-4.851	0.000	1.00	-0.1
EMIS	|	-0.011	-5.500	0.000	0.99	-1.1
NONE	|	-3.062	-13.572	0.000	0.05	-95.3

β = raw coefficient
z = z-score for test of b=0s
P>|z| = p-value for z-test
e^b = exp(b) = factor change in odds for unit increase in X
% = percent change in odds for unit increase in X

LPG engines are less preferred than gasoline engines (odds decreased by 30.8%). This can be attributed to perceived negative health impacts of LPG fuel. The perception stemmed from taxis in Metro Manila that have improperly installed or mistuned LPG fuel system. This resulted in gas leaks in the vehicle that affected drivers and passengers which are then reported in news. Many taxi operators switched to LPG because of lower prices and presence of government support but some had their system installed by untrained personnel to lower installation cost.

BEV decreases its odds of being chosen by a factor by 23%. This can be attributed to the perception of BEV as being expensive, travels less number of kilometers, has lower engine power, and slower speed as previously shown in the descriptive data.

Lowering the price of a vehicle up to a maximum of Php1 million increases its odds by 26% compared to the base price of more than Php1 million. Further decrease of price up to a maximum of Php700,000 increases the odds to 29%, a 3% increase from the previous level.

The range variables do not show any logical pattern. The range variable *Over450km* is not significant. Against theoretical expectations, the range variable *r450km* is less preferred than the base variable *r200kms* as shown by the negative sign of the coefficient.

As expected, vehicles with incentives increase the odds of being chosen by 27%. In terms of cost of travelling 100 kms, a Php1 increase in cost decreases the odds of the being chosen by 0.1% (or 1% decrease in odds for every Php10 increase in cost of travel).

Increasing the emission level by 1% relative to current day car decreases the odds of that vehicle being chosen by 1.1%. Conversely, the odds increase by 1.1% for every 1% decrease in emission level. The actual probability of being chosen for each vehicle characteristics assuming mean values for other attributes is given in Table 20.

Table 20. Predictions for choice

Attribute	Variable	Coef (β)	e^β	Probability
ENGINE	GAS	0.000	1.00	20%
	DIESEL	0.211	1.24	25%
	LPG	-0.367	0.69	14%
	HEV	0.200	1.22	25%
	BEV	-0.264	0.77	16%
PRICE (in Php'000)	Less than Php700	0.258	1.29	36%
	Php700 to 1,000	0.233	1.26	36%
	More than Php1,000	0.000	1.00	28%
RANGE	More than 450kms	0.077	1.08	38%
	450kms	-0.235	0.79	28%
	200kms	0.000	1.00	35%
INCENTIVE	WITH incentive	0.243	1.28	56%
	NO incentive	0.000	2.3	44%

4.3. Preference by Respondent Segments

Using Choice Model 2, a conditional logit model was estimated on various segments of the respondents. This was undertaken to identify possible differences in preference level of different segments of the respondents. The focus of discussion for this part will on the choices of vehicle engines although significant findings on other explanatory variables will be discussed as well, if there is any. The discussion here only describes the result and not the exact differences in odds and choice probabilities. The segments were made according to the characteristics of the respondents as shown in Table 21.

Table 21. Respondent characteristics used for segmentation

Respondent Characteristics	Segments	Remarks
Income level (monthly)	Income of Php100,000 or less	Low income
	Income of more than Php100,000	High income
Age	30yrs or younger	Young
	31 to 50 yrs old	Middle
	51yrs or older	Old
Number of vehicles	1 vehicle	
	2 or more vehicles	
Education	NO college or graduate education	Low educational attainment
	WITH college/graduate education	High educational attainment
Household size	5 or less	Average
	6 or more	Large
Daily Travel	20kms or less	
	More than 20kms	

4.3.1. By income level

Richer households are less averse to BEV and LPG vehicles. The impact of incentives in the choice of vehicle is lesser for richer households compared to the other income group.

Households with lesser income prefer diesel over gas more than richer households do due to lower fuel cost.

For a vehicle worth a maximum of Php1 million, households with lower income surprisingly tends to choose it more than richer household do compared to the base price of More than Php1 million. However, this can be a result of richer households having multiple income earners all of whom have different preferences that are not reflected by the respondent in the survey

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4.3.2. By age group

Older respondents do not prefer diesel vehicles over gas. But they have higher preference for HEV over gas vehicles more than the other age groups. Younger respondents are less averse to LPG vehicles compared to other age groups. BEV is less preferred to gas vehicles by all age groups. Incentives have minimal impact on vehicle choice of older respondents.

4.3.3. By number of vehicles owned

Diesel vehicles are less likely to be chosen by households with only one vehicle. Households with more than one vehicle are less averse in choosing LPG and BEV but they have lesser preference for HEV compared to the other group.

4.3.4. By educational attainment

Those who have at least college education prefers diesel over gas vehicles while the opposite can be said for those who do not have college education. Those who have higher education are less averse to LPG and BEV vehicles. Surpisingly, those with lower educational attainments have higher preference for HEV. Incentives have a higher positive impact on vehicle choice for those with higher education compared to those with lower educational attainment.

4.3.5. By household size

Larger households prefer diesel vehicles over gas vehicles more than average-sized households do. This is due to lower fuel cost per liter and higher pulling power (torque) of diesel vehicles. Large households are less averse to LPG and BEV.

4.3.6. By daily travel distance

Those who travel 20kms or less prefer diesel over gasoline engines more than those who travel longer. Those who travel longer distances (more than 20 kms) dislike LPG more than those who travel short distance. Both groups are averse to BEV relative to gasoline engines. Those who travel long distances prefer incentives more than those who travel short distances. Emission levels have more impact on vehicle choice for those who travel longer distances.

4.4. Extended Model

In Choice Models 1 and 2, only the vehicle characteristics served as the explanatory variable of vehicle choice. In the extended model, respondent characteristics were added as explanatory variables. The purpose of this is to determine which respondent characteristics significantly affect vehicle choice. Inclusion of respondent characteristics also allows for comparison with the base model to evaluate predictive effectiveness of adding explanatory variables (Ewing & Sarigollu, 2000).

Respondent characteristics were chosen based on their potential relationship on vehicle attributes and on vehicle choice. For example, household income is assumed to have direct relationship to the purchase price of a vehicle. The number of kilometers travelled may be related to the range of the vehicle and/or the cost of travel. The respondent characteristics used in estimating the extended model were categorized as Personal/Household Characteristics, Characteristics of Existing and Future Vehicles, and Travel Characteristics. The initial list of respondent characteristics is shown in Table 22.

To run the extended model, variables were interacted with the vehicle attributes (e.g. *C100km* x *Dailykmave*) to allow the estimation of the conditional logit model. Because observations referring to each respondent would be the same (fixed), interaction was necessary to have variability in the observations corresponding to one particular respondent. As previously mentioned, the extended model was based in Choice Model 2 where the variables *C100km* and *EMIS* were treated as quantitative variables.

Table 23 shows the result of the extended model. As expected not all respondent characteristics in the initial list was statistically significant. Variables found to be not significant was excluded. Respondent characteristics included in the extended model are: *Age, Household Size, Occupation, Dailykmave, Annualkm, Max Wtp, Next Vehicle Class*, and *Fuel Consumption Monitoring*. The specific interaction of these variables to vehicle attributes is also shown in Table 23.

The extended model shows a slight improvement in model fit compared to Choice Model 2. There is a slight improvement in log likelihood (-2582 to -2529) and Pseudo R2 (0.2166 to 0.2299) which is expected since there is an increase in the number of explanatory variables.

Table 22. Initial list of respondent characteristics used in the extended model

Variable	Description
PERSONAL	
Age	Age of the respondent in years
Sex	Sex of the respondent (1 if male, 0 if female)
Household Size	Number of household members
HH Income	Number of household members with income
No. Of Vehicle	Number of vehicles owned by the household
Fuel Monitor	Fuel consumption monitoring by the respondent (1 if Yes, 0 if No)
Consider Environment	If respondent considers environmental impact when choosing a vehicle (1 if Yes, 0 if No)
Max Wtp	The maximum amount the respondent is willing to spend for his/her next vehicle (in Php'000)
Monthly Income	Monthly household income (1 if over Php100,000 and 0 if otherwise)
Occupation	Occupation of the respondent (1 if businessman/self-employed, 0 if otherwise)
Public Transpo	Use of public transportation by the respondents (1 if Yes, 0 if No)
TRAVEL	
Annualkm	Number of vehicle kilometers travelled in one year
Dailykmave	Number of daily vehicle kilometers travelled
Daysperweek	Number of days a vehicle is used in a week
Fuelweekly	Weekly fuel expense
Kmweekly	Number of weekly vehicle kilometers travelled
Maintenance	Annual vehicle maintenance cost (excluding fuel expenses)
VEHICLE	
Age Of Vehicle	Age of vehicle in years
Current Fuel Type	Fuel type of current vehicle (1 if diesel, 0 if otherwise)
Current Vehicle Type	1 if compact/sub-compact, 0 if otherwise
Engine Size	Engine size in liters
Next Vehicle (New Or Old)	Preferred condition of next vehicle (1 if brand new, 0 if otherwise)
Next Vehicle Class	Preferred type of next vehicle (1 if sedan, 0 if otherwise)

Table 23. Extended model

VARIABLES	Coef.	Std. Err.	z	P>|z|	[95 Conf. Interval)	
ENGINE						
DIESEL	0.245	0.077	3.200	0.001	0.095	0.395
LPG	-0.388	0.094	-4.130	0.000	-0.572	-0.204
HEV	0.164	0.092	1.790	0.074	-0.016	0.344
BEV	-0.299	0.077	-3.860	0.000	-0.451	-0.147
PPRICE (in Php'000)						
LessP700	0.231	0.061	3.790	0.000	0.111	0.350
P700to1m	0.175	0.061	2.860	0.004	0.055	0.295
RANGE						
r450 kms	0.352	0.203	1.730	0.083	-0.047	0.750
Over450 kms	0.638	0.201	3.180	0.001	0.245	1.031
WITH_incntv	0.098	0.055	1.770	0.076	-0.010	0.206
C100KM	-0.001	0.000	-3.000	0.003	-0.002	0.000
EMIS	-0.016	0.003	-4.640	0.000	-0.022	-0.009
NONE	-3.097	0.231	-13.430	0.000	-3.549	-2.645
Next Vehicle Class and PPRICE						
LessP700	0.294	0.149	1.970	0.049	0.002	0.585
P700to1m	0.454	0.142	3.200	0.001	0.176	0.731
Age and RANGE						
r450 kms	-0.0136	0.005	-2.640	0.008	-0.024	-0.004
Over450 kms	-0.013	0.005	-2.480	0.013	-0.023	-0.003
Annualkm and RANGE						
r450 kms	-0.0000166	0.000	-2.180	0.030	0.000	0.000
Over450 kms	-0.0000132	0.000	-1.920	0.055	0.000	0.000
C100KM Travel and						
Occupation	-0.000454	0.000	-1.870	0.062	-0.001	0.000
Max wtp	0.00000048	0.000	1.820	0.068	0.000	0.000
Dailykmave	-0.00001260	0.000	-2.500	0.013	0.000	0.000
EMIS and						
Household Size	0.001	0.000	1.890	0.059	0.000	0.001
Max wtp	0.00000404	0.000	2.140	0.033	0.000	0.000
Fuel monitor	-0.005	0.002	-3.500	0.000	-0.008	-0.002
WITH_incntv and						
Dailykmave	0.007	0.002	3.420	0.001	0.003	0.010
Next vehicle class	0.224	0.105	2.140	0.033	0.019	0.429
LR chi2(26) = 1510.70						
Prob > chi2 = 0.0000						
Log likelihood = -2529.5028						
Pseudo R2 = 0.2299						

All variables and interaction terms are significant at 10% confidence level.

All the coefficients are significant only at 10% significance level although some variables are significant at 1% and 5%. Unlike in Choice Model 2, all of the *range* variables is significant in the extended model and follows theoretical expectations (i.e.the longer the range, the higher the probability of being chosen). There were some changes in the values of the rest of the coefficients in the extended model but the signs remain the same as in Choice Model 2 (i.e. LPG and BEV is less preferred than gasoline engines, etc).

The extended model indicates the following:

- Those who wanted sedans as their next vehicle are willing to pay more than those who wanted other vehicle types.
- Range does not show a big impact on choice.
- Businessmen tend be more adversely affected by an increase in cost of travel.
- Those with higher daily travel tend to more adversely affected by higher cost of travel.
- Those with high WTP for their next vehicle are less affected by higher cost of travel.
- Those who monitor fuel consumption are aware/prefer lower emission levels.
- Those with longer daily travel have higher preference for incentives.
- Those who wanted sedan as their next vehicle also has higher preference for incentives.

CHAPTER 5. POTENTIAL ADOPTION OF LOW EMISSION VEHICLES

5.1. Potential Adopters of Hybrid and Battery Electric Vehicles

There are currently several issues associated with LEVs that affect its adoption (Romm, 2006 identified six barriers, see Section 1.1.3. in p. 5). Among these are two issues directly related to consumers' income and basic travel needs. For HEV and BEV, the acquisition cost is significantly higher relative to other vehicles of the same body type. While HEV have extended range, BEV on the other hand has limited range which is related to on-board battery technology and influenced by recharging time and stations. In assessing the potential adoption of HEV and BEV, focus was made on price of the vehicle and their range.

5.1.1. Cost of hybrid and battery electric vehicles in the Philippines

The Toyota Prius, first introduced in 2007, costs around Php2.2 million (US$51,948)[6] (www.toyota.com.ph) including government duties and taxes for imported vehicles. In 2012, a smaller and cheaper Prius C was introduced with a lower price of around Php1.5 million (US$34,650). Because of government taxes, both of these HEV models are at least twice as expensive as conventional vehicles of similar size and make.

There is currently no BEV available from major car companies in the Philippines. However, there are BEV advertised by some small companies. The cost of these BEVs varies by type of vehicle, i.e. e-jeepney, e-trike, etc. This can range from Php60,000 to 220,000 for motorcycles; Php250,000 to 350,000 for e-trikes; and up to Php900,000 for cars and other large vehicles. For comparison, the recently-released Nissan LEAF has a manufacturer's suggested retail price of $35,200 in the USA (www.fueleconomy.gov) or

[6] At US$1 = Php43.29

around Php1.5 million excluding potential import taxes. In Japan, it costs JPY3.8 million or roughly Php2.1 million excluding taxes. The Nissan LEAF is not available locally as of this writing.

5.1.2. Willingness-to-pay for a new vehicle

Assuming respondents prefer vehicles made by more established automotive company, the potential adopters of HEV and BEV were estimated by a simple comparison of the maximum willingness to pay for their next vehicle and the price of HEV and BEV. As shown in Table 24 , only 13% of the respondents are willing to spend at least Php1.5 million which is close enough to the current price of an HEV or BEV.

Table 24. Willingness to pay for next vehicle purchase

WTP	No. of respondents (%)
Less than Php700,000	65 (22%)
Php700,000 to 1million	159 (53%)
Php1.0 to 1.49 million	37 (12%)
Php1.5 million and above	39 (13%)
Total n	300
Mean WTP	Php970,900

However, the potential adopters are not necessarily limited to choose only HEV or BEV, thus the actual share would be lower if preference for other vehicle attributes is considered as shown in the discussion later. But for this part, those who are willing to spend at least Php1.5 million (13%) were considered as the potential buyers of HEV and BEV.

5.1.3. Daily travel and range

Range anxiety, a term given to the fear of not having enough fuel (or battery charge) to reach a desired destination, is one of the important concerns for BEV. For BEV to be viable to a potential buyer, its range must match their daily travel distance especially if recharging infrastructure is non-existent as in the case of Metro Manila. Since HEV have extended range, daily travel distance is not an issue for its adoption. Table 25 shows the range of BEVs that are currently available and potentially available in the market.

Table 25. Range of locally available and potentially available BEVs.

Model	Range	Remarks
15kw eCar (Eagle Motorcycles)	150-180km	Published range in company website
Nissan LEAF	76 – 113 km	• Range varies depending on driving condition with some estimates going up to 200kms. This range is based on US EPA rating (113km) and heavy traffic with air conditioner turned on (76kms) • Potentially available
Mitsubishi MiEV	100 km	Potentially available

Note: These BEVs are approximately similar in body type and size.

Figure 6 shows the regularity of respondents' daily travel in a week. On the average, respondents use their vehicle for 25 kilometers or less five days a week. This can be due to the proximity of their residence to their daily destination which is within and around Metro Manila. Based on this two initial information, there is a good potential for BEV to replace conventional vehicles for daily use.

Figure 7 shows that most of the respondents (83%) travel 25 kilometers or less daily. An additional 11% and 3% travel up to 50 kilometers and 75 kilometers, respectively, both distances within the range of a BEV. If daily travel is the lone factor to be considered, as much as 97% of the respondents are potential owners of a BEV.

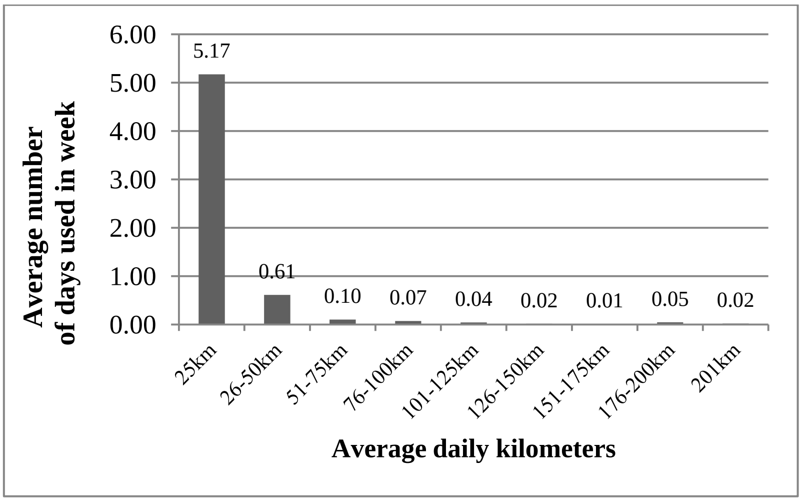


Figure 6. Average daily kilometers by the number of days vehicles are used in a week.

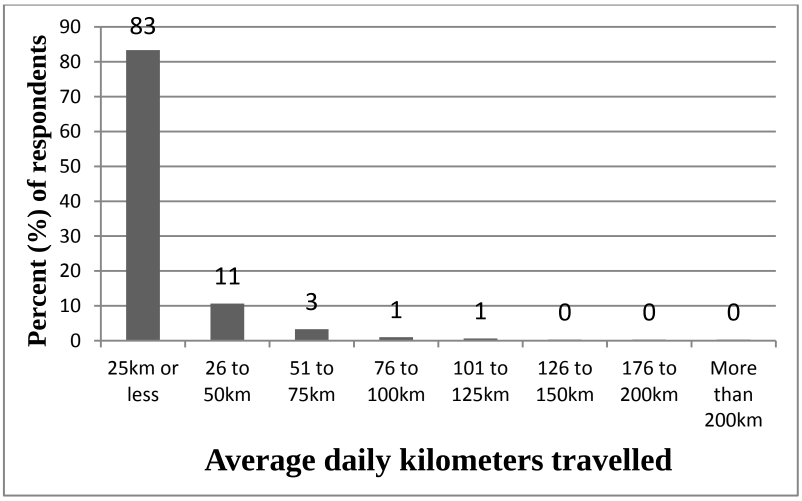


Figure 7. Distribution of respondents by average daily kilometers category

5.1.4. Potential adopters based on willingness to pay and daily travel

To further assess potential BEV adoption, WTP for next vehicle and daily vehicle kilometers of each respondent was used simultaneously. For this, respondents who reported a daily travel distance of more than 75 kilometers in any day of the week were excluded to account for the limited range of BEV. Based on the result (Figure 8), around 10% of the respondents (n=31) are potential BEV buyers. These respondents are those who travel at most 75 kilometers a day on a regular basis and are willing to spend at least Php1.5 million for their next vehicle. (For the succeeding discussions, the term “potential adopters” shall refer to potential HEV/BEV adopters which is 13% of the respondents. The rest of of the respondents will be called “non-adopters”).

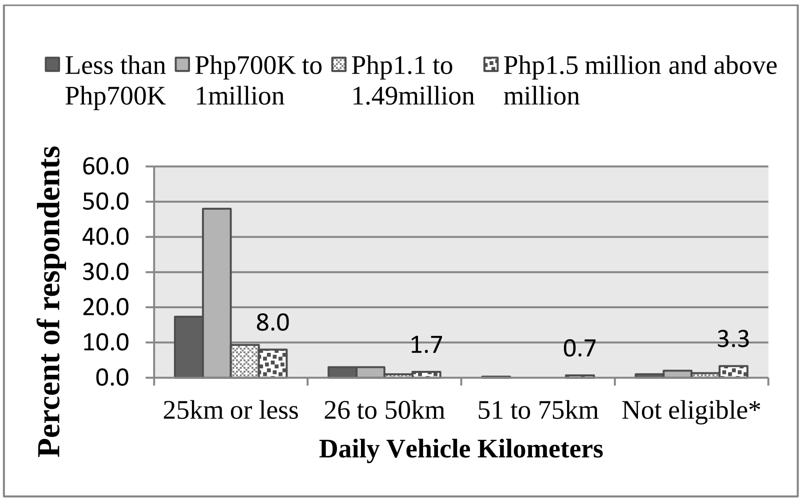


Figure 8. Distribution of respondents by daily travel distance and WTP for next vehicle

5.2. Market Share Simulation

The previous discussion showed that at most 13% of the respondents are potential adopters of HEV or BEV. However, it was also noted that these potential adopters are not limited to choose between HEV and BEV hence if preference for other vehicle attributes in the choice model are considered, it is expected that the share of these vehicles would be reduced. In this analysis, market share simulations were undertaken to estimate share of all vehicle types included in this study. Three simulations were done with constraints introduced to the second and third simulations to add real world situations in vehicle choice (Table 26).

Table 26. Description of the market simulations

Description	Simulation 1	Simulation 2	Simulation 3
Constraint			
Price (HEV/BEV Adopters and Non-adopters)	None	Yes	Yes
Supply (No. of vehicle variants as scale parameter)	None	None	Yes
Simulation method	Straight forward application of Choice model 2	Two-stages: • For adopters – using a choice model estimated from their data • For non-adopters – Choice Model 2	
Other	11 policy scenarios	One of the 11 policy scenarios used. Different situations simulated using this single scenario (Simulation 3)	

5.2.1. Policy scenarios

Market share for different vehicle types were estimated for different policy scenarios. The scenarios are characterized by changes in vehicle characteristics which may be brought about by various policy, technology and market situations. This is a common method of identifying possible courses of actions that may increase market share of desirable goods. For this, the five vehicles types differentiated by engines were compared. The scenarios used in this analysis are described below (see Appendix A for the specific characteristics of the vehicles in each scenario):

Scenario 1 – LEVs are introduced (Base Scenario)

This scenario is where LEVs are introduced in the market. Gasoline vehicles were priced the cheapest followed by diesel and LPG vehicles. HEV and BEV were priced the highest. All vehicles do not have incentives and have similar cost of travel. A strong assumption of equal emission for all vehicle types was made for this scenario.

Scenario 2 – Incentives for LEVs

In this scenario, incentives were given to LPG vehicles, HEV and BEV. The rest of the vehicle characteristics are similar to the Scenario 1.

Scenario 3 - Price increase for diesel and gas vehicles

Disincentives for conventional vehicles were hypothetically put in this scenario resulting in price increases for diesel and gasoline vehicles. The rest of the vehicle characteristics are the same as in Scenario 1.

Scenario 4 – Significant emission reduction for LEVs

In this scenario, emission was reduced significantly for LEVs – LPG at 70%, EV at 50%, and BEV at 0%. Emission for gasoline and diesel vehicles was likewise reduced to 90% and 95% respectively. The rest of the variables are the same as in Scenario 1.

Scenario 5 – Lower cost of travel for LEVs

Higher fuel economy resulted in lower cost of travel for LEVs. The rest of the variables remained the same as in Scenario 1.

Scenario 6 – Incentive and reduced emission for LEVS

This scenario is a combination of Scenarios 2 and 4.

Scenario 7 – Incentives for LEVS and increase in price for diesel and gasoline vehicles

This scenario is a combination of Scenarios 2 and 3.

Scenario 8 – Incentives for LEVs and increase cost of travel for diesel and gasoline vehicles

This is Scenarios 2 and 5 combined.

Scenario 9 – Reduced emission and lower cost of travel for LEVs. This is Scenarios 4 and 5 combined.

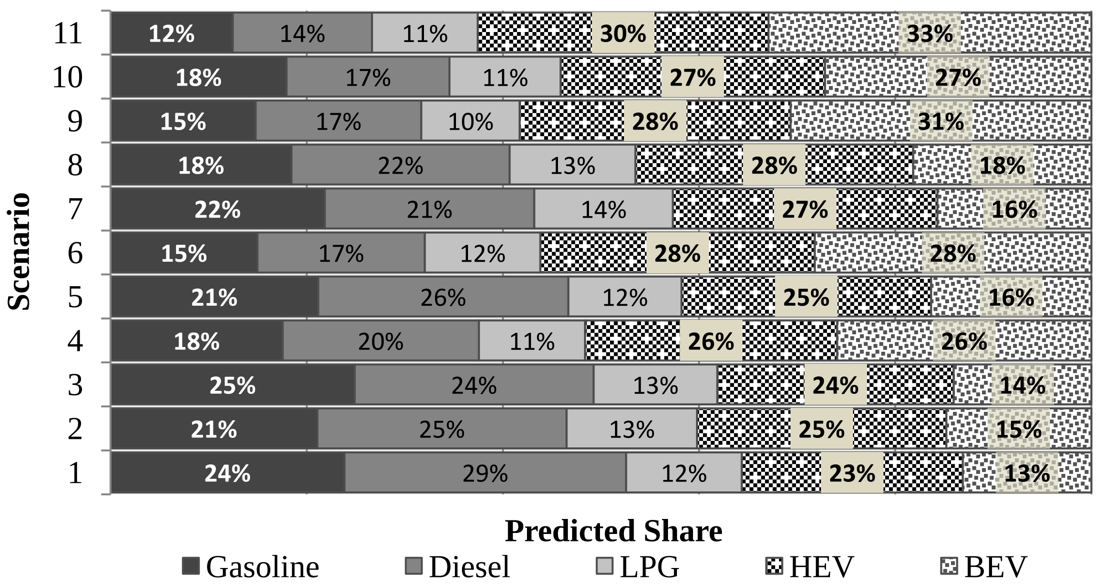
Scenario 10 – Reduced emission for LEVs and price increase for diesel and gasoline engines. This is a combination of Scenarios 4 and 3.

Scenario 11 – Incentives, lower cost of travel and reduced emission level for LEVs. This scenario is close to the real situation regarding the vehicle attributes.

For estimating market share, Choice Model 2 was used. The changes in market share were computed relative to Scenario 1 (Base Scenario).

5.2.2. Simulation 1: Vehicle shares using Choice Model 2

Currently, gasoline vehicles form 87% of the personal vehicles. However, introduction of the LEVs (Scenario 1) made diesel vehicles with the largest share of 29% as shown in Figure 9. Share of gasoline vehicles dropped to 24%. HEV's share is at 23%, BEV 13% and LPG vehicles with the lowest share at 12%.



For personal vehicles, current actual share is estimated at Gasoline (86%) and Diesel (13%)

Figure 9. Result of Simulation 1.

The change in market share in each scenario for each vehicle type is shown in Table 27. Incentives for LEVs (Scenario 2) resulted in small increase in share of those types of vehicle (2% to 3%). However, incentives were enough for HEV to have an equal share with diesel at 25% and have a higher share over gasoline.

Table 27. Percent change in market share of vehicle types by scenario

Scenarios	Gasoline	Diesel	LPG	HEV	BEV
1	-	-	-	-	-
2	-3	-3	2	3	2
3	1	-4	1	2	1
4	-6	-9	-1	3	13
5	-3	-3	0	3	3
6	-9	-12	0	**5**	**15**
7	-2	-7	**2**	4	3
8	-5	-6	1	6	5
9	-9	-12	-2	5	18
10	-6	-12	0	4	14
11	-11	-15	-1	7	20

Increasing the price of the diesel and gasoline vehicles (Scenario 3) decreased the share of diesel vehicles by 4% and surprisingly increased share of gasoline vehicles by 1%. This implies that there is some shifting of preference towards gasoline vehicles when price of both gasoline and diesel vehicles are increased. Among the LEVs, the increase is highest for HEV at 2%.

The reduced emission (Scenario 4) increased the share of HEV and BEV to 26% each surpassing gasoline (18%) and diesel (20%). The highest gain in share is by BEV at 13%. This is a result of the reduced emission level for HEV and BEV which implies that it has a big impact on choice probabilities.

The higher cost of travel (Scenario 5) decreased the share of gasoline and diesel vehicles by 3% each while increasing the share of HEV and BEV by the same percentage each.

Among the different combinations of scenarios, Scenario 11 resulted in the highest total share of LEVs – LPG 11%, HEV 30% and BEV 33%. This is a result of a combination of favourable conditions for LEVs such as low emission levels, lower cost of travel and the presence of incentives. Among these variables, emission level is the main contributor to the increase in market share.

5.2.3. Simulation 2: Simulation for potential adopters and non-adopters

Previously, it was shown that only 13% of the respondents are potential HEV and BEV adopters based on WTP for next vehicle purchase. Potential BEV adopters is 10% if the daily travel is factored in. This clearly shows a discrepancy compared to the results in Simulation 1 especially with Scenario 11. To account for the constraint imposed by the price of HEV and BEV, a second simulation was done in two stages – first stage is simulation only for the potential adopters using all vehicle types. A choice model estimated from the data of potential adopters was used in this stage. For the second stage, a simulation for non-adopters using the Choice Model 2 was done for gasoline, diesel and LPG vehicles only. The resulting vehicle share for the first and second stage will refer to the 13% potential adopters and 87% non-adopters, respectively. The characteristics of each vehicle used in this simulation are exactly the same as the ones used in Scenario 11 in Simulation 1.

In the first stage, simulation result shows a market share of gasoline 39%, diesel 6%, LPG 2%, HEV 23%, and BEV 30%. This shows that potential adopters have a different preference as shown by high share of gasoline and BEV. In the second stage, the market share is gasoline 33%, diesel 38% and LPG 29%. Multiplying the vehicle shares in the first and second stage by 13% and 87%, respectively, then summing the resulting values by each vehicle type gave the vehicle shares for all the respondents (Figure 10).

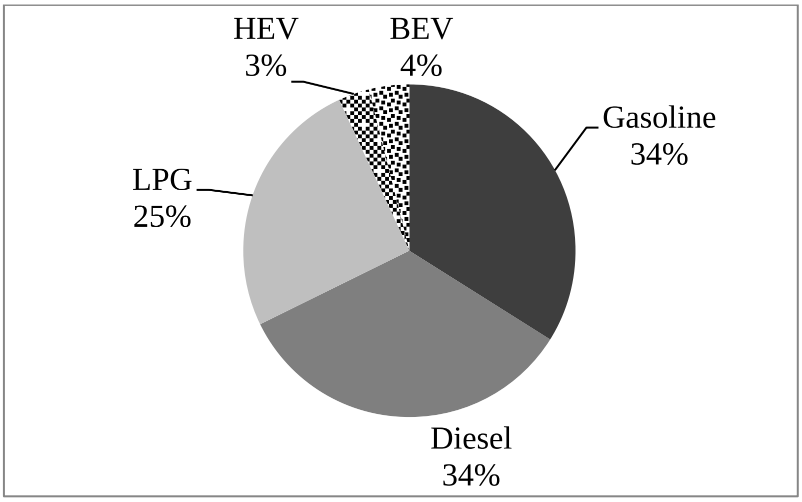


Figure 10. Result of Simulation 2

By doing separate simulation for potential adopters and non-adopters, it was shown that the share of HEV is only 3% and BEV 4% - a significant reduction from the result in Simulation 1. This shows that the significantly higher price of HEV and BEV has a large impact on their potential market share by limiting the number of potential adopters.

5.2.4. Simulation 3: Simulation with number of vehicle model variants

Simulation 2 considered the fact that not all people can afford or are willing to spend the amount of money to buy an HEV or BEV. And this has reduced the share of those vehicles to a more "realistic" level. To further assess the potential share of HEV and BEV, the number of available model variants for each vehicle (fuel) type was included in computing choice probabilities. This process acknowledged the fact that conventional vehicles currently have more commercially available models and variants compared to LEVs, and thus has higher probability of being chosen.

Consider the basic form of the choice model:

$$\text{Prob}\ (a \mid C = a,b,c,\ldots J\ ) = \exp(\mu V_a) / \sum_{j=a}^{J} \exp\ (\mu V_j)$$

where μ is assumed to be equal to 1 for all alternatives and respondents implying homogenous characteristics for both. For this simulation, it was assumed that μ takes different values based on some differences in each type of vehicle. By doing this, the differences among vehicles types were taken into account in estimating market shares.

Ben-Akiva, Gunn, & Silman (1984) described models for trips and destinations. In their paper, specific or elemental destinations can grouped into an “aggregate destination.” “*The choice probability of an aggregate destination is equal to the probability that the traveller chooses one of its elemental alternatives*”. As an analogy with the vehicle types in this study, the probability that one type of vehicle will be chosen is equal to the probability that a buyer chooses one of its model variants. With this, the probability is affected by the size or number of the available variants in each vehicle type.

(a) Vehicle models and variants

Each vehicle type has several models made by different car companies in the Philippines. For each model, there are several variants that offer various performance, safety, comfort, and other features. For some models, there exist variants of different fuel types as shown in Table 28. Using the total number of existing variants, the market share was estimated for each vehicle type.

An inventory of the vehicles in the Philippines shows that there are more models and variants of gasoline vehicles than diesel vehicles and that LEVs have far less number of available variants. For personal vehicles, there are a total of 217 gasoline variants, 144 diesel variants, and 3 HEV variants. There is no existing LPG-ready vehicle models as most of LPG vehicles in the country are gasoline vehicles retro-fitted with an LPG fuel system. As for BEV, there is no existing model available from any of the major car companies in the Philippines.

Table 28. Number of model and variants by vehicle type

Fuel Type	Total No. of Models	Total No. of Variants
Gasoline only	63	183
Diesel only	23	107
Gas and diesel	13	-
Gasoline	-	34
Diesel	-	37
HEV only	2	3
TOTAL	101	364

Note: This inventory includes vehicles from 11 car companies the Philippines. The initial list was taken from listing of sales agents then validated with the websites of each car company. Vehicles meant for commercial (e.g. trucks) and non-personal use (i.e. cabs and ambulance) were excluded.

Variants in each model refers to differences in engine, transmission, comfort features, etc among vehicles. Difference in color was not used as a distinguishing factor among variants of the same model.

(b) Simulation situations

Different situations were used to simulate the share of each vehicle type. Each situation is characterized by different number of model variants for each LEV. The different situations used is shown in Table 29 and described thereafter.

Table 29. Situations by vehicle type for Simulation 3

Situation	Number of Variants				
	Gas	Diesel	LPG	HEV	EV
LEV_1 – “near future”	217	144	3	3	1
LEV_2	217	144	33	33	27
LEV_2b	217	144	33	33	27
LEV_3 – “drastic change”	217	217	217	217	217

- LEV_1 – termed as “near future.” It closely resembles the current situation except for the existence of LPG and BEV variants.

- LEV_2 – the total model variants for LPG and HEV is 15% of the number of gasoline variants. For BEV, it is 12.5%.

- LEV_2b – the number of variants is the same as LEV_2 but the price of HEV/BEV is reduced to Php1 million which increased the potential adopters from 13% to 25% (see Table 24).

- LEV_3 – the number of model variants for all vehicles is the same which can be described as a drastic change.

The key assumptions for this simulation are:

- The number of variants for gasoline and diesel vehicles remains the same for all situations.
- Technically, all gasoline variants can be fitted with an LPG system. But it will be assumed here that LPG vehicles refer to those that are LPG-compatible out of the production line.
- HEV has a higher number of variants than BEV in all situations since the current condition shows that there is far more models and variants of HEV (including PHEV).
- The vehicle characteristics used in estimating the probabilities were the same as Scenario 11 in Simulation 1.

The simulation was undertaken in 2 stages similar to Simulation 2. The result of the Simulation 3 is shown in Table 30. As expected, the number of model variants played a significant role in determining the share for each vehicle type. Even though diesel engines have higher preference level over gasoline engines in the choice model, the higher number of variants for the latter resulted in it to have a higher market share over the former in all simulated situations. However, the share of diesel vehicles have increased compared to the existing situation in the personal vehicle sector.

Table 30. Result of Simulation 3

Scenarios	Share (%)				
	Gasoline	Diesel	LPG	HEV	BEV
LEV_1 – "near future"	60.9	38.4	0.6	0.1	0.04
LEV_2	56.1	35.9	6.2	0.9	1.0
LEV_2b	48.2	35.8	5.8	4.7	5.4
LEV_3 – "drastic change"	33.9	33.8	25.4	3.0	3.9

Increasing the number of variants of LEVs was expected to reduce share of gasoline and diesel vehicles since the model variants for these vehicles remained constant in all the situations. For LEV_1 , results shows a much lower share for HEV at 0.1% and BEV at 0.04% which is a result of the combined effects of low number of potential adopters and low number of available variants.

In LEV_2, the share of HEV and BEV increased but remained low at 0.9% and 1%, respectively. The share of LPG which is as high 29% in the Simulation 2 is reduced to only 0.6% and 6.2% in LEV_1 and LEV_2, respectively due to lower number of available model variants. By reducing the price of HEV and BEV to Php1 million (in LEV_2b), the number of potential adopters increased which also increased the share of HEV to 4.7% and BEV to 5.4%. This is a fivefold increase from LEV_2.

The drastic increase in the available variants for all LEVs as described in LEV_3 showed exactly the same result as in Simulation 2 (see Figure 10). By setting the number of variants constant for all vehicle types, its effect on probability is removed making the simulation similar to Simulation 2. In this case, LPG benefitted the most as it is not affected by the price constraint.

In all situations, LPG vehicles gained the highest market share among LEVs. This is due to its lower price compared to HEV and BEV, hence not restricting it to individuals with high willingness to pay. The opposite can be said of HEV and BEV since only 13% (25% in

LEV_2b) of the respondents are assumed to be "potential adopters". This alone limited their share considering that the potential adopters are not restricted to choose between HEV and BEV and may in fact choose other available vehicle types. Since the main barrier for HEV and BEV is its price (acquisition cost), price reduction will be necessary to gain market share.

5.2.5. Summary of simulation results

HEV and BEV showed decent potential for early adoption based on basic factors such as daily vehicle kilometers and WTP for next vehicle. Without constraints imposed by its high price, HEV and BEV each can exceed 30% share due to low emission levels – a vehicle characteristic that showed a big positive impact choice probability. However, the reality is that the current price of these vehicles limits the number of potential buyers, therefore also limiting its potential share. The low number of available model variants further reduces its market share by restricting the choices for the potential buyers. On the other hand,based on recent trends and results of this survey, there is an increasing preference for larger vehicles such as SUVs. This vehicle type are completely different from the compact/sub-compact type where most HEV and BEV belong.

5.3. Impact of Plug-in Hybrid Vehicles on CO_2 emission

5.3.1. Plug-in hybrid vehicle: Description and characteristics

According to the US Department of Energy (www.fueleconomy.gov):

> "Hybrid-electric vehicles combine the benefits of gasoline engines and electric motors and can be configured to obtain different objectives, such as improved fuel economy, increased power, or additional auxiliary power for electronic devices and power tools"

These objectives are achieved by using advanced automotive technologies such as regenerative braking where energy from braking is used to recharge batteries, electric motor assistance to provide additional power to the gasoline engine and automatic start and shut off of engine during vehicle stops.

On the other hand:

> "Plug-in Hybrid Electric Vehicles (PHEV) are hybrids with high capacity batteries that can be charged by plugging them into an electrical outlet or charging station. PHEV can store enough electricity from the power grid to significantly reduce their petroleum consumption under typical driving conditions."

There are different concepts of PHEVs:

- Fully driven by electric motors. Gasoline engine recharges the battery pack once the initial charge has been used up. Also called Extended Range Electric Vehicles or Series PHEV.
- PHEV that operates similar to HEV once the initial battery charge is used up. Also called Parallel or Blended PHEV.

Because of the increased fuel economy and reduced consumption of fossil fuels, PHEV can significantly lower emissions. However, there are also disadvantages in using this kind of vehicles including concerns about charging time and inability to maximize fuel economy in case of discharged batteries. In addition, overall CO_2 emission depends on the source of local electricity on which the grid emission factor depends.

5.3.2. CO_2 emission reduction from plug-in hybrid vehicles

In this analysis, the vehicles used by all the respondents were hypothetically replaced by PHEV. Using the daily and annual vehicle travel, changes in CO_2emissions were estimated. As shown in Figure 11, CO_2 reduction from using PHEV is at least 80%. The high emission reduction is due to short daily travel reported by the respondents. This means that a large proportion of travel is made using the blended mode which has a very low CO_2 emission per kilometer. In addition, since PHEV also have low emission factor when using only the gasoline engine, travel made outside the blended mode also resulted in low CO_2 emission estimates.

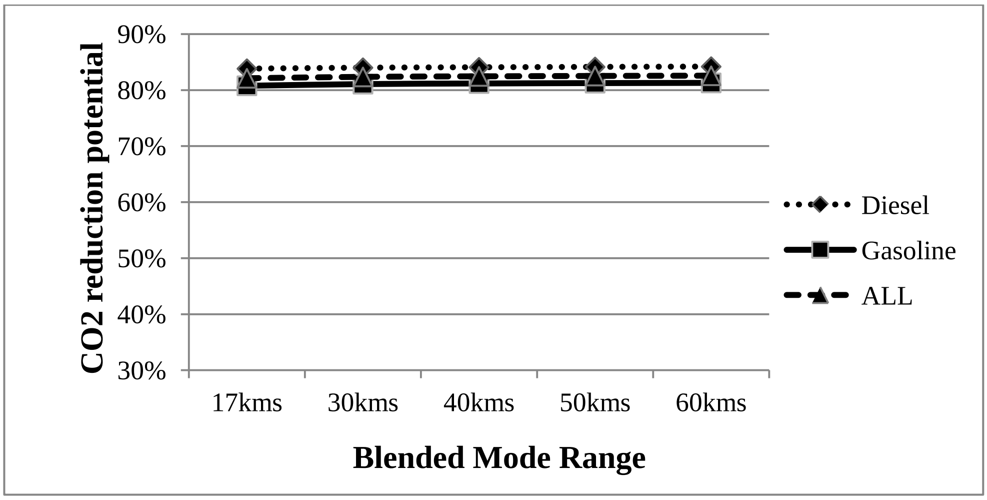


Figure 11. PHEV potential CO_2 reduction by blended mode range and type of fuel

The emission reduction for respondents using diesel vehicles is marginally higher than those using gasoline vehicles. This is due to the larger difference between the emission factor of diesel vehicles and PHEV compared to gasoline versus PHEV. The results also show that the range of the blended mode is directly proportional to the emission reduction.

Although the difference in emission reduction among the annual travel categories is very small due to dominance of short daily travels, results show that generally, the lower the annual travel, the higher the percent CO_2 reduction (Figure 12).

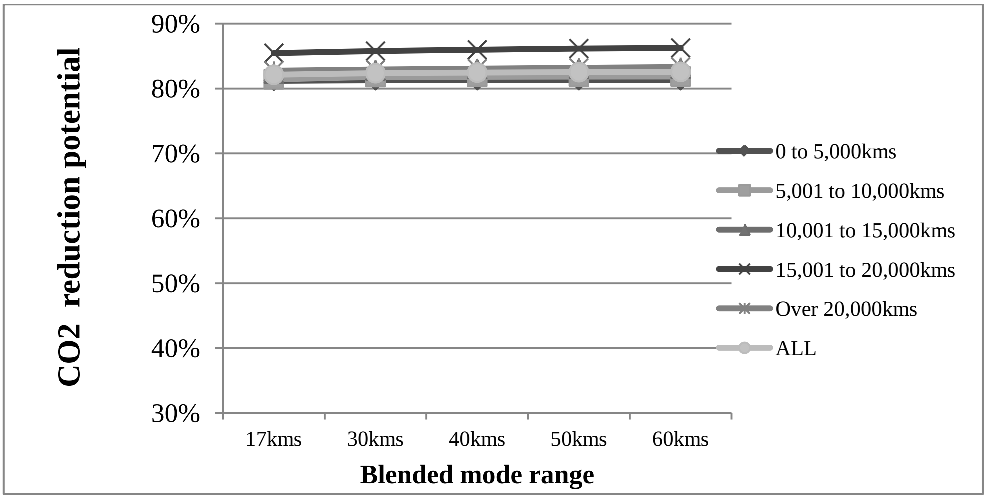


Figure 12. PHEV potential CO_2 reduction by blended mode range and annual travel

However, those with longer travel distances have the bigger potential to further reduce CO_2 emission as result of increasing blended mode of PHEV. This may benefit either personal vehicle owners that regularly travel long distances or even public transport operators (e.g. taxis).

5.4. Benefit-Cost Analysis of Low Emission Vehicles

5.4.1. Estimating willingness-to-pay for vehicle attributes

In Choice Model 1 and 2, purchase price was represented by three categories each with their own parameter estimates. To compute for the willingness to pay of the vehicle owners for specific vehicle attributes, it is necessary to convert the price attributes from categorical to a quantitative variable. This will yield a single coefficient for the price attribute.

Table 31 shows how the price attribute was converted to a quantitative variable. The variable range was also converted the same way as the price attribute. However, since the respondents were not shown the quantitative version of the said variable, bias is expected considering the change in the form of the variable. To account for this, the resulting model was compared to Choice Model 2 to see if there are big differences among the estimated coefficients.

Table 31. Conversion of variables from categorical to quantitative

Attributes	Categorical / Qualitative Levels	Quantitative Levels
(ENG)	Gasoline Diesel LPG-Gas Flexifuel Hybrid-Electric Electric	Not applicable
(PPRICE)	Less than Php700,000 Php700,000 to Php1 million More than 1 million	Php699,000 Php1,000,000 Php1,500,000
(C100)	Php450 Php600	Php450 Php600
(RANGE)	200km 450km More than 450	200km 450km 600km
(INCNTV)	WITH Incentive NO Incentive	Not applicable
(EMIS)	Same as present day passenger car 80% or less of present day passenger car	100% 80%

Consumer's marginal willingness to pay for a specific attribute is the marginal rate of substitution with respect to the price coefficient (Vermeulen, Goos, & Scarpa, 2008). It can be computed from the model using the equation:

$$WTP = -\beta_{ATTRIBUTE}/\beta_{PRICE}$$

Willingness-to-pay is the quantified trade-off between one attribute against the cost attribute or simply the implicit prices of the attributes (Hanley et al., 2001).

5.4.2. Model with quantitative variables

The resulting Choice Model 3 is shown in Table 32. Except for the variable *RANGE*, the rest of the explanatory variables are highly significant at 95% confidence level. Compared to Choice Model 2, the p-values do not vary except for range which altogether became not significant. The coefficients of the variables for engine, incentive , cost of 100km travel and emission had slight difference with those of Choice Model 2.

Table 32. Choice Model 3

Variables	Coef.	Std.	Err.	z	$P>\lvert z\rvert$ [95% Conf. Interval]	
Diesel	0.210	0.075	2.81	0.005	0.064	0.357
LPG	-0.368	0.092	-4.00	0.000	-0.549	-0.188
HEV	0.202	0.090	2.25	0.025	0.026	0.378
BEV	-0.261	0.076	-3.45	0.001	-0.409	-0.113
PPRICE	-0.000304	0.000	-4.42	0.000	0.000	0.000
RANGE	0.000057	0.000	0.41	0.682	0.000	0.000
WITH_incntv	0.240	0.040	6.05	0.000	0.162	0.318
C100KM	-0.001	0.000	-4.79	0.000	-0.001	-0.001
EMIS	-0.011	0.002	-5.60	0.000	-0.015	-0.007
NONE	-3.481	0.241	-14.45	0.000	-3.953	-3.009

Number of obs = 9000	Pseudo R2 = 0.2108
LR chi2(10) = 1389.56	Log likelihood = -2601.0583
Prob > chi2 = 0.0000	

Choice Model 3 showed a slight decline in model fit as shown in its log-likelihood and Pseudo R2. But it is nevertheless good to use in estimating marginal WTP estimates for various vehicle attributes.

5.4.3. Results of the willingness to pay estimates

The summary of the WTP estimates is shown in Table 33. Special focus is given to quantitative variables *RANGE*, *C100KM*, and *EMIS*. Two variables, *C100KM* and *EMIS*, have corresponding negative marginal WTP. Negative implicit prices imply that consumers expect compensation for an increase in that attribute (Wikstrom, 2003) as higher values of these variables are less preferred. Conversely, consumers are willing to pay for a decrease (i.e. negative increase) in cost and emission levels.

Table 33. Marginal WTP for vehicle attributes

Variable	Unit	WTP (in Php)
DIESEL	dummy	691,582
LPG	dummy	-1,210,648
HEV	dummy	663,955
BEV	dummy	-857,311
PPRICE	Php'000	
RANGE	kilometers	**187**
WITH_incntv	dummy	788,831
C100km	Php	**-3,120**
EMIS	percent	**-36,510**
NONE		

Based on the results, consumers are willing to pay an additional Php187 for every additional kilometer on the range of the vehicle in one full tank or full charge. This is a very small amount considering the apparent importance of range. However, it should be noted that this variable has very minimal impact on vehicle choice as shown in the model and is not statistically significant.

Consumers are willing to spend an additional Php3,120 for every Php1 decrease in cost of 100 kilometer travel. This means for a Php100 reduction in cost of 100 kilometers of travel, a consumer is willing to pay additional Php312,000 for that vehicle. Financially, this benefits those who travel longer distances as it translates to more cost savings. If fuel price increases, consumers can expect additional benefits from vehicles with lower travel costs.

Marginal WTP for a 1% decrease in emission is Php36,510. This is a considerable amount for a small change in emission level and so the result should be interpreted with caution due to the manner Choice Model 3 was estimated. However, looking beyond the value, this shows that respondents have positive preference for emission reduction which is expected to increase their welfare.

5.4.4. Comparison of conventional, battery electric and plug-in hybrid vehicles

A simple 10-year cost analysis was done to compare different types of vehicles. The assumptions for this analysis are:

- Purchase prices for BEV and PHEV were based on Japan retail price converted to Philippine peso.
- Fuel cost is based on annual travel. Values used for conventional vehicles is the weighted average for gasoline and diesel vehicles.
- Operating cost for conventional vehicles was computed from the survey data. Operating cost for LEVs is assumed to be 10% higher (although reports say it should be the same as conventional vehicles).
- The lifespan of critical components of the LEVs (battery and electric motor) is well within the estimated total travel that can be made in 10 years. Hence, the cost of replacing these components was excluded in the analysis.
- The estimated values refer to one unit of vehicle only
- Reported values are present values. Discount rate used is 10%

The results show that among the three options, conventional vehicles have the lowest total cost over a 10 year period (Table 34). BEV has the highest total cost mainly due to high acquisition cost. Fuel savings for BEV and PHEV relative to conventional vehicles is

Php204,000 and Php192,000, respectively. The amount of savings is very small compared to the additional money needed to shift from conventional vehicle to BEV or PHEV. This confirms costs issues associated with latter.

Table 34. Cost analysis for conventional vehicle, BEV, and PHEV

Item	Conventional	BEV	PHEV
Costs (in Php'000)			
Purchase price	900	2,139	1,698
Fuel cost (10 years, discounted)	249	44	57
Maintenance cost (10 years, discounted)	186	205	205
TOTAL	1,335	2,387	1,960

5.4.5. Value of CO_2 reductions from battery electric and plug-in hybrid vehicles

One of the co-benefits of using LEVs is the reduction of green house gases which is the main cause of climate change. This study did not directly estimate the willingness to pay for climate change mitigation but some form of economic valuation was undertaken given the information generated by this research and by other studies.

This study put monetary value on CO_2 reduction attributed to usage of PHEV and BEV. While this may not reflect the total economic value of CO_2 reduction, the valuation will provide meaningful information which can be used in promoting clean vehicles (e.g. possible source of financing for LEVs).

The data from this study refers to privately used vehicles only, thus motorcycles/tricycles and public utility vehicles were excluded. Table 35 shows the number of personal vehicles in Metro Manila. Only cars and SUVs were assumed to be privately used vehicles. The number of taxis in Metro Manila (est 30,000) was also excluded. Of the total number of cars and SUVs, only 30% was used, consistent with the proportion of the number of vehicles registered in Metro Manila.

Table 35. Estimated number of personal vehicles in Metro Manila, 2010

Vehicle type	Number
Cars	808,583
(Less taxis)	(778,583)
Sports Utility Vehicles (SUV)	261,213
Total Philippines	1,069,796
Total Metro Manila (est)	311,939

Source: Land Transportation Office (except for Metro Manila estimate)

The vehicles were further classified according to the type of fuel used. Considering all types of vehicles, 31% use diesel and 69% gasoline. However, for cars and SUV alone, 15.5% is diesel and 84.5% is gasoline. The reduction in share of diesel vehicle is due to exclusion of utility vehicles, trucks, and buses. The estimated total number of privately used vehicles in Metro Manila by body type and fuel is shown in Table 36.

Table 36. Estimated number of personal vehicles in Metro Manila by fuel type, 2010

Vehicle Type	Gas	Diesel	ALL Cars
Cars	220,558	13,017	233,575
SUVs	42,878	35,485	78,364
ALL	263,436	48,503	311,939
Share by fuel	84.5%	15.5%	100.00%

To estimate CO_2 emission and reduction, three scenarios were used (Table 37). Scenario 1 is the existing situation. For Scenarios 2 and 3, PHEV and BEV were included in varying vehicle share. To reflect the shifting preference from gasoline to diesel vehicles, the remaining vehicle share not taken by PHEV and BEV was equally divided between the two conventional vehicles.

Table 37. Scenarios for estimating CO_2 reduction

Scenario	Gasoline	Diesel	PHEV	BEV
(1) Current situation (%)	84.5	15.5	0	0
(2) PHEV 20% BEV 10%	35.0	35.0	20	10
(3) PHEV 30% BEV 20%	25.0	25.0	30	20

The average annual kilometers by the respondents were used to estimate the daily travel from which the distance of blended mode travel for PHEV can be computed. These were used to calculate the CO_2 emissions for travel in blended and in gasoline only mode. The range of the blended mode used was 17 kilometers. Emission factors used for PHEV were the ones indicated in Section 2.4.4. (b) Emission Factors.

Results show that under the current situation, estimated annual CO_2 emissions from privately used vehicles is around 877,981 tons (Table 38). If the share of PHEV and BEV is 20% and 10%, respectively (Scenario 2), an 8% reduction in CO_2 emission is estimated. If the share is further increased to PHEV 30% and EV 20% (Scenario 3), the emission reduction can be as high as 28%.

Table 38. Annual CO_2 reduction from BEV and PHEV use in Metro Manila

Item	Normal Situation	PHEV (20%) BEV (10%	PHEV (30%) BEV (20%)
Annual CO_2 (in tons)	877,981	806,143	630,044
CO_2 reduction (in tons)	-	71,837	247,936
Percent reduction	-	8%	28%
Total value of CO_2 reduction	-	US$ 718,373	US$ 2,479,364
(US$ 10/ton CO_2)	-	Php 31,098,365	Php 107,331,679

Php at US$ 1 = Php43.29

The reduction in CO_2 emission can be claimed as carbon credit. The credits can be traded in existing carbon markets and has corresponding monetary value. The carbon credits can also be transferred to other sector of the country (e.g. energy) to allow for more emission in that sector without increasing the total emissions of the country.

Assuming a carbon price of US$10 per ton of CO_2, the value of carbon reduction for Scenario 2 is Php31 million per year. Scenario 3 presents a higher amount at Php107 million. On a per vehicle basis, the total amount is small but it can accrue over the lifespan of the vehicle. Furthermore, it can be used to finance promotion of LEVs in the country.

The emissions can be reduced further if the current grid emission factor in the Philippines is lowered. This is possible by increasing the share of low-carbon energy sources in the energy mix such as geothermal, hydro, wind and solar. Increasing the efficiency of coal-fired and other fossil fuel-fed power plants can likewise lower the grid emission factor.

As shown in Figure 13, reduction in the grid emission factor further decreased the total CO_2 emission for both Scenarios 2 and 3. For Scenario 2, a 10% decrease in grid emission factor resulted in emission reduction of 8.7% from the original 8%. A 50% decrease in grid emission factor resulted in 10.6% reduction in emission.

For Scenario 3, the emission reduction is larger due to higher number of PHEV and BEV. In this case, a 10% decrease in grid emission resulted in 29.1% emission reduction. A 50% decrease in grid emission factor reduced emission by 32%

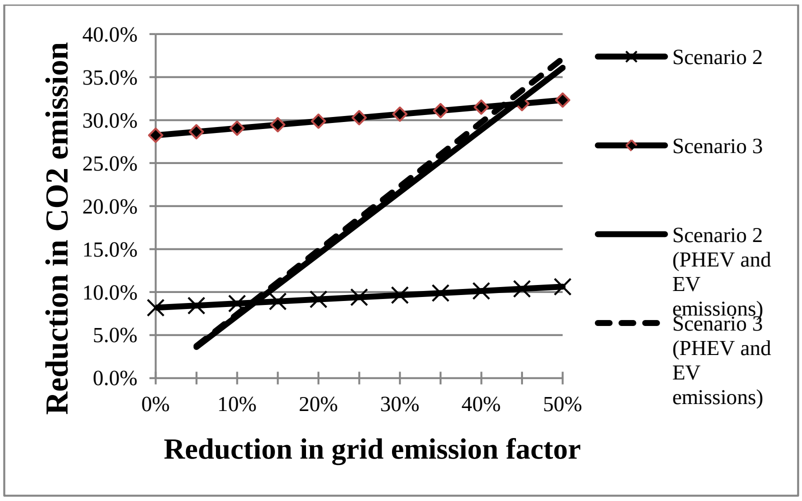


Figure 13. Percent emission reduction by grid emission factor reduction

Also shown in Figure 13 is the reduction in the combined emission from PHEV and BEV. The decrease in grid emission factor resulted in drastic emission reduction from both vehicles which contributed to the overall reduction of emission from the personal vehicle sector. From a low 4% emission reduction resulting from a 10% decrease in grid emission factor, the emission reduction is increased to 37% when grid emission factor is reduced by 50%. This is due to the dependence of the emissions of these vehicles on the grid emission factor.

CHAPTER 6. SUMMARY AND CONCLUSIONS

The purpose of this study is to model vehicle choice of owners of personal vehicles in Metro Manila using a discrete choice experiment. Preference for different types of vehicle including conventional gasoline and diesel vehicles and low emission vehicles such as LPG Dual-fuel (LPG), Battery Electric (BEV) and Hybrid Electric Vehicles (HEV) were determined. Vehicle share on different scenarios and impacts on CO_2 emissions of selected LEVs were consequently estimated.

Most of the respondents have high household income and are well-educated. The average number of cars owned per household is 1.9 but majority owns only a single vehicle. Mean annual travel of respondents is 7,727 kilometers with more than 97% travelling an average of 75 kilometers or less daily. Only 38% knows what an LEV is while 44% have heard about it but do not know any additional details. Of all the respondents who know LEVs, 60% (or 23% of all respondents) said they will buy an LEV in the next 5 to 10 years, 34% said they may consider buying it, and 6% said they will not buy an LEV.

A conditional logit model was estimated from the choice experiment data. The results indicate that there is shifting preference from gasoline to diesel engine vehicles. Although LEVs like LPG vehicles and BEV are least preferred among the vehicle types, there is emerging preference for HEV. The preference for diesel and HEV indicate an increasing need of vehicle owners for higher fuel economy as a result of rising fuel prices in the country.

Based on government data (LTO 2005), gasoline dominates diesel vehicles in the personal vehicle share by 87% to 13%, respectively. But the simulation without any constraint (Simulation 1) showed a higher share of diesel vehicles confirming the initial finding of increasing preference for diesel vehicles even in presence of LEVs.

Favourable situations expectedly increased the share of LEVs in the market simulation, albeit in varying degrees. The scenario involving incentives, reduced emission level and lower cost of travel for LEVs resulted in highest total share for such vehicles – LPG 11%, HEV 30% and BEV 33%. The high share of HEV and BEV was due to the big impact of reduced emission levels on choice probability.

Considering that only 13% of the respondents are potential adopters of HEV and BEV based on their willingness to pay for their next vehicle, a second simulation was done separately for potential adopters using all vehicle types and for non-adopters using only gasoline, diesel and LPG vehicles. Simulation 2 revealed a market share of 34% diesel, 34% gasoline, 25% LPG, 3% HEV and 4% BEV. The reduced share of HEV and BEV resulted from the high price of these vehicles that limited the number of its potential adopters.

A third simulation was done using the number of available model variants for each vehicle type as a factor in estimating choice probabilities. Results of Simulation 3 showed further reduction in the share of HEV (0.9%) and BEV (1%). This is due to the combined effects of limited number of model variants for HEV and BEV and its high purchase price. LPG vehicles likewise had significant reduction in share due to limited number of available variants. Furthermore, gasoline vehicle overtook diesel's share in this simulation. However, when the price of HEV and BEV is reduced to Php1 million, the potential adopters increased to 25%. This increased the share of HEV to 4.7% and BEV to 5.4%.

Despite this low market share, there is a benefit from using LEVs. Assuming all respondents use PHEV, their CO_2 emission is reduced by at least 80%. The percent reduction is higher for those who travel shorter distances due to higher proportion of travel made under the blended mode. The reduction further increased as the range of the blended mode is increased.

There is a marginal WTP of Php3,120 for every Php1 decrease in the cost of travelling 100 kilometers. For every 1 kilometer increase in the range of the vehicle, marginal WTP is only Php187. The marginal WTP for 1% decrease in emission level relative to current vehicles is Php36,510.

A simple cost analysis reveals that conventional vehicles have lower cost than BEV and PHEV over a 10-year period. While there is 40% fuel cost savings for both BEV and PHEV, the savings is not enough to compensate for the higher cost of the LEV.

However, the use of BEV and PHEV would result in reduction of CO_2 emission from the personal vehicle sector due to lower fuel consumption and low grid emission factor. An 8% reduction in vehicular CO_2 emission was estimated for 20% PHEV and 10% BEV share among personal vehicles. The reduction is 28% if share is increased to 30% PHEV and 20% BEV. The value of reduced CO_2 ranged from Php31 million to Php107 million annually. The potential value of carbon credit per unit of BEV and PHEV is small (less than Php1,000 per vehicle) so alternative financing incentives and government support is needed. A sensitivity analysis on the effect of further reducing the grid emission factor showed small decrease in CO_2 emissions for both scenarios.

This study concludes that there is preference for cleaner vehicles as shown by the impact of reduced emission levels on vehicle choice probabilities. There are also benefits from shifting to HEV and BEV in the form of reduced CO_2 emissions and fuel savings. However, due to significantly higher price of these vehicles and the low number of available model variants to choose from, the potential market share is very small. The value of the CO_2 reduction and the 10-year fuel savings is also small compared to the additional costs involved. These make it financially unattractive to ordinary consumers. Therefore, significant price reduction of LEV from current levels is necessary to stimulate adoption of these vehicles.

CHAPTER 7. RECOMMENDATIONS

7.1. Pathway to Sustainable Personal Vehicle Ownership

High investment cost (i.e. purchase price) is one of barriers to successful adoption of AFVs including LEVs (Romm, 2006). Given this barrier in developed countries, it is imperative to examine if such kind of vehicles should be introduced in the Philippines, a developing country with a much lower per capita income "facing an economic struggle in the operation of the transportation sector" (NESTS Report 2010). Despite the high-income characteristics of the respondents of this study, results show that only a small percentage is capable and willing to acquire an LEV. Furthermore, there is still preference for gasoline and diesel vehicles. HEV is the only one with a preference level comparable to conventional vehicles.

Given this situation and assuming an inverted U-shaped Environmental Kuznets Curve[7](EKC), the Philippines would have to endure more pollution from the road transport sector as it strives to develop its economy and as vehicle owners increase their wealth before gradually cleaning up (commonly known as "Grow now, clean up later"). While this has some theoretical and empirical logic, Kahn (1998) and later Cox, Collins, Woods, & Ferguson (2012) have shown otherwise in their study about EKC and transport emissions. Their similar results have shown that poor households tend to pollute more to due to their older and inefficient vehicles. On the other hand, richer households also emit more pollution despite owning newer and more efficient vehicles due to increase in vehicle holdings and total travel. Whether the inverted U-shape of EKC holds true or not for the road transport sector, the reality is that the pollution curve must be flattened or by-passed in the process of economic development.

[7] In layman, Environmental Kuznets Curve assumes an inverted-U shaped relationship between income and pollution. This implies that as the economy grows, more pollution is emitted but pollution tends to decrease after reaching a certain income level as society becomes more aware of the environmental problems and now can afford to mitigate pollution.

Any wealth gained from pollution-emitting economic activities might be offset by health and non-health costs of local air pollution and the potential catastrophic of effect of climate change. Therefore, even a developing country like the Philippines must exert efforts to mitigate pollution. As Dunlap & Mertig (1995) pointed out, the old assumption that non-industrialized nations will not worry about environmental protection until they have achieved economic development is incorrect. Therefore, reducing vehicle emissions is an immediate necessity especially in developing countries and it should not be considered as a function of wealth, both at the national and individual level. Although Dunlap & Mertig (1995) found that Filipinos (with three other countries) expressed unwillingness to pay higher prices for environmental protection, this study has shown the opposite, showing that owners of personal vehicles has positive marginal WTP for reduced tailpipe emission. In the public transportation sector, Francisco (2010) showed that households in Metro Manila have a positive WTP for a cleaner public transportation. Fabian (2002) also showed positive WTP by passengers and pedestrians for improved levels of suspended particulate matter (SPM) in Metro Manila.

Vehicular emission reduction programs are complicated by the economic situation of the stakeholders both in private and public transportation sector. Therefore, different pathways should be explored if we want LEVs to become an integral component of emission reduction. In addition, Romm (2006) stated that for change in vehicle ownership patterns towards low-emission vehicles (or alternative fuel vehicles) to succeed will require advanced technology and strong government action. In addition to this, stakeholder support will play a critical role as this transition involves costs both at the individual and institutional level and will require fundamental changes on how we view transportation.

Clearly, not all LEVs identified in this study are immediately viable given the current condition in the Philippines - even if personal vehicle sector is the sole focus. Travel patterns

(.i.e. frequency and distance) affected by socio-economic and cultural norms should be considered in identifying LEV pathways. LPG retro-fit systems paved the start for cleaner vehicles but the lack of quality control and monitoring resulted in adverse impacts despite its potential to reduce emissions and its minimal infrastructure requirement. BEV is relatively new, expensive and has limited range which may not be suitable for single vehicle households that travel longer distances from time to time either for business, leisure or personal reasons (e.g. visits to relatives in provinces). HEV and the newly-commercialized PHEV present a strong potential to replace current vehicle fleet. As Romm (2006) discussed, it has the capability to reduce emission without drastically affecting the demands of the commuters and without requiring major infrastructures such as refuelling or charging stations. And considering that majority of travels are short distances, the blended mode will greatly benefit emission reduction efforts. However, the high acquisition cost of HEV/PHEV and BEV puts it in a market disadvantage limiting the potential adopters.

Right now, most of the focus is on public transportation and rightly so because most of the travel is through this mode. However, private vehicle owners can contribute by being the pioneer adopters for low-emission automotive technologies.

7.2. Future Research and Policy Recommendation

Traffic demand management still remains the most effective tool in reducing vehicular emissions. LEVs can be a critical part of this as private vehicle ownership and commuting is projected to increase in the next decades. While this study is limited to ownership of personal vehicles, the results provided an initial picture regarding preference and attitudes towards LEVs. Initial estimates of preference for HEV are encouraging but other promising cleaner fuel/vehicles are less preferred such as BEV and LPG vehicles.

Age wise, the vehicle fleet in Metro Manila is a mix of old and new vehicles. Current economic situation does not allow for a change to newer and more efficient vehicle on a regular basis (e.g. every 5 years). And with HEV and BEV significantly costing more than conventional vehicles, AutoLPG can be promoted as a bridge pathway towards more advanced LEVs. This is a viable LEV option in Metro Manila given the existing infrastructure for AutoLPG refilling and the mature retro-fit technologies available. Currently used mostly by taxis, the negative publicity on AutoLPG brought by the supposedly adverse health impacts must be addressed first. The first step is to inform the public about its safe usage in other countries (e.g. the extensive use in taxis in Tokyo, Japan). This should be accompanied by the government's effort to improve and maintain quality standards for both equipment and workmanship of LPG retrofit systems. This is to prevent gas leakage and to increase reliability of LPG systems in vehicles. Additional incentives for AutoLPG users can be provided after a careful study to identify the appropriateness of such incentives.

In the case of HEV and BEV, incentives for these vehicles and/or disincentives for conventional gasoline and diesel vehicles can partially increase adoption of LEVs. However, as this study has shown, the significantly higher cost of acquiring an HEV or BEV is the primary barrier as it limits the number of consumers who can afford it. Legislations currently pending in the Philippine congress that aims to support HEV and BEV through tax exemptions and other incentives can greatly reduce the price of these vehicles and increase the number of potential adopters. Although the monetary value of CO_2 emission is very low on a per vehicle basis due to short distances travelled by private vehicles, this can still be pursued as a potential source of finance. The potential for HEV to replace some mode of public transportation (e.g. taxis) should be explored since benefits from emission reduction increase proportionally with travel distance.

The choice model estimated in this study can be expanded further to include more types of vehicles and more explanatory variables to increase accuracy and precision of estimates. An integrated model to include existing transport models (e.g. emission models and mode choice models) will definitely help in the planning process similar to what is being used in developed countries.

Changes in the overall vehicle fleet will reflect changes in energy demand. Any attempt to further promote alternative fuels especially LPG and electricity should be accompanied with studies on energy demand. This will help understand how energy demand will react under increasing use of alternative fuels.

As the result of the survey has shown, there is also increasing preference for larger types of vehicles such as SUV and AUV/MPV. While this is not reflected in the choice model, this trend will have an impact on emissions assuming that bigger vehicles with bigger engines consume more fuel with everything else the same. Therefore, it is a possibility to identify and implement appropriate incentive scheme for vehicles based on emission levels and body types or sizes, whether it is an LEV or a conventional vehicle.

This study found that increasing the adoption of LEVs in the private vehicle sector has some difficulty due to financial or price constraint that overshadows the benefits of reduced emission. So, the overall key is to provide a list of LEV options with corresponding incentives to allow consumers to choose within the framework of an open market economy.

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APPENDIX A

Details of the scenarios in Simulation 1

Scenarios	Attribute	Vehicle Type				
		Gasoline	Diesel	LPG	HEV	BEV
1	Price (in Php'000)	700	700 to 1,000	700 to 1,000	Over 1,000	Over 1,000
	Range (in kilometers)	Over 450	Over 450	450	Over 450	200
	Incentive	None	None	None	None	None
	Cost of travel (in Php)	450	450	450	450	450
	Emission Level (in %)	100	100	100	100	100
2	Price (in Php'000)	700	700 to 1,000	700 to 1,000	Over 1,000	Over 1,000
	Range (in kilometers)	Over 450	Over 450	450	Over 450	200
	Incentive	None	None	**Yes**	**Yes**	**Yes**
	Cost of travel (in Php)	450	450	450	450	450
	Emission Level (in %)	100	100	100	100	100
3	Price (in Php'000)	**700 to 1,000**	**Over 1,000**	700 to 1,000	Over 1,000	Over 1,000
	Range (in kilometers)	Over 450	Over 450	450	Over 450	200
	Incentive	None	None	None	None	None
	Cost of travel (in Php)	450	450	450	450	450
	Emission Level (in %)	100	100	100	100	100
4	Price (in Php'000)	700	700 to 1,000	700 to 1,000	Over 1,000	Over 1,000
	Range (in kilometers)	Over 450	Over 450	450	Over 450	200
	Incentive	None	None	None	None	None
	Cost of travel (in Php)	450	450	450	450	450
	Emission Level (in %)	**90**	**95**	**70**	**50**	**0**

APPENDIX A (continued)

Details of the scenarios in Simulation 1

Scenarios	Attribute	Vehicle Type				
		Gasoline	Diesel	LPG	HEV	BEV
5	Price (in Php'000)	700	700 to 1,000	700 to 1,000	Over 1,000	Over 1,000
	Range (in kilometers)	Over 450	Over 450	450	Over 450	200
	Incentive	None	None	None	None	None
	Cost of travel (in Php)	450	450	**350**	**200**	**100**
	Emission Level (in %)	100	100	100	100	100
6	Price (in Php'000)	700	700 to 1,000	700 to 1,000	Over 1,000	Over 1,000
	Range (in kilometers)	Over 450	Over 450	450	Over 450	200
	Incentive	None	None	**Yes**	**Yes**	**Yes**
	Cost of travel (in Php)	450	450	450	450	450
	Emission Level (in %)	**90**	**95**	**70**	**50**	**0**
7	Price (in Php'000)	**700 to 1,000**	**Over 1,000**	700 to 1,000	Over 1,000	Over 1,000
	Range (in kilometers)	Over 450	Over 450	450	Over 450	200
	Incentive	None	None	**Yes**	**Yes**	**Yes**
	Cost of travel (in Php)	450	450	450	450	450
	Emission Level (in %)	100	100	100	100	100
8	Price (in Php'000)	700	700 to 1,000	700 to 1,000	Over 1,000	Over 1,000
	Range (in kilometers)	Over 450	Over 450	450	Over 450	200
	Incentive	None	None	**Yes**	**Yes**	**Yes**
	Cost of travel (in Php)	450	450	**350**	**200**	**100**
	Emission Level (in %)	100	100	100	100	100

APPENDIX A (continued)

Details of the scenarios in Simulation 1

Scenarios	Attribute	Vehicle Type				
		Gasoline	Diesel	LPG	HEV	BEV
	Price (in Php'000)	700	700 to 1,000	700 to 1,000	Over 1,000	Over 1,000
	Range (in kilometers)	Over 450	Over 450	450	Over 450	200
	Incentive	None	None	None	None	None
9	Cost of travel (in Php)	450	450	**350**	**200**	**100**
	Emission Level (in %)	**90**	**95**	**70**	**50**	**0**
	Price (in Php'000)	700	700 to 1,000	700 to 1,000	Over 1,000	Over 1,000
	Range (in kilometers)	Over 450	Over 450	450	Over 450	200
10	Incentive	None	None	None	None	None
	Cost of travel (in Php)	450	450	450	450	450
	Emission Level (in %)	**90**	**95**	**70**	**60**	**50**
	Price (in Php'000)	**700 to1,000**	**Over 1,000**	700 to 1,000	Over 1,000	Over 1,000
	Range (in kilometers)	Over 450	Over 450	450	Over 450	200
11	Incentive	None	None	**Yes**	**Yes**	**Yes**
	Cost of travel (in Php)	450	450	350	200	100
	Emission Level (in %)	**90**	**95**	**70**	**60**	**50**

APPENDIX B

Survey Questionnaire

CONSUMER SURVEY ON VEHICLE CHOICE IN THE METRO MANILA, PHILIPPINES

This survey is being conducted as part of the graduate research of Mr. Hadji C. Jalotjot, a masters student at the University of Tokyo's Graduate Program in Sustainability Science (GPSS)
http://www.sustainability.k.u-tokyo.ac.jp/index.html

NAMES ARE OPTIONAL FOR THIS SURVEY. ALL INFORMATION GATHERED FROM THIS SURVEY WILL BE AGGREGATED WITH THE OTHER SURVEY RESULTS AND WILL BE TREATED AS CONFIDENTIAL.

THE UNIVERSITY OF TOKYO
GPSS Graduate Program in Sustainability Science

PART 1. Characteristics of Your Current Vehicle

1.1 What is the model of the personal vehicle you use MOST OFTEN:

Brand (e.g. Nissan, Kia)	
Model & Variant (e.g. Altis J, Civic S)	
Year (e.g. 2003)	
Engine displacement (in liters or cc)	
Fuel type	

1.2 When did you buy this vehicle? ______**Year**

1.3 Is this vehicle purchased new or used? ☐ Brand **new** ☐ **Second hand**

1.4 How was the vehicle acquisition financed?
- ☐ **Car loan (instalment)**
- ☐ **Wholly financed by the company/employer**
- ☐ **Partially financed by the company/employer**
- ☐ **Fully paid (cash or by other means)**
- ☐ **Others _________________**

1.5 How much did you pay to acquire this vehicle? **Php**________________

1.6 On the average, how much do you spend on fuel weekly? **Php**__________

1.7 On the average, how much do you spend in maintaining this car **per year**, EXCLUDING the fuel expenses? *Please use you best estimate*

Php___________________ **per year**

1.8 Do you monitor the fuel consumption of this vehicle (e.g. kilometers travelled per liter or per full tank)? ☐ **No** ☐ Yes ☐ Not applicable (for electric vehicles only)

1.7.1 If YES, by your best estimate, how many kilometers does your vehicle travel in one liter of fuel? ______ **kilometers per liter**

1.9 How many more years do you think you will use this vehicle before acquiring a replacement? _____ **years**

1.10 Including the car mentioned above, how may vehicles does your household currently own and use? ______ **vehicles**

APPENDIX B (continued)

Survey Questionnaire

PART 2. Vehicle Usage and Travel Behaviour

This part describes vehicle usage and related travel behaviour. Please use your best estimate if necessary.

2.1 What is the primary purpose of using this vehicle? *Check only one*

- ☐ Going to work
- ☐ Bringing child/children to school
- ☐ Business related
- ☐ Others (Specify _________________________)

2.2 On the average, how many KILOMETERS PER DAY do you drive your vehicle? *(Use your best estimate)*

Day of the Week	Total no. of kilometers driven per day
Mondays	
Tuesdays	
Wednesdays	
Thursdays	
Fridays	
Saturdays	
Sundays	

2.3 Please describe the frequency of usage of your vehicle based on the specific day of the week.

Day of the Week	Frequency of Usage (Please check only one per specific day)				
	Not at all	Once every few months	Once a month	A few per month	Every week
Monday	☐	☐	☐	☐	☐
Tuesday	☐	☐	☐	☐	☐
Wednesday	☐	☐	☐	☐	☐
Thursday	☐	☐	☐	☐	☐
Friday	☐	☐	☐	☐	☐
Saturday	☐	☐	☐	☐	☐
Sunday	☐	☐	☐	☐	☐

2.4 Please state the frequency of your long distance travel per year

Distance of travel	No. of times per year
100km to 200km	
201km to 300km	
301km to 400km	
Over 400km	

2.5 Based on your best estimate, how many kilometers did you drive this vehicle in the last 12 months (one year)? (*You can use your odometer/trip meter readings or your best estimate)* _________________ **kilometers per year**

2.5.1 Describe accuracy of estimate (for interviewer)

☐ Very accurate ☐ Fairly accurate ☐ Best estimate ☐ Not accurate

2.6 Do you use public transportation on a regular basis besides your vehicle (at least once every week)? ☐ **YES** ☐ **NO**

2.6.1 If YES, please check only those you use regularly:

- ☐ BUS ☐ JEEPNEY
- ☐ LRT/MRT ☐ TAXI
- ☐ PNR ☐ OTHERS(please specify_______________

PART 3. Knowledge on Vehicles

3.1 When making a vehicle purchase decision, who would you normally consult from your household? *Choose only one*

- ☐ Nobody ☐ Friends
- ☐ Spouse /Partner ☐ Car sales agents
- ☐ Son or Daughter ☐ Others

APPENDIX B (continued)

Survey Questionnaire

3.2 When you receive information about vehicles, how do you rate the various sources of information?

Sources of Information	Very useful	Useful	Not useful		Not Applicable
Government	☐	☐	☐		☐
Press (Newspapers, TV, Radio, etc.)	☐	☐	☐		☐
Personal testimonies (i.e. friends)	☐	☐	☐		☐
Internet websites and forums	☐	☐	☐		☐
Advertisements	☐	☐	☐		☐
Your own experience	☐	☐	☐		☐
Consumer reports	☐	☐	☐		☐
Others______________	☐	☐	☐		☐

3.3 How important are the following vehicle attributes when buying a vehicle?
<u>VI</u> – Very Important, <u>I</u> – Important, <u>N</u> – Neutral, <u>NI</u> – Not Important, VU-Very unimportant

Attribute	Response	Attribute	Response
1. Fuel consumption		7. Engine power	
2. Interior and trunk space		8. Price	
3. Type of fuel used		9. Comfort features	
4. Durability and reliability		10. Maintenance	
5. Safety and security		11. Aesthetics (looks)	
6. Pollution level			

3.4 When you were deciding to buy a vehicle, did you consider the impacts of vehicle use on the environment? ☐ **YES** ☐ **NO**

3.3.1 If YES, what specific environmental impacts of vehicle use came into your mind? ____

3.5 Do you feel your current vehicle is environmental-friendly? ☐ **YES** ☐ **NO**

3.6 Is there is a commercially-available vehicle in the Philippine market today that you consider environmental-friendly? ☐ **YES** ☐ **NO**

3.7 Do you know what a low-emission vehicle (LEV) is?

☐ No
☐ I have heard about it but I do not know details about it
☐ Yes

3.7.1 If YES, will you consider buying a low-emission vehicle in the next 5 to 10 years? (such as Hybrid-Electric, Electric and even LPG-fuelled vehicle)

☐ Yes, definitely.
☐ No, I'm not interested in LEVs
☐ Maybe

3.7.2 State your opinion on Low Emission Vehicles such as Electric and Hybrid Electric compare to conventional vehicles?

Answer key:
1 - Less
2 - Same
3 - More
4 - Do not know

a) The reliability of LEVs is _______ compared to conventional vehicles.
b) LEVs travel __________ number of kilometers compared to conventional vehicles.
c) LEVs have ___________ engine power compared to conventional vehicles.
d) The purchase price of LEVs is __________ compared to conventional vehicles.
e) The speed of LEVs is ___________ compared to conventional vehicles

APPENDIX B (continued)

Survey Questionnaire

PART 4. Future Vehicle Choices (Choice Experiment)

For this section, let us assume a hypothetical situation wherein your primary vehicle has reached the end of its life. You and your family are now considering buying a new vehicle that will serve the same purpose. For example, if you use your primary vehicle to go to work, this new vehicle will also be used to take you to work. This vehicle will replace the vehicle you currently use most often.

You will be asked to make a series of ten (10) vehicle comparisons. Each comparison involves CHOOSING BETWEEN TWO TYPES OF HYPOTHETICAL VEHICLE. Select the type that you would most likely choose as your next vehicle purchase, if your choices were limited to these two.

Assume that both vehicle types are of the same quality to your current primary vehicle. Also assume that the two vehicles are the same except for the information stated.

Please consider each comparison independently of the others, and read each one carefully.

There is no right or wrong answer for this part. Please select the vehicle that you wil most likely choose given the options.

Before you proceed, kindly answer the following questions:

4.1 What type of vehicle will you most likely buy next.

- ☐ Asian Utility Vehicle (AUV)
- ☐ Compact/Sub-compact
- ☐ Pick-up
- ☐ Full/medium-sized Car
- ☐ Van
- ☐ Motorcycle
- ☐ Compact SUV
- ☐ Others ___________
- ☐ SUV

If not sure, indicate the preferred brand and model______________

☐ Brand New ☐ Second Hand

4.2 What is the maximum amount that you are willing to spend for this next vehicle?

PhP___________________

Remember, both vehicle types are of similar quality to your current primary vehicle. Also assume that except for the information stated, the two vehicles are the same.

INSERT CHOICE EXPERIMENT HERE

(5 pages, 2 Choice Sets per page)

Please note that there are 3 sets of choice experiments (A, B and C).
Each set has 10 Choice Sets.
Each set shall have 100 respondents.

AND DELETE THIS PAGE

APPENDIX B (continued)

Survey Questionnaire

PART5. Views on Technology and the Environment

Below are statements about environment, technology and society in general. Kindly indicate your thoughts about the statements by checking one of the indicators

i.e. SA - Strongly Agree ; A – Agree; UD - Undecided ; D - Disagree (D); SD - Strongly Disagree

Statement	SA	A	UD	D	SD
The pollution issue has not bothered me because I think it is overrated and not that serious.	☐	☐	☐	☐	☐
I rarely ever worry about the effects of pollution on myself and family.	☐	☐	☐	☐	☐
I am really not eager to go out of my way to do much to help the environment.	☐	☐	☐	☐	☐
We should accept higher levels of pollution if it will result in more jobs and employment for the people.	☐	☐	☐	☐	☐
We should take steps now to counteract global warming.	☐	☐	☐	☐	☐
For a developing country like the Philippines, it is impossible to have continuous economic development without increasing levels of pollution.	☐	☐	☐	☐	☐
I'd be willing to write to our lawmakers about ecological problems.	☐	☐	☐	☐	☐
I would be willing to go door to door to discuss and distribute materials about the environment.	☐	☐	☐	☐	☐
The government is not doing enough in protecting the environment.	☐	☐	☐	☐	☐
I would be willing to take the bus or train to work in order to reduce the air pollution.	☐	☐	☐	☐	☐
I am willing to buy a product that is more ecologically friendly but is a little more expensive.	☐	☐	☐	☐	☐
The world will be completely destroyed in 40 years if we do not improve the quality of our environment.	☐	☐	☐	☐	☐
I would probably never join a group, club, or organization that is concerned solely with ecological issues.	☐	☐	☐	☐	☐
There is never enough time in a day to get everything done.	☐	☐	☐	☐	☐
Things have become so complicated in the world today that I really do not understand just what is going on.	☐	☐	☐	☐	☐
The world's destiny is predetermined and history takes its course.	☐	☐	☐	☐	☐
I am excited by the possibilities offered by new technologies.	☐	☐	☐	☐	☐
New technologies cause more problems than they solve.	☐	☐	☐	☐	☐
I would support a government law requiring automakers to produce environment-friendly cars.	☐	☐	☐	☐	☐

PART 6. Information About Yourself

6.1 Name *(optional)* ________________ 6.2 Respondent Age: ____________ 6.3 Sex: ☐ Female ☐ Male

6.4 City or municipality of residence: _____________

6.5 Highest Level of Education: *(Select one only)*
- ☐ Elementary
- ☐ High school Diploma
- ☐ College / University Degree
- ☐ Vocational
- ☐ Post-graduate units (no degree yet)
- ☐ Post-graduate degree
- ☐ Others

6.6 Primary Occupation: *(Select one only)*
- ☐ Employee
- ☐ Business / Self-employed
- ☐ None
- ☐ Others (specify _______________)

6.7 Position *(Select one only)*
- ☐ Senior Management Position
- ☐ Junior Management Position
- ☐ Rank and file
- ☐ Newly employed
- ☐ Owner of business/company
- ☐ Others (specify ____________)

6.8 Monthly Household Income Level *(Select one only)*

_____Below Php 15,001
_____Php15,001 – 30,000
_____Php30,001 - -75,000
_____Php75,001 – 100,000
_____Over Php100,001

6.9 Household Size: _______

6.10 No. of Household Members who are studying: _______

6.11 No. of Household Members who has income: _______

THANK YOU VERY MUCH FOR YOUR TIME!