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Study on the Effect of the Alternative Fuel Vehicles on the Market Using the Joint Mixed Logit Model

- Case of Korean Automobile Market -

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Abstract

Analyzing the Effect of the Increasing HV and EV on the Automobile Market through the Changes in the Customers′ Preferences

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Preserving the environment has been one of the key topics of the government and industry′s goal in the 21st century. As part of the movement, developing an eco-friendly vehicle has become one of the most promising method in sustaining the environment. The key to successful transformation of the automobile market will require both the support from government policies and the research & development effort of the firms to produce the right kind of alternative fuel vehicles. Based on the Korean market, this research use both revealed preference (RP) and stated preference (SP) data through joint mixed logit estimation to analyze the effect of the increasing EV and HV vehicles in the automobile market through the changes in the customer′s preferences. The results of this research will determine which alternative fuel vehicle is most preferred by the consumers, and how the market will change when such vehicles are diffused.

Keywords: Eco-friendly vehicles; automobile market; RP data; SP data; joint mixed logit; alternative fuel vehicle

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1. Introduction

Climate change caused by the industrial development has become one of the major policy and industrial concerns. As a result, governments and firms worldwide have taken several measures to respond to these growing environmental issues. One of the key aspects of the respective response strategies is to replace the consumption of traditional fuel with its more environmentally-friendly alternatives. As a part of this plan, the automobile industry has developed various kinds of alternative fuel vehicles, such as LPG, biofuel, hybrid, and so on. Since automobiles are an essential necessity in today's society, developing an eco-friendly vehicle has become one of the most promising methods in sustaining the environment. Similarly to other parts of the world, the Korean government and its automobile firms have joined the movement towards adapting more eco-friendly vehicles. The key to successfully transforming the market will require both the support from government policies and the research & development effort of the firms to produce the appropriate kind of alternative fuel vehicles. Based on the Korean market, this paper will analyze the effect of the increasing alternative fuel vehicles in the automobile market through the changes in the customers' preferences. The results of this research will determine which alternative fuel vehicle is most preferred by the consumers, and how the market can change when such vehicles are distributed with the assistance of governmental policies.

In 2012, the global eco-friendly vehicle market grew by 78.8%, with more than 1.5 million vehicles sold throughout the world. Although the growth rate poised in t 2013, it still

remained strong, reaching 7.8%. (Kim 2013). Among the many alternative vehicles that were developed, the hybrid car is one of the most successful alternative fuel vehicles in the market. Although it is not completely independent of traditional fuel, the hybrid vehicle uses both electric and gasoline to fuel its engine. This combination of two different types of fuel drastically increases the fuel efficiency as compared to traditional vehicles. As a result, hybrid vehicle is very likely to retain its dominant position among alternative fuel vehicles in the near future (Kim 2013).

To raise public awareness of the advantages and the market share of alternative fuel vehicles, various policies have been proposed by governments worldwide. For example, the U.S. government under president Obama proposed the Climate Action Plan in 2008, which has been updated every two years ever since. The plan's main goal is to reduce carbon dioxide emissions by encouraging the usage of alternative fuels by introducing specific technological requirements for the automobile industry. By 2016, all manufactured vehicles need to have fuel efficiency of 15.1 km/l and tail-gas emission of 155g/km. The ultimate goal of the Climate Action plan is to raise the standards to average fuel efficiency of 23.2 km/l and tail-gas emission of 101g/km by year 2025. (Lee 2013). Similarly to the U.S. government, the Korean government has been increasing its complementary policies to aid the expansion of alternative fuel vehicles in the market.

Alongside with the government's effort to aid the increase of alternative fuel vehicles, different automobile firms have taken various corporate strategies to respond to the

transforming market. Many major automobile firms have taken three main types of strategies, namely: technology complementary, technology exchange, and proprietary development. Ford and Daimler have agreed on technology complementary pact to accelerate the development of affordable fuel cell electric vehicle. Two biggest automobile producers in the world, BMW and Toyota, have agreed on technology exchange pact to develop the next generation alternative fuel vehicles. Rather than forming a partnership, Korea and Germany's domestic mega firms Hyundai/KIA and Volkswagen have started their proprietary research to develop their unique technology and products.

Ever since 2010, the market share of import cars has gradually increased in Korea, hitting 12% in 2013 (Kim 2013). In 2004, the majority of import car were large luxury sedans, which differentiated them from standard Korean cars. Over time, the heavy tariff on import cars was alleviated by the EU and U.S. Free Trade Agreement (FTA) and various categories of import cars started flooding into the Korean market. As of 2013, 70.9% of foreign cars in Korea were of German origin, 69.9% of the total foreign cars were diesel cars, while small and mid-size sedans under 2,000cc amounted to 53.4% of the foreign market share. These statistics are significant in that they exhibit the changing preferences of the Korean consumers in choosing automobile. For one, the strong market share of German cars shows that consumers prefer both safe and efficient cars that are different from domestic cars. The high percentage of diesel cars and small/mid-size cars is also a clear indication that foreign cars are no longer regarded as 'classic luxury' cars, but rather as more efficient and standard automobiles (Lee 2013).

In order to analyze the market and estimate potential changes, two different types of methodologies were considered. The BLP methodology developed by Berry, Levinsohn and Pakes (1995) and the joint mixed logit methodology developed by Ben-Akiva (1991) which was later improved by Hensher (2008). Both papers studied the similar topic in that they analyzed and estimated the changes of the automobile market. The BLP methodology (Berry et al. 1995) is useful in that it only uses revealed preference data of the past to estimate the future. On the other hand, the joint mixed logit (Ben-Akiva, 1991) uses both stated preference data and revealed preference data to make a more reliable estimation. Ben-Akiva (1991, 1994) and Hensher (2008) propose a flexible mixed logit methodology to combine revealed preference and stated preference data. The idea was to increase the SP data set's reliability and RP's accuracy by combining them. Brownstone et al. (2000) improved the joint estimation method and used it to analyze the demand and consumer preferences for the alternative fuel vehicles in the market.

While considering both methodologies, it became evident that BLP methodology requires extensive amount of revealed preference data to make a stable estimation. As the data in possession were composed of both general revealed preference data over a short period and stated preference data, using the joint mixed logit methodology was the logical choice. The joint mixed logit is one of the discrete choice models that incorporate two different types of data to forecast a single outcome. Stated preference data and revealed preference data both have different advantages and disadvantages that distinguish them from other data. Simply put,

stated preference data can make data about hypothetical product that are not in the market. Yet, the data are always at risk of being highly biased. Revealed preference data are the data about the actual market and can be taken as a fact. However, product attributes have multicollinearity problem which makes a solid RP data scarce in most cases (Train 2009). Also, as RP data are only available for the products that are in the market, it is impossible to make an estimate about any products that are not yet available. For this research, stated preference data from the 'Survey on smart-device usage' of 2010 and the revealed preference data of the survey respondents were used.

This paper will use the steps and the research framework similar to the ones proposed by Brownstone and co-authors (2000). Specifically, we will first make pure stated preference data and pure revealed preference data estimation and compare them to the joint mixed logit estimation results. The pure estimations are estimated by the mixed logit model and later compared to the results of the joint mixed logit model. By using the joint mixed logit, there are more attributes and aspects of the market that can be explained by two different types of data. As a result, the comparison will serve as evidence to support the advantages of using two types of data simultaneously.

The results of the estimation will be interpreted to describe the future of the Korean automobile market, with the potential changes of the alternative vehicles' market share and that of other vehicles. After drawing the individual coefficients from the results, a market simulation will be performed to represent the execution of the government subsidies and technological

development of the future. (Train 2009) Such analysis will give the current government and firms a guide to set up their policies and strategies in the future. For example, at present, there are more policies that support the increase of alternative fuel sedans; however, if there is evidence that people prefer SUV or other alternative fuel over hybrid, this evidence can be used to model new government policies and firm strategies in the future.

The remainder of this study is organized as follows. In Section 2, we summarize the theoretical background and overview previous studies that analyze the automobile industry. Furthermore, Section 3 presents the empirical model setup, followed by the empirical studies. Sections 4 and 5 present the results, discussion, the limitations of this study and suggestion for further research. Our findings provide helpful insights on consumer preferences study as well as analyzing the validity of policies promoting alternative fuel vehicles.

2. Previous research and theoretical background

2.1. Environmental issues and the alternative fuel vehicle market

In 2012, the International Energy Association announced the Blue Map Scenario (BMS) plan. The BMS plan focuses on reducing the global CO_2 emissions for over the next 50 years. Based on the report completed in year 2009, which forecasted the energy industry up to the year 2030, the BMS plans to design and propose a technological and political roadmap to reduce the global CO2 emissions by 50%. (Son 2014)

The increasing interest and the development of the alternative fuel vehicles are due to the rising standards of environmental regulations like the BMS. The environmental concern of global warming has been continually rallying interest ever since the 20th century. As one of the most prominent solution to the environmental problem, promoting the development of the alternative fuel vehicles has been the goal of numerous government policies and firm strategies. Throughout the decade, the government has gradually increased the tail-gas emission and fuel efficiency standards according to the technological capacity of the time.

Next generation cars are referred to as the Green Car, which is defined by the Korea Evaluation Institute of Industrial Technology (KEIT) as any cars that has superior energy efficiency and satisfy the pollution-free or low emission standards. (Son 2014) As of now, there are two main classes of alternative cars that are being considered by the major policy makers. First, there are electric based cars which use electric and fuel cell to directly generate ‘high

output electric power' for driving. There are various types of alternative fuel vehicles that enter this EV classification; electric vehicle (EV), plug-in hybrid (HEV/PHEV), and the fuel cell electric vehicle (FCEV). The other classification of the Green Car are the advanced versions of the conventional engine based vehicles. These vehicles uses traditional fossil fuel but comply with the required fuel efficiency and low emission standards. Researchers forecasted that clean diesel vehicles (CDV) and natural gas vehicles (NGV) to be the most promising field of improved conventional fuel vehicles. (Son 2014)

There has been many recent signs that demonstrated the changes in the environment surrounding the alternative fuel market. According to KEIT report in 2014, developed nations of Europe and U.S. have been leading the renovation process of reinforcing the tail-gas emission and fuel efficiency regulations. Emerging nations such as China and India has established itself as the top producer in the global automobile industry. Compared to the increasing influence of the emerging nations, Korea's domestic automobile market has stagnated over the past 3 years with the rising share of imported cars.(Lee 2013)

In the alternative fuel vehicle market, developing innovative and sustaining core technologies will be key in staying ahead of the competitions. Currently, with no dominant type of alternative fuel vehicles except hybrid cars, the race to preempt the alternative fuel vehicle market is accelerating. Many governments and firms are focusing on multi-option research and development effort to grow into the leader of the next generation automobile market. (Lee 2013) For example, Japan is focusing its main efforts on developing the HEV along with both EV

and CDV. In case of the traditional fuel based vehicles, such efforts include downsizing, weight lightening, and increasing the fuel efficiency of the car. In case of the EV's, reducing the price of the vehicle and developing convenient powertrain for application is the key to succeed in the next generation automobile market.

2.2. Government policies

With the increasing environmental concerns and the volatile oil market, the alternative fuel vehicle market has been gradually expanding ever since its introduction. Customers, governments and firms are recognizing the importance of the CDV, EV, HEV, FCEV, and other alternative fuel vehicles' role in the future market. In 2012, the global alternative fuel vehicle market grew by 78.7%, with more than 1,500,000 vehicles sold over the world. Although the growth rate poised compared to the year before, it still recorded 7.8% in 2013. Recently, to strengthen the transformation of the automobile market, numerous governments and automobile firms established new environmental policies and corporate partnerships to aid the development of the alternative vehicle market. (Kim 2013)

The U.S. government under president Obama proposed the Climate Action Plan in 2008, which has been updated for every two years since. The plan focuses on reducing the carbon dioxide emissions, preserving forests, encouraging the use of alternative fuels, and increasing the study of climate change. CA plan has set specific technological requirements for the automobile industry. By 2016, all of the cars being manufactured will have average fuel efficiency of 15.1 km/l and tail-gas emission of 155g/km. By 2025, these standards are set at

average fuel efficiency of 23.2 km/l and tail-gas emission of 101g/km.

Similar to the U.S. government, Europe, China and Japanese governments recently proposed their version of the climate action plans. European climate plan is called the 20-20-20 plan, and it focuses on reducing the overall tail-gas emission over the next decade. China is testing the CERs (Certified Emission Reductions) trade market targeted to 635 firms within the Guangdong region, and plans to gradually expand the area of effect. Japanese government plans to install heavy fines and specify minimum technological requirements for the automobile firms in order to avoid them. The table below summarizes the highlight of each governments' climate policies that support the development of the eco-friendly vehicles (Kim 2013)

Table 1 Government Policies

Nation		Description
U.S.	-	By 2016, kmpg 15.1km/l, emission 155g/km
	-	By 2025, kmpg 23.2km/l, emission 101g/km
	-	When requirements are not met, the government plans to fine the automaker $5.5 for every 0.1 mpg
Europe	-	By 2015, kmpg 17.9km/l, emission 130g/km
	-	By 2020, kmpg 23.2km/l, emission 95g/k
	-	From 2015, any vehicles with the tail-gas emission exceeding 130g/km will be fined up to €95
Japan	-	By 2015, kmpg 16.8km/l, emission 130g/km
	-	By 2020, kmpg 24.4km/l, emission 105g/km
	-	From 2015, any automakers that don't meet the criteria will be fined
China	-	Establish CER trade market over Guangdong region to reduce emission
	-	Gradually expand the CER market over the nation

※Kookmin Bank Business Research Center

2.2.1. Korean government policies

The Korean government's policies to accelerate the establishment of the alternative fuel vehicles has been in motion ever since the Korea Ministry of Industry announced the "Law on the Development and Promotion of the Environmentally Friendly Cars" in 2013. (Son 2014) These set of policies have defined the kinds of alternative fuel vehicles that has the potential to become the dominant design for the next generation automobile market. The KMI policies have been updated in January, 2014 that reflect the recent technological and industrial development of the alternative fuel vehicle market. The policy categorizes the types of the alternative fuel vehicles that can be considered for the governmental aid as of now and in the near future. Table 2 summarizes the characteristics of the cars defined by the KMI. For this paper, I focused specifically on the policies that consider the EV and HV, which are already being sold in the market.

Table 2 Definition of Vehicles

Type of vehicle	Defining Attributes
Electric Vehicle (EV)	Vehicle that uses electric energy received from electricity power source to operate
Solar Power Vehicle (SPV)	Vehicle that uses solar energy to operate
Hybrid Vehicle (HV)	Vehicle that uses a combination of either gasoline, diesel, LPG, and CNG with an electric energy source to operate
Fuel Cell Electric Vehicle (FCEV)	Vehicles that employ electric energy produced by hydrogen as a power source
Natural Gas Vehicle (CNG)	Vehicle that uses compressed natural gas and liquefied natural gas as a power source
Clean Diesel Vehicle (CDV)	Vehicle that uses the mechanical energy created by transforming the kinetic energy created within the diesel engine

※Korea Ministry of Industry

2.2.2. Electric Vehicle in Korea

EV market in Korea officially kicked off in 2011 with the establishment of Car Sharing businesses that installed electric vehicles for rent. Car Sharing market was first introduced in the U.S. and Western European cities to create new efficient intra-city transportation method by lending eco-friendly vehicles for hours. (Park 2011) The market was originally designed to target the consumers that didn't own a car but that needed vehicles for minor occasions. However, after the global financial crisis of 2008, the new trend of socially viable consumption spread throughout the world. Increasing the public interest in sustainability and economic values of using the car sharing programs. In addition to the increasing attention, the development of the IT technology accelerated the diffusion of the item and new subscribers exploded into the market. In response to the market trend, the Korean government has initiated its own car sharing program within the metropolitan area in 2012 under the supervision of the Ministry of Knowledge Economy. From the start, the Korean government implemented EV to be the dominant vehicle used in the program. The trend that started in Paris France proved that EV were the most efficient intra-city vehicle. When using the car sharing program, most consumers tend to travel short distance over a short period of time. With the right amount of charging infrastructure installed, the EV can become the most efficient mode of car for intercity travel. (Park 2011) The car sharing program is one of the most promising form of marketing for the automakers to allure new consumers. With more users entering the market daily, Korean firms are benchmarking the case of U.S. Zipcar and Japan's Orix Cars to establish their own form of vehicle-rent market. Each car sharing users who experience the EV first-hand are the

potential buyers of the product, and firms and government must prepare proper strategies in order to exploit these chances.

The car sharing program has assisted the diffusion of the EV market throughout Korea. There are currently 177 electric charging stations across the country with over 2,672 registered users. The increasing number of registered users and the number of electric charging stations represent Korea's growing interest in the EV market. Table 3 describe the nine different electric vehicles that government operates through public transportation system as of 2014.

Table 3 Government Operated Electric Vehicles

Maker	Car	Type	Description
Kia	LAY	Mini	- Top speed: 130km/h - Total mileage per charge: 91km
GM	SPARK	Mini	- Top speed: 145km/h - Total mileage per charge: 135km
Renault	SM3	Mid	- Top speed: 135km/h - Total mileage per charge: 123km
BMW	I3	SUV	- Top speed: 150km/h - Total mileage per charge: 126.8km

Table 3 continued

Kia	SOUL	Mid	- Top speed: 150km/h - Total mileage per charge: TBD
Nissan	LEAF	Mid	- Top speed: 145km/h - Total mileage per charge: TBD
Dongwon	OLEV	Bus	- Top speed: 85km/h - Total mileage per charge: 75.5km
Fiber-X	E-Primus	Bus	- Top speed: 100km/h - Total mileage per charge: 69.8km
PM Grow	BEGINS	Bus	- Top speed: 80km/h - Total mileage per charge: TBD

※Electric Vehicle Charging Information System.

A number of government policies that provide various forms of subsidies to EV owners and users are increasing. Recently, from October to December 2014, the regional office of Seoul provided a financial aid up to 2000 million won to private consumers trying to purchase an EV. The recipient of the aid were chosen through a process of lottery with an average competition of 3.31 to 1. The 182 draws that will have a chance to experience the EV first-hand

and become the early adopters to initiate the mass diffusion of the product. Other forms of financial aid include 100% exemption of major toll fees within Seoul, 50% reduction of public parking fee, and tax incentives over acquisition and consumption tax. At the time, the presence of EV in the Korean automobile market is close to 1%. However, the market is expected to grow with the help of the increasing government subsidies and the expansion of the necessary infrastructure. One of the key features that will mark the growth of the Korea's EV market is the upcoming production of the Ray EV and SOUL EV by KIA motors for the public. (Park 2011)

2.2.3. Hybrid-vehicles in Korea

The HV (hybrid vehicle) has been the dominant type of alternative fuel vehicle around the world for the past decade. According to the 2015 market report by the Korea Automotive Research Institute, the HV market is expected to lead the overall growth of the eco-friendly vehicles in Korea. The introduction of the domestic hybrid vehicles by automakers Hyundai and KIA last year marked the starting point of the competition with the imported HVs. (Lee 2013) Although the overall market sales dropped in 2014 due to the reduced supply of Toyota's Camry and Prius, it is likely that the rate will bounce back in 2015. Toyota currently holds close to 95% of the HV market share with 5 hybrid models from Lexus and 2 from Toyota. Last year, it had problem supplying the core battery parts for the Toyota cars which made it difficult to supply the most popular models Camry Hybrid and the Prius. It had to make up for the loss in Toyota by providing aggressive promotions and extended warranty of Lexus vehicles. As a

result, the Lexus HVs increased from 1,886 vehicles sold in 2012 to 3,365 vehicles sold in 2014

Hyundai and KIA motors are manufacturing three sedans HVs as of now and plan to add different types of models in the upcoming year. Current models are Hyundai's Grandeur Hyrid and KIA's K5 and K7 Hybrid. Three additional HVs are the Hyundai's subcompact Avante Hybrid and new models of the K5 and K7 hybrid. In the global stage, the Korean automakers are beginning to show competitiveness in the HV market. In the U.S. which holds the largest HV market in the world, Hyundai and KIA sold 35,680 hybrid versions of Sonata and the K5, accounting for 7.2% of the total U.S. HV market share. According to the KARI report, this rate is expected to grow at an average rate of 15.7% annually.

2.2.4. Policies regarding EV and HV

In order to increase the overall public interest and sales of the EV and HVs the Korean government proposed various policies to support the consumers financially by providing tax incentives and subsidies. One of the important features of the Korea's 'Support for the buyers of eco-friendly cars' policy introduced by the Korean Ministry of Strategy and Finance include providing subsidies to consumers who buy EV and HV. These subsidies come in various forms; such as paying the difference between the price of a conventional car and the EV and HV, and mediating the grant of favorable auto financing. (Kim 2013) The policy also allow the regional administrations to provide any adequate form of policies that is deemed necessary to increase the region's public purchasing intensions of the EV and HVs. Table 4 and Table 5 summarizes

the specific monetary support for the EV and HV purchases provided by the MOSF policies. The following policies are only subjected to EV and HV that satisfy the technological criteria defined by the “Law on the development and promotion of environmentally friendly cars” updated every year by the Ministry of Trade Industry and Energy.

Table 4 Incentive policies for purchasing Hybrid Vehicle

Subsidy category	Description	Relevant Ministries
Individual Consumption Tax	- Exemption from the consumption tax when buying HV. - Full exemption if the fee is less than one million won. - One million won exemption if the fee exceeds one million won.	Ministry of Strategy and Finance
Education Tax	- Subsidy up to 30% of the consumption tax. - Up to three hundred thousand won.	Ministry of Strategy and Finance
Acquisition Tax	- Exemption from the acquisition tax when buying HV. - Full exemption if the fee is less than 1.4 million won. - 1.4 million Won exemption if the fee exceeds 1.4 million won.	Ministry of Public Administration and Security
Reduction in bond purchases	- Up to four hundred thousand won.	Ministry of Land, Transport and Maritime Affairs

※Korea Ministry of Strategy and Finance article 2 section 5

Table 5 Incentive policies for purchasing Electric Vehicle

Subsidy category	Description	Relevant Ministries
Individual Consumption Tax	- Exemption from the consumption tax when buying EV. - Full exemption if the fee is less than two million won. - Two million won exemption if the fee exceeds two million won.	Ministry of Strategy and Finance - In effect until the end of 2014
Education Tax	- Subsidy up to 30% of the consumption tax. - Up to six hundred thousand won.	Ministry of Strategy and Finance
Acquisition Tax	- Exemption from the acquisition tax when buying EV. - Full exemption if the fee is less than 1.4 million won. - 1.4 million Won exemption if the fee exceeds 1.4 million won.	Ministry of Public Administration and Security - In effect until the end of 2014
Reduction in bond purchases	- Up to two million won.	Ministry of Land, Transport and Maritime Affairs

※Korea Ministry of Strategy and Finance article 2 section 5

According to the MOTIE (Ministry of Industry and Energy) report in May 2014, HVs following the technological specifications of the Table 6 and the hybrid vehicles described by Table 7 were specified to receive the subsidies.

Table 6 Technological specifications required for HV

Category	Energy consumption efficiency (km/l)		
	Gasoline	Diesel	LPG
1,000cc>	25.5	-	20.6
1,000cc~1,600cc	20.6	27.2	16.5
1,600cc~2,000cc	16.8	19.1	13.5
2,000cc<	14.0	16.8	11.1

※Korea Ministry of Industry and Energy

Table 7 HV models subject for reward

Maker	Model
Hyundai	Avante 1.6 LPI Hybrid
	Sonata 2.0 Hybrid
	Grandeur 2.4 Hybrid
KIA	Forte 1.6 LPI Hybrid
	K5 2.0 Hybrid
	K7 2.4 Hybrid
Honda	Civic Hybrid (1339cc, 1497cc)
	Insight (1339cc)
	CR-Z Hybrid (1497cc)
Lexus	RX450h (3456cc)
	CT200h (1798cc)
	GS450h (3456cc)
	ES300h (2494cc)
Toyota	PRIUS (1798cc)
	Camry Hybrid (2362 cc, 2494cc)
Korea GM	eAssist 2.4 Hybrid

Table 7 continued

Ford	Fusion Hybrid (1999cc, 2488cc)
	Lincoln MKZ Hybrid (1999cc)

※Korea Ministry of Industry and Energy

Table 8 define the technical specifications of EV and Table 9 describe the current EVs in the market that satisfy them.

Table 8 Technical specifications of EV

Category	Low-speed EV	High-speed EV		
	Mini, Small, Mid	Mini	Small	Mid
Energy consumption efficiency (km/kWh)	Over 5.0			

※Korea Ministry of Industry and Energy

Table 9 Definition of EV and models subject for reward

Technical specifications defined by the Automotive Control Act	
Low-speed EV	- More than 27km of travel distance for every charge - Top speed less than 60km
High-speed EV	- More than 92km of travel distance for every charge. - Top speed higher than 60km

Qualified EV	
Maker	Model
KIA	- RAY EV - SOUL EV
Renault	- SM3 ZE EV

Table 9 continued

Korea GM	-	SPARK EV
BMW	-	i3 EV

※Korea Ministry of Industry and Energy

The policies introduced above demonstrate the significance of the EV and HV market in the upcoming automobile industry. With the government's intervention striving to create public support of EV and HV, it will be crucial for them to analyze the consumer preference about the products and set the policies that meet their needs.

2.3. Firm Strategies

Automobile firms are adapting different strategies to respond to the rise of the alternative fuel vehicle market. As the introduction of the diesel-fuel vehicles changed the automobile market in the 90s, the alternative-fuel vehicles based on hybrid engines will likely bring similar effect. Table 10 denotes the firm strategies proposed by the global automakers.

Table 10 Firm strategies

Type of strategy	Global automakers
Technology Complementary (Supplement)	Ford+Daimier AG+Renault
Technology Exchange	BMW+Toyata, GM+Honda
Proprietary	Hyundai/Kia, VolksWagen

Ford, Daimier AG and Renault-Nissan has set up a corporate partnership to accelerate the commercialization of fuel cell electric vehicle technology. The three corporations has signed a unique three-way agreement for the joint develop of common fuel cell system to speed up the

availability of zero-emission technology and significantly reduce the investment costs. Such collaboration is expected to lead the launch of the world's first affordable mass-market fuel cell electric car as early as 2017. The unique collaboration between three different firms from three different continent will help define a global specifications and component standards the new type of vehicles. This pact not only demonstrate the global potential of the alternative-fuel vehicle, but sends a clear signal for firms and policymakers to encourage the further development of the eco-friendly infrastructure worldwide.

GM and Honda has set up a different kind of collaboration effort to speed up the commercialization of the fuel cell and hydrogen vehicles. In July, 2013 the two corporates announced the collaborative agreement to co-develop the next generation fuel cell system and hydrogen storage technologies, aiming for the 2020 time frame. The collaboration expects to share expertise, economies of scale and common sourcing strategies. GM and Honda are acknowledged leaders in fuel cell technology ranking 1 and 2 in the Clean Energy Growth Index. Respectively, they have filled more than 1,200 total fuel cell patents between 2002 and 2012.

2.3.1. Proprietary development: Hyundai/Kia, Volkswagen

According to the KIS Industry Outlook annual report, the rise of the hybrid vehicles will soon change the traditional market shares among the Korean automobile market. The change in the Korean auto share and the global auto market due to the increase in the alternative fuel vehicles have the potential to change the landscape of the Korea's manufacturing industry. Currently,

the Korean manufacturing firms produce essential parts for the hybrid cars including the fuel cell battery. With the increase in the hybrid cars and the development of the 100% fuel-cell vehicles, Korea's manufacturing industry could evolve into a global supplier in the automobile market.

2.4. Previous Researches/ Literature Review

2.4.1. Researches on automobile market share analysis

There has been many researches on analyzing the automobile market in the past. Different methods have been used to forecast the market shares and distinguish the consumer preferences among the vehicle attributes. Every papers had its unique contribution to this research field which enabled me to start on my research. The first part of this section provide general description of the papers that focused on the market analysis of the automobile industry in the past. The next two sections explain the key papers and methodologies I considered in applying to this research in detail.

The research on market forecast is one of the most popular topics in the discrete choice analysis. However, the analysis of the eco-friendly products are relatively new to the field, especially in the automobile industry. New alternative fuel vehicles like EV and HV was invented years ago, but they are still emerging through the early stage of the production stage. In 2010, Oliver et al. (Oliver & Lee 2010) studied the consumer's intention of purchasing a hybrid car through a cross-cultural analysis. Oliver (2010) investigated the difference of the purchase intention between the U.S. customer and the Korean customer caused by the cultural

difference. The research collected the survey data categorized by the Likert scale to define the consumer preferences on purchasing eco-friendly product. The data was applied to the partial least squares structural model which proved that there was a positive correlation between the cultural norms to preserve the environment and the purchase intention to buy HVs.

In 2012, Koo (Koo et al. 2012) analyzed the consumer preference for automobile energy-efficiency grades by using both mixed logit and the MDCEV model. It used the revealed preference data of the Korean automobile market to estimate the consumer preference of vehicles based on their energy efficiency grade. As a result, the estimation demonstrated that consumer preference for the vehicle increased as the product's energy efficiency level improved.

In 2000, Ewing and Sarigollu (Ewing & Sarigiii 2000) wrote a paper on a similar topic to this paper. The paper analyzed the consumer preferences for clean-fuel vehicles with the discrete choice experiment. At the time, there weren't enough CFV, clear fuel vehicle, produced in the market. So they designed various hypothetical products by combining different levels of vehicle attributes to analyze the consumer preferences. The research framework was designed to consider the higher price and the maintenance cost, and the potential government subsidies given to the CFV owner. Through this research, they found out that people did consider the environmental issues related to tail-gas emission when buying a car. However, its effect was relatively low and minimal compared to the influence of the technical attributes of the car.

2.4.2. BLP methodology

With its diversity in technological aspects and unity in product characteristics, the automobile market has been one of the most popular subject in the marketing studies. Recently, the main focus of the researches regarding the automobile market has been scaling the effect of the alternative fuel vehicles and estimating the aftermath. S. Berry, J. Levinsohn, and A. Pakes developed the BLP methodology to analyze the equilibrium in the U.S. automobile market after the increase in the hybrid vehicles. (Berry et al. 1995) Their main goal was to estimate a model that allows for products that are differentiated in multiple dimensions, richer distributions of taste parameters, and unobserved product characteristics. The interesting part of the BLP analysis is that it can make predictions based on the revealed preference data only.

The general approach posits a distribution of consumer preference over difference vehicles. The preferences are recorded according to the sales of the vehicles over the targeted period. The preferences are aggregated into a market-level demand system, which is combined with an assumption on cost functions and on pricing behavior to generate equilibrium prices and quantities. The major framework are split into three major parts. First, a joint distribution of consumer characteristics and product attributes that determine the preferences over the market products are recorded. Secondly, the consumer's price taking assumptions are determined according to the product and consumer attributes. Lastly, the Nash equilibrium assumptions are determined from the producer's aspect.

Similar methodology was used by Nevo to analyze the market power in the ready-to-eat

cereal industry. (Nevo 2001) Nevo focused on applied the BLP methodology in estimating the PCM (Price-Cost Margin) of the cereal market. In the process, he investigated the corporates' ability to differentiate products and analyzed the firm's multi-production effect on it's the market share. The difference between the Berry (1995) paper was that he added the brand specific dummy to differentiate the products rather than just using the product attributes present in the market. However, he still used the observed product attributes to simulate the substitution pattern of the market.

Recent paper that used the BLP methodology for the similar topic of this research is the paper by Beresteanu and Shanjun. Beresteanu and Shanjun published a paper on the analysis of the demand for hybrid vehicles in the U.S. by considering the changes in the gasoline prices and the government support. (Berestianu & Shanjun 2011) It analyzed the changing market environment when a new product entered the market. According to the results, government subsidies proved to be significant factor affecting the consumer preferences of the hybrid vehicles.

The advantages of the BLP model is that it solved the common endogenous problem of estimation process. In the automobile market studies, common endogeneity problem arises when the price of the product is correlated with the other unobserved attributes of the products. Color, design, and personal preferences account for these unobserved attributes. Berry et al (1995, 2004) used their new technique to estimate the market share of the new vehicles and the changes in the conventional vehicles' shares.

Although this technique has many advantages in that it only requires revealed preference data, it also has many limitations. First of all, an extensive amount of customer and product specific data are needed. In the Berry et al. (1995, 1998, and 2004) paper, they used three kinds of RP data for estimation. These type of data are not easy to come by, and the estimation using RP data often requires much more data than using stated preference data.

Table 11 Berry et al (2004) data descriptions

Product level	Sales and characteristics of the model sold in a given year, market share, price
Consumer level (CAMIP) choice based sample drawn	Each household sampled list certain household attributes and their second choice vehicle if its observed choice were not available
Current Population Survey	Provides information on the distribution of consumer attributes in the population at large

2.4.3. BLP interaction term methodology

In 2014, Kang included the interaction term in the BLP model to account for the effect of the environmental changes on the automobile market. (Gilmo 2014) The paper developed an architectural approached to strategic product development. The paper stated that product modification process relied heavily on creating new products based on creativity of the innovator. However, in order to satisfy the growing variety of customers, the product development process involved into an incremental design practice. Incremental design denotes the process of improving the former design of the product to meet the new market demand or customer preferences. Kang (2014) proposed a new method of firm strategy to establish a more efficient incremental design process.

The proposed method is an improvement from the former BLP method introduced in the Berry et al (2004), and includes interaction term to account for exterior (environmental) effect. The author changed the BLP model into a logit framework and assumed three design constraints for each products. The additional design constraints (attribute interrelationship, technology speed, design constraint) and the environmental constraint (interaction term) to the basic BLP model provided a more efficient way to estimate the utility maximizing product based on customer's preference.

2.4.4. Joint mixed logit model

Joint mixed logit model was first proposed in Ben-Akiva et al. study on forecasting intercity rail ridership. (Ben-Akiva, Morikawa Takayuki 1991) The paper presented a mixed logit framework combining both revealed preference and stated preference data. It was one of the first discrete choice model that incorporated two different types of data to forecast a single outcome.

Stated preference data and revealed preference data both have different advantages and disadvantages that distinguish them from the other types of data. Simply put, in marketing studies, stated preference data can make a data about hypothetical product that are not in the market. Yet, the data is always at risk of being highly biased. Revealed preference data are data about the actual market, and can be taken as a fact. However, product attributes have multicollinearity problem which makes a solid RP data scarce in most cases. (Train 2009) Also, as RP data are only available for the products that are in the market, it is impossible to make

an estimation about any products that are not already in the market. Table 12 demonstrate the RP attributes that were used in the past studies about cars that used the joint mixed logit methodology.

Table 12 Previous RP attributes

RP Attributes	Attributes				
Studies	Cost	Fuel Cost	Horse Power	Fuel Efficiency	Class/Model
Brunch et al (1993)	O	O	O	O	O
Brownstone et al (2000)	O	O	O	O	O
Ewing and Sarigollu (2000)	O	O	O	O	
Eyzaguirre (2004)	O	O			O
Greene et al. (2005)	O	O			
Horne et al (2005)	O	O	O		
Axsen (2004)	O	O	O		O

Ben-Akiva et al. (1991) proposed a more flexible mixed logit methodology to combine revealed preference and stated preference data. The idea was to increase the SP data set's reliability and RP's accuracy by combining them. There are three key benefits from combining these two data sets; customer and product attributes can be estimated more efficiently, stated preference data's bias can be reduced, and preferences about hypothetical products can be obtained. In the joint estimation method, there has to be a unified attribute parameter that distinguish the tradeoff between the SP and RP data. In the estimation process, there are data specified attribute parameters that are only specified by their data set.

Brownstone et al. improved the joint estimation method and used it to analyze the demand

and consumer preferences for the alternative fuel vehicles in the market. (Brownstone et al. 2000) The proposed discrete choice methodology estimates both revealed preference data and stated preference data at the same time. The main objective of the Brownstone et al. (2000) was to demonstrate the effectiveness of the combined estimation method to represent the introduction of the alternative-fuel cars in the conservative automobile market.

Hensher et al. (2008) is relatively recent study that uses the joint mixed logit methodology. (Hensher et al. 2008) Hensher, Rose, and Greene used the combined revealed preference and stated preference data to set up a more flexible mixed logit model that incorporated panel and scale effects. In the paper, they improved the methodology introduced in the Brownstone (2000) by including the RP choice dummy variable and socio-demography attributes for the SP data set. With these addition, the paper propose a modified general mixed logit model that embrace between-alternative error structure including choice sets, RP-SP scale difference, unobserved preference heterogeneity and reference dependency.

In order to use the BLP methodology to analyze the changes in the market share of vehicles through the effect on the customer's preferences, it would require extensive amount of aggregate market data. The data should include monthly sales of each products, vehicle characteristics, and customer attributes. However, the required market data to use the BLP methodology for market forecast could not be obtained for this research. As a result, the only feasible way was to apply the joint mixed logit methodology for this paper. The SP data set is used to analyze the consumer preferences on the alternative fuel vehicles EV and HV and the

RP data is used as the baseline for the current market.

In essence, the advantage of the joint mixed logit estimation combining both revealed preference and stated preference data is as follow. Many of the past researches about market forecast depended only on the states preference data for estimation. Segal (1995) used the conjoint analysis to forecast the market simulations of the alternative fuel vehicle market. Conjoint analysis is a multi-attribute utility market forecast methodology developed with the field of marketing research. It refers to the process of creating the survey and collecting the stated preference data to analyze the consumer preferences. From the paper, Segal concludes that California's ZEV (zero emission electric vehicle) market is too small to satisfy the sales mandate. In 1993 Bunch et al analyzed the demand for clean-fuel vehicles and their attributes that distinguished them from the conventional gasoline vehicles. For the research, stated preference survey data collected from approximately 700 respondent were estimated through the nested multinomial logit model. However, all of the estimations proposed in the researches presented above had a risk of being biased. Whether for an environmental or political reasons, most people tend to make a biased choice under the conjoint analysis, because there is no real risk or issues to be considered in the hypothetical setting. As a result, people look into other details and consider different attributes in the conjoint analysis than under the real world setting. The difference in the choice making process and the relative importance of the attributes being considered is shown through the relative importance of the attributes in section four.

The joint mixed logit estimation of combining both the revealed preference data and the

stated preference data can alleviate the biasness of the stated preference data. By adding the revealed preference data in the estimation process, it can serve as a baseline for the choices made by the consumers.

3. Empirical model setup

3.1. Research Framework

The first step will involve the separate mixed logit estimation of revealed preference data and the stated preference data. The two data sets have common attributes that are present in both data set and the unique attributes that are only present in one data set. In order to compare the results with the joint mixed logit estimation, which combine two data set, each data set will first be estimated separately. After that, the data set will be combined to be estimated by the joint mixed logit model. The results will be compared to prove whether the joint mixed logit is actually beneficial. Lastly, based on the estimated coefficients and the potential alternatives of the market, the future market share will be simulated.

3.2. Data

3.2.1. Stated Preference

For this study, the stated preference data from the "Survey on smart-device usage" in 2010. The survey was done in order to analyze the customer's general preference and usage of the upcoming smart devices such as smart TV, pad, car, and cellphone. Table 13 denote the attributes the respondents had to consider when choosing the car. The SP data elicited respondent's preferences among gasoline, diesel, hybrid, and electric vehicles with various attributes.

Each respondents were given three card sets which included four hypothetical cars that were randomly produced with different attributes. In the end each respondents had to make three choices among 12 different hypothetical cars. Each sets of cards had four types of fuel types that was divided equally among SUV and Sedan. The actual form used in the survey is inserted at the Appendix.

Table 13 SP Variable Descriptions

Choice Set	Description
Type of body	Sedan, SUV
Type of fuel	Gasoline, Diesel, Hybrid, EV
Fuel Cost (₩/km)	50,100,200
Price of the vehicle(ten thousand won)	2500, 3000,3500,4000
Station availability (%)	50, 80, 100
Purchase intentions (Choice)	0,1
Smart Car Option	0,1

The total SP data set consisted of 8100 observations with 675 respondents making three choices among 12 alternatives. Each time the respondent makes a choice is considered independent from other choices, but they all share the same demographic values for the individual.

The Type of body variable is denoted as SUV, and represent the body type of the vehicle in the alternative. The body type variable's values are 0 and 1; 0 represent all the body types that is not considered as SUV, and 1 represent the SUV and CUV body type. Type of fuel variable represent the fuel type of the vehicle in the alternative. The four fuel types considered in the survey are petroleum gasoline, diesel, hybrid, and electricity. For the estimation and

interpretation purpose, it is coded into four dummy variables representing each types of fuel. Every type was distributed evenly among the alternatives, producing 2025 alternatives for each type. The Price variable's values are divided into four parts with 5 million won differences from 25 million won to 40 million won. Similar to the fuel type values, the price values are evenly distributes among random alternatives. Fuel cost variable denotes the alternative vehicle's cost of traveling each kilometer (₩/km). The values of fuel cost variable is 50, 100, and 200 won, which is randomly distributed among the alternatives.

The next variable is the Station availability which represent the gas station and electric charging infrastructures availability. Its values are 50%, 80%, and 100%. 50% represent the hypothetical availability of the electric charging station compared to the gas stations. In reality, the station availability of the gasoline, diesel, and hybrid vehicles would always stay close to 100%, while the electric charging station will be much less than 50%. Choice variable takes the value of 0 and 1, which represent the respondents most preferred vehicle among the four alternatives. Lastly, the SmartCar variable takes the value 0 and 1, which denote the installment state of the smart car option in the car. The survey takes deeper inspection of the smart car option by laying out specific smart car options entering in the market. However, the preference of each options is not analyzed in this research.

For the social domestic variables, the data for respondents collected at the initial stage of the survey was used. Table 14 summarizes the values used to represent the socio demographic variables of the respondents.

Table 14 Socio demographic variable

Variable	Response
Ownership of the house	1. Owner
	2. Spouse of the owner
	3. None of the above
Occupation	1. Business owner
	2. Sales/Service
	3. Artisans
	4. General work (civil site work)
	5. Corporate work (white collar)
	6. Management/managers (level 5 manager)
	7. Professional
	8. Housewives
	9. Students
	10. Unemployed
	11. etc:_____
Education	1. Elementary school
	2. Middle school
	3. High school
	4. College
	5. Graduate school and above
Family	The number of the family members
Type of house	1. House
	2. Multi-family house
	3. Townhouse
	4. Apartment
	5. Condominium apartment
	6. etc: _____
Type of ownership	1. Owner
	2. Charter
	3. Monthly rent
	4. etc
Size of the house	Size of the house in floor area
Driver	1. Drive
	2. Don't drive

The socio demographic variables distinguished the respondents from each other and combined the three different responses under one ID in the data estimation. The following tables provide descriptive statistics of the stated preference data.

Table 15 Summary of stated preference

Variable	Obs	Mean	Std. Dev.	Min	Max
choice	8100	0.25	0.433039	0	1
Price	8100	32.21296	5.583141	25	40
FC	8100	135.4568	66.86201	50	200
TypeDiesel	8100	0.25	0.433039	0	1
HB	8100	0.25	0.433039	0	1
EV	8100	0.25	0.433039	0	1
SUV	8100	0.480864	0.499665	0	1
SEDAN	8100	0.519136	0.499665	0	1
Ava	8100	84.65309	18.9192	50	100
SmartCar	8100	0.5	0.500031	0	1

Table 16 Correlation of SP attributes

	Price	FC	TypeDi~l	HB	EV	SUV	SEDAN	Ava	SmartCar
Price	1								
FC	-0.085	1							
TypeDiesel	0.1169	-0.0872	1						
HB	-0.0522	0.0872	-0.3333	1					
EV	-0.0575	0.0872	-0.3333	-0.3333	1				
SUV	-0.0734	-0.037	-0.0723	-0.0723	0.1166	1			
SEDAN	0.0734	0.037	0.0723	0.0723	-0.1166	-1	1		
Ava	0.0262	0.05	0.0557	-0.1141	0.0557	0.0195	-0.0195	1	
SmartCar	0.0218	0	0.0921	0.0921	-0.0921	-0.0487	0.0487	0.0506	1

In total, there are 8100 responses made by 675 respondents. Each of the respondents chose 1 vehicle out of 4 alternatives three times, which equaled 12 alternatives and 3 choices for each person. As one can see, the TypeDiesel, HB, and EV each had mean value of .25, meaning that every fuel type was distributed equally among the alternatives. The value of the Price variable

was reformed by dividing the price by 100 to match the scale with the other variables. This was useful in matching the values with the values for the Price variable in the revealed preference data set later. The Price and FC (fuel cost) variables have a relatively reasonable mean and standard deviation values. SUV and Sedan variable's mean show that each vehicle type was distributed close to 50% among the alternatives. SmartCar variable's mean and standard deviation show that it was evenly distributed among the alternatives. The correlation among the variables show little significance, as there are no correlations above 0.5.

3.2.2. Revealed Preference

The revealed preference data used in this analysis are the mechanical specifications of the automobiles owned by the "Survey on smart-device usage" respondents. Each respondents recorded the vehicle's purchase date, model, smart-car availability, price at the time of purchase, and fuel efficiency. In order to describe the vehicles more specifically, the vehicle attributes such as horsepower, displacement, size, and the torque has been collected for each model. The table below describe the total attributes collected for the revealed preference data set.

Table 17 Summary of revealed preference

Attributes	Descriptions
Year	Purchase Date
Month	1~12
Model	1~114 vehicle list
Body	1 (Sedan), 2 (SUV)
Type	Fuel Type (1 gasoline, 2 diesel, 3 Hybrid)
SmartCar	1 compatible, 2 not compatible
Fuel Cost	₩/km
Price	In 10,000 won
Fuel Efficiency	km/l

Table 17 continued

Annual Mileage	1000 km
HP	Horsepower
Displacement	CC
Size	Number of passenger
Torque	Kg/m

The attributes are the main specifications of a vehicle that is considered by an average consumers. Many of the attributes were the common attributes considered in the past researches that studied the automobile market. In the survey, vehicle's technical specs like the fuel efficiency, horsepower, displacement, and torque weren't recorded. As a result, these specifications were matched by the vehicle model number and their official information provided the NAVER automobile site. In the case of fuel efficiency, people were allowed to write their own idea of the rate in the survey; however, this caused problem in the estimation stage by having much bigger variations compared to the alternatives provided. As a result, the official fuel efficiency of the models were used rather than the values recorded by the respondents. In the survey, respondents could choose among four types of fuel; gas, diesel, LPG, and hybrid. However, among the 857 respondents, there were only 51 people who owned LPG type vehicle and only 3 people who owned a hybrid vehicle. As a result, only gasoline and diesel type vehicles were considered for the revealed preference estimation. After taking out the LPG and hybrid vehicles, 148 outliers and values that were too different from the majority of the groups were deleted. As a result, the remaining 655 respondents' specs were reorganized into the long type data set for estimation. The following table denotes the

descriptive statistics of the revealed preference data.

Table 18 Summary stats of RP data

Variable	Obs	Mean	Std. Dev.	Min	Max
choice	6550	0.1	0.300023	0	1
Price	6550	22.33986	8.787708	2	100
FC	6550	137.8096	33.04973	77.6733	308.813
FuelEffi	6550	13.1127	2.454781	6	22
TypeDiesel	6550	0.400153	0.489967	0	1
SUV	6550	0.2	0.400031	0	1
Displacement	6550	1900.373	511.8664	796	3778
Torque	6550	22.68633	8.08192	7.3	56

Table 19 Correlation of RP data

	Price	FC	FuelEffi	TypeDi~l	SUV	Displa~t	FC
Price	1						
FC	0.557	1					
FuelEffi	-0.6493	-0.9121	1				
TypeDiesel	0.1705	-0.5717	0.2402	1			
SUV	0.1346	0.1911	-0.2959	0.1019	1		
Displacement	0.9231	0.6753	-0.7717	0.0647	0.174	1	
FC	0.557	1	-0.9121	-0.5717	0.1911	0.6753	1

The summary table show that there were total of 655 respondents who chose 1 vehicle among 10 alternatives. The 10 alternatives that each respondents considered were elected based on the models on the top 10 sales of the 2014 Korean automobile market. (Park 2014) The chosen alternatives are described by table 20. The 10 alternatives were set up to assume the decision making process of the respondents when they made the purchase.

Table 20 Revealed preference alternatives

Number	Body	Fuel Type
1	Mini	Gas
2	Small	Gas
3	Compact	Gas
4	Compact	Diesel
5	Mid	Gas
6	Mid	Diesel
7	Large	Gas
8	Large	Diesel
9	SUV	Gas
10	SUV	Diesel

The specific attributes of these cars are given by the average mean values of the specifications of the models sold in 2012. These alternatives represent the actual vehicles an average consumer may have considered before making a purchase. The construction of the alternatives was based on the research framework of Brownstone's paper in 2000. (Brownstone et al. 2000). In Brownstone's paper, the alternatives for the revealed preference data analysis was designed with 13 combinations of body types and various fuel types. A total of 689 categories were scaled down to 28 alternative choice set that approximated the universe of new and used cars to simulate the choices made by the respondents. In the paper, the 28 alternatives included 7 new vehicles, 7 1-2 year old vehicles, 7 3-10 year old vehicles, and 7 more than 10

year old vehicles. However, for this paper's analysis, the relative years of the vehicles were not considered. In fact, we only analyzed the decision process of the respondents when they made the first purchase of car.

3.3. Methodology

3.3.1. Mixed logit framework

The joint mixed logit estimation used in this research is based on the mixed logit model proposed by Train and McFadden (2000). It is a highly flexible model that can approximate any random utility model. It obviates the three limitations of standard logit by allowing for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time. The logit model assume that every consumers or respondents has the same preference for the alternatives. With the logit model, there are only one β produced for every attribute, and the overall choice probability is defined for the one representative consumer. This assumption is not applicable in the real world, where all the consumers have different preferences and variations among the alternatives. As a result, the mixed logit is used in many cases. The single most important advantage of mixed logit compared to the original logit model is that it allow heterogeneity for each consumers. Also, in the process, the researcher can assume the distribution of each β of the attributes. However, the mixed logit model cannot directly reflect the individual social demographic attributes in the preference of the alternatives. Unlike probit, which is limited to normal distributions, it can assume other distributions. The derivation of the mixed logit is simple and simulation of its choice probabilities is

computationally straightforward. (Train 2009)

In order to analyze the consumer preferences of the products, random utility equations need to be set up based on the logit formula. In the equation (1), the respondent n 's utility of choosing the alternative j is denoted as U_{nj} .

$$U_{nj} = V_{nj} + \varepsilon_{nj} = \beta' X_{nj} + \varepsilon_{nj}, \quad \beta \sim N(b, W) \quad \text{---------- Eq. (1)}$$

Each respondent's utility is based on the deterministic term, or observed attributes, V_{nj} and the stochastic term ε_{nj} .

The deterministic term can be divided and explained by product of the attributes X_{nj} related to the alternative j and the relative importance of that attribute β_n defined by person n . Variable β_n represents the coefficient of the attribute following the normal distribution with an average value of b and the variance of W . The stochastic term ε_{nj} can be assumed to take other distribution than normal. However, for this research, it is assumed to be independent following the type 1 extreme distribution.

The mixed logit model is defined on the basis of the functional form for its choice probabilities. Any behavioral specification whose derived choice probabilities take this particular form is called a mixed logit model. Mixed logit probabilities are the integrals of standard logit probabilities over a density of parameters. In essence, the choice probability of

a mixed logit can be expressed in the form of equation (2)

$$P_{ni} = \int L_{ni}(\beta) f(\beta) d\beta \quad \text{---------- Eq. (2)}$$

Where $L_{ni}(\beta)$ is the logit probability evaluated at parameters β described by the equation (3).

$$L_{ni}(\beta) = \frac{e^{V_{ni}(\beta)}}{\sum_{j=1}^{J} e^{V_{nj}(\beta)}} \quad \text{---------- Eq. (3)}$$

$V_{ni}(\beta)$ marks the observed portion of the utility, which depends on the parameter β. If the utility is linear in β, then $V_{ni}(\beta) = \beta' x_{ni}$ and the mixed logit probability takes its usual form like equation (3). Simply put, the mixed logit probability is a weighted average of the logit formula evaluated at different values of β, with the weights given by the density $f(\beta)$. In this case, the mixed logit probability takes its usual formula equation (4)

$$P_{ni} = \int \left(\frac{e^{b' x_{ni}}}{\sum_{j} e^{\beta' x_{nj}}} \right) f(\beta) d\beta \quad \text{---------- Eq. (4)}$$

The mixed logit probability is a weighted average of the logit formula evaluated at different values of β, with the weights given by the density $f(\beta)$. In statistics, the weighted average of several functions is referred as the mixed function, and the density that provides the weights is called the mixing distribution. The mixed logit is a mixture of the logit functions evaluated at different β's with $f(\beta)$ as the mixing distribution. In this sense, the standard

logit can be explained as a special case of the mixed logit that assumes the $f(\beta)$ as a fixed parameter equaling 1. However, in many applications, $f(\beta)$ is specified to be continuous with β following the normal distribution with mean b and covariance W. As a result the choice probability is modified under this assumption.

$$P_{ni} = \int \left(\frac{e^{b' x_{ni}}}{\sum_j e^{b' x_{nj}}}\right) \phi(\beta \mid b, W) d\beta \quad \text{---------- Eq. (5)}$$

Where $\phi(\beta \mid b, W)$ denotes the assumption of the density function. In order to analyze the choice probability using the mixed logit model, the researcher must estimate both β and the parameter of the density function $f(\beta)$. This process is denoted as $f(\beta \mid \theta)$, where θ is the density of β. As a result, the mixed logit probability takes the form of equation (6), which are functions of θ.

$$P_{ni} = \int L_{ni}(\beta) f(\beta \mid \theta) d\beta \quad \text{---------- Eq. (6)}$$

For the research's mixed logit framework a person faces a choice among J vehicles, which will be modeled using a random utility framework. For estimation purposes, I assume that the person's utility from choosing any vehicle can be decomposed into a nonstochastic, linear-in-parameters part that depends on observed data and the personal preferences, and another stochastic part that is independently, identically distributed over alternatives and people. The utility of the person n from choosing alternative i is denoted by equation (7)

$$U_{nj} = \beta_n' x_{nj} + \varepsilon_{nj} \text{ ---------- Eq. (7)}$$

Variable x_{jn} denotes the vector of observed variables relating to the alternative j and person n; β_n' is a vector of structural parameters which characterizes the taste of the person n on the attribute; and ε_{in} is a random term with zero mean that is i.i.d. over alternatives and does not depend on underlying parameters or data. The coefficients vary over respondents in the population with density $f(\beta)$, which is the function of parameters θ that represent the mean and the covariance of β. Under the mixed logit model, the value of β represent each respondent's personal preference, which makes it easier and much more realistic for interpretation purposes. The respondent is assumed to make a logical decision of choosing alternative i, which produce $U_{ni} > U_{nj} \forall j \neq i$, based on the fact that he knows his β_n and ε_{nj} for every j. As a result, the choice probability is modified to equation (8)

$$L_{ni}(\beta_n) = \frac{e^{\beta_n' x_{ni}}}{\sum_j e^{\beta_n' x_{nj}}} \text{ ---------- Eq. (8)}$$

With the unconditional choice probability changed through the process of

$$P_{in} = \int \Pr(U_{ni} > U_{nj}, \forall j \neq i) f(\beta) d\beta)$$

$$\int \Pr(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}, \forall j \neq i) f(\beta) d\beta)$$

$$\int \Pr(\varepsilon_{nj} - \varepsilon_{ni} > V_{ni} - V_{nj}, \forall j \neq i) f(\beta) d\beta) \text{ ---------- Eq. (9)}$$

$$\int \frac{\exp(V_{ni}(\beta))}{\sum_j \exp(V_{nj}(\beta))} f(\beta) d\beta)$$

$$\int \frac{\exp(\beta_n' x_{ni})}{\sum_j \exp(\beta_n' x_{ni})} f(\beta) d\beta)$$

To equation (8) to get the approximated choice probability. (Train 2009) The mixed logit model was fitted using the maximum simulated likelihood method.

$$P_{ni} = \int (\frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}}) f(\beta) d\beta \text{ ---------- Eq. (10)}$$

The following attributes of the data shown in table 21 were chosen for the mixed logit analysis of the separate estimation. For the joint estimation, the common attributes were combined, including the unique attributes of each data set.

Table 21 Attributes

RP Attributes	SP Attributes
Price	Price
FC	FC
TypeDiesel	TypeDiesel
SUV	SUV
Displacement	HB
Torque	EV
	Ava
	SmartCar

3.3.2. Simulations

The probabilities are approximated through simulation for any given value of θ. The process of simulation is as follow. First, a value of β drawn from $f(\beta \mid \theta)$. Then the logit formula based on the drawn β is calculated. The two steps are repeated many times, and the average of the results is the simulated probability. The following equation denote the average of the simulated probability.

$$\breve{P}_{ni} = \frac{1}{R}\sum_{r=1}^{R} L_{ni}(\beta^r) \text{ ---------- Eq. (11)}$$

Where β^r denote the rth draw of the β, and R denoting the total number of draw. The probability's variance decreases as the number of draw increases. It is always positive, so that $\ln \breve{P}_{ni}$ is defined. The $\breve{P}_{ni}$ sums to one over the alternatives, which makes it useful in forecasting the market share in the future. (Train 2009) The random β's drawn from the distribution of the coefficients denote the randomness of the simulation process. It is different from the sensitivity check of attributes because not a single β is fixed for each individuals.

4. Empirical studies and results

4.1. Separate estimations

The results are shown in the following manner: mixed logit estimation results using the pure stated preference data, mixed logit estimation results using pure revealed preference data, and (Hole 2007) the joint mixed logit estimation results that combined both data sets.

4.1.1. Stated preference data estimation

The attributes chosen for the stated preference data estimation were Price, FC, TypeDiesel, TypeHB, TypeEV, Availabilty, and SmartCar. The following utility function was constructed based on these attributes.

$$U_{nj} = \beta_{price} X_{price} + \beta_{FuelCost} X_{FuelCost} + \beta_{TypeDiesel} X_{TypeDiesel} + \beta_{TypeHybrid} X_{TypeHybrid} + \beta_{TypeEV} X_{TypeEV} + \beta_{SUV} X_{SUV} + \beta_{Availability} X_{Availability} + \beta_{SmartCar} X_{SmartCar} + \varepsilon_{nj} \quad \text{---- Eq. (12)}$$

Actual estimation was done by the mixlogit command developed by Hole in STATA 12.1. (Hole 2007) Table 22 summarizes the results.

Table 22 Stated preference data results

choice	Mean Coef.	Std. Err.	z	P>z	Distribution
Price	-0.14771***	0.296347	-6.45	0	Log-normal
Fuel Cost	-0.00623***	0.15437	-32.89	0	Log-normal
Type Diesel	-0.60789***	0.107401	-5.66	0	Normal
Type Hybrid	-0.0399	0.104646	-0.38	0.703	Normal
Type EV	-0.64643***	0.111159	-5.82	0	Normal
SUV	0.132846**	0.063744	2.08	0.037	Normal
Availability	0.012148***	0.002031	5.98	0	Normal
SmartCar	0.845794***	0.084687	9.99	0	Normal
Log likelihood = -2563.2729					

※Statistically significant at 0.01***, 0.05***, 0.1*

From the results, it shows that all of the attributes are significant at the 0.01 level except the Type Hybrid variable and the SUV variable, which show significance under 0.05 level. The Price variable represented the actual price of the vehicle divided by the log normal of the income of the respondents. (Brownstone et al. 2000) The distribution for variable Price and Fuel Cost was assumed to be log-normal because all of the respondents showed that they has a negative preference for these two variables. In the standard mixed logit model, all of the coefficients β_n are assumed to follow the normal distribution. However, this would mean that there has to be some people who has a positive coefficients for the Price and Fuel Cost variables. Meaning that consumer's preference for the vehicle will rise as the price and the fuel cost of the vehicle increase. Such analysis is unrealistic which makes it plausible to assume that the coefficients of these variables follow the log normal distribution. (Hong et al. 2012)

When a distribution other than the normal distribution is assumed for the variable, one

must use the modified coefficients $C = f(\beta)$ of the assumed coefficients. In this case, where all of the consumers have a negative coefficient for the price and fuel cost without equaling 0, $C = \exp(\beta)$ should be placed in the utility function. The modified utility function is shown below

$$U_{nj} = C(\beta_{price})X_{price} + C(\beta_{FuelCost})X_{FuelCost} + \beta_{TypeDiesel}X_{TypeDiesel} + \beta_{TypeHybrid}X_{TypeHybrid} + \beta_{TypeEV}X_{TypeEV} + \beta_{SUV}X_{SUV} + \beta_{Availability}X_{Availability} + \beta_{SmartCar}X_{SmartCar} + \varepsilon_{nj} \quad \text{---Eq. (13)}$$

As a result, the modified simulated choice probability is obtained by including the $C = \exp(\beta)$ in equation 9.

$$P_{ni} = \int \left(\frac{e^{C(\beta')x_{ni}}}{\sum_j e^{C(\beta')x_{nj}}}\right) f(\beta) d\beta \quad \text{----------Eq. (14)}$$

In order find out whether the Type Hybrid variable is actually significant in itself, and see if its effects were disturbed by the other variables, a univariate estimation was done. The result of this analysis show that Type Hybrid variable was in fact not significant in affecting the choice.

Table 23 Univariate estimation (SP)

choice	Mean Coef.	Std. Err.	z	P>z	Distribution
Hy	-0.00022	0.073381	0	0.998	Normal

Variable Price represented the vehicle price divided by the log of the respondent's

income, while variable Fuel Cost denoted the actual ₩ required per traveling a kilometer with the vehicle. TypeDiesel, Type Hybrid, and Type EV variables denoted what type of fuel was chosen by the respondents. The variables extended from the fuel type variable in the survey data, which originally had a value of 1 to 4. In order to run the logit the variable was reorganized to take a value between 0 and 1. Gasoline type vehicle was regarded as the baseline with the value of 0, while the other fuel type variables had a value of 1 to represent its fuel type. The Availability variable represent the current ratio of the charging stations relative to the gas stations. (Hong et al. 2012) The SmartCar variable denoted the presence of the smart car option in the vehicle. Its value was between 0 and 1 where 0 meant that the vehicle didn't have a smart car option and 1 meant that it already had smart car option installed. In the survey, consumers could choose among the various smart car options that may have differed in consumer preferences. However, in this study, only the installment state of the smart car option is considered.

The signs of the coefficients are interpretable by itself. The negative signs of the Price and the Fuel Cost coefficients are as expected. The fuel type variables represent the consumer's preference for the fuel type of the vehicles. Among the three variables, only TypeDiesel and TypeEV variable show significance. When comparing diesel type with the gasoline type vehicle, people preferred gas type. Interpreting the TypeEV coefficient, under the same circumstances, people preferred non EV cars. The rest of the variables' coefficients showed that people preferred SUV vehicle over sedan types, higher availability of charging station, and

the installment of the smart car option. The positive coefficients of the variable Availability is promising for this research in that consumer preference for EV may increase with the establishment of the charging infrastructure. Also, the positive coefficient for the SmartCar variable show that people are already showing interest in the smart car option that may open a new market for the automobile firms. The table below describe the relative importance of the attributes for the consumers.

Table 24 Relative importance of stated preference attributes

Attributes	Relative Importance
Price	36.74%
Fuel Cost	15.49%
Type Diesel	10.08%
Type Hybrid	0.66%
Type EV	10.71%
SUV	2.20%
Availability	10.07%
SmartCar	14.02%

The relative importance of the attributes show that people showed about 50% importance in the cost part of the vehicle. The relative importance of the fuel type variables showed that people's consideration of whether the vehicle was gas or diesel and whether it was EV or non EV is about the same in the hypothetical setting. Variables like Availability and SmartCar option combined for about 25% of the decision making process. This meant that people actually considered the EV relative to the availability of the electric charging stations. Also, SmartCar option, with 15% importance, shows promising sign that it may become one of the important

specifics when choosing a vehicle.

4.1.2. Revealed preference data estimation

The attributes chosen for the revealed preference estimation were Price, Fuel Cost, TypeDiesel, SUV, Displacement, and Torque. Common attributes like the Price, Fuel Cost, TypeDiesel, and SUV explained the same factors by the same value as in the stated preference estimation. Variable Displacement and Torque are uniquely present in the revealed preference data. The Displacement variable represent the displacement and the Torque variable denoted the torque of the chosen vehicle. Similar to the stated preference analysis, both Price and Fuel Cost coefficient's distributions are assumed to be log normal. The equation below denote the utility function constructed for the revealed preference data estimation. Table 25 summarize the results of the revealed preference data following the utility function 14

$$U_{nj} = C(\beta_{price})X_{price} + C(\beta_{FuelCost})X_{FuelCost} + \beta_{TypeDiesel}X_{TypeDiesel} + \beta_{SUV}X_{SUV} + \beta_{Displacement}X_{Displacement} + \beta_{Torque}X_{Torque} + \varepsilon_{nj} \quad \text{---------- Eq. (15)}$$

Table 25 Revealed preference estimation

choice	Mean Coef.	Std. Err.	z	P>z	Distribution
Price	-1.47554***	0.090622	4.29	0	Log normal
Fuel Cost	-0.09857***	0.049524	-46.78	0	Log normal
TypeDiesel	-7.76145***	0.436745	-17.77	0	Normal
SUV	0.898827***	0.172668	5.21	0	Normal
Displacement	0.006504***	0.000472	13.79	0	Normal
Torque	0.274543***	0.03051	9	0	Normal
Log likelihood = -726.3215					

※Statistically significant at 0.01***, 0.05***, 0.1*

The estimation results show that all of the variables are significant, meaning that respondent is affected by all of them when choosing a vehicle. The signs of the mean coefficients of the variables are readily interpretable. The correlation between the horsepower, displacement, and torque variables were too high. As a result, last two variables that showed significance in the estimation were included and horsepower was excluded.

Based on the revealed preference estimation, the Price and Fuel Cost coefficients show that consumer preference decreases as the vehicles price and the fuel cost rises. TypeDiesel coefficient show that people actually preferred gasoline vehicles until 2012. Contrary to the preference for gasoline type vehicle, people had high preference for SUV body type. This opposition may have been caused by the lack of diesel engine SUV's at the time. As for the Displacement and the Torque coefficient, it had positive signs that represented the consumer preference for stronger vehicles. The following table denotes the relative importance of the attributes in affecting the decision making process of the consumers.

Table 26 Relative importance of revealed preference attributes

Attributes	Relative Importance
Price	69.25%
Fuel Cost	10.91%
Type Diesel	3.71%
SUV	0.43%
Displacement	9.28%
Torque	6.4%

From the table above, one can see that people are very concerned about the price of the

vehicle and the maintenance cost (fuel cost) of the vehicle. The cost part of the purchase took up close to 80% of the relative importance in making the purchase of the vehicle. Both displacement and torque showed 10% and 5% significance, meaning that people put very little importance to these attributes. The type diesel and SUV variables actually had closer to 0 importance. However, this may be due to the fact that revealed preference data was used in the estimation. In the real world, people would probably made their decision about the type of body and fuel type before looking at the alternatives. As a result, during the actual decision making process, people would pay little concern on the body type and the fuel type.

4.2. Joint estimation

The joint estimation was done through the same procedures of the revealed and stated preference data under the assumption that the stochastic part of the utility function were equal. In this sense, the consumer preference varied with the number of alternatives being considered only at the level of the attributes provided. Both data sets were stacked up on top of each other with the attributes combined for the estimation.

The attributes chosen for the joint estimation included the common attributes present in both data set and the revealed preference and stated preference data unique attributes. In total variable Price, Fuel Cost, Type Diesel, Type Hybrid, Type EV, Availability, SmartCar, Displacement, and Torque were used for the estimation. These variables were combined to construct the total utility function below.

$$U_{nj} = C(\beta_{price})X_{price} + C(\beta_{FuelCost})X_{FuelCost} + \beta_{TypeDiesel}X_{TypeDiesel} + \beta_{TypeHybrid}X_{TypeHybrid} + \beta_{TypeEV}X_{TypeEV} + \beta_{Availability}X_{Availability} + \beta_{SmartCar}X_{SmartCar} + \beta_{SUV}X_{SUV} + \beta_{Displacement}X_{Displacement} + \beta_{Torque}X_{Torque} + \varepsilon_{nj} \quad \text{--Eq. (16)}$$

Table 27 Total estimation result

choice	Mean Coef.	Std. Err.	P>z	Distribution
Price	-0.70901***	0.067082	0	Log normal
Fuel Cost	-0.01169***	0.064421	0	Log normal
Type Diesel	-1.39415***	0.120407	0	Normal
SUV	0.093129*	0.053896	0.084	Normal
Type Hybrid	-0.26192**	0.113868	0.021	Normal
Type EV	-1.10164***	0.122037	0	Normal
Availability	0.023536***	0.00257	0	Normal
SmartCar	1.30408***	0.10624	0	Normal
Displacement	0.002588***	0.000174	0	Normal
Torque	0.070989***	0.010304	0	Normal
Log likelihood = -3775.6676				

※Statistically significant at 0.01***, 0.05***, 0.1*

The total results shown by the table 27 denote that all of the variables are significant to some level. The total estimation model shows improvement in some areas. For one, variable Type Hybrid is shown to be significant here, which may have been due to the correlation effect with the other fuel types. Also, the signs of the variables didn't change from the signs of the separate estimations of the data sets. As a result, many of the coefficients can be interpreted in the same way as the separate estimations. The table below describe the relative importance of the combined attributes. From the first look, one can see that the rates are close to the relative importance of the revealed preference data. The difference between the total attributes' relative

importance to the relative importance of the stated preference data may be the evidence of the stated preference bias. In the survey of choosing among hypothetical alternatives, people may consider factors normally not considered in real settings. Table 28 may have scaled these bias by combining them with the revealed preference relative importance. The difference between the stated preference data estimation and the total estimation could signify advantages of combining the revealed preference data set. In the stated preference data estimation, the relative importance of the attributes showed that people were more considerate about the other attributes compared to the case of the revealed preference data estimation. Under the joint estimation, the relative importance is shown to be much similar to the real life situation, which could indicate the reduction of bias inherent in the stated preference estimation.

Table 28 Total attributes relative importance

Attributes	Relative Importance
Price	81.21%
Fuel Cost	3.53%
Type Diesel	1.62%
SUV	0.10%
Type Hybrid	0.30%
Type EV	1.28%
Availability	1.37%
SmartCar	1.52%
Displacement	9.02%

4.2.1. SUV and Sedan estimation

In order to analyze the different effect of the attributes have for the SUV and sedan type cars, the total data set with combined revealed and stated preference data was divided according to the choice. At first, the option of generating SUV interaction terms was considered. However, the model with the interaction terms didn't fit, and the data was divided according to the body type of the chosen vehicle. Total data is divided based on the group that chose a sedan type vehicle and the group that chose the SUV type vehicle. Except for the SUV variable, same attributes as the Total estimation in the previous section is used. Following tables describe the estimation results for each group

Table 29 Total Sedan group estimation

choice	Mean Coef.	Std. Err.	z	P>z	Distribution
Price	-0.42672***	0.155858	-5.46	0	Log Normal
Fuel Cost	-0.00886***	0.125803	-37.57	0	Log Normal
Type Diesel	-0.92888***	0.144821	-6.41	0	Normal
Type Hybrid	-0.13991	0.10252	-1.36	0.172	Normal
Type EV	-1.39187***	0.134136	-10.38	0	Normal
Availability	0.002042	0.003232	0.63	0.527	Normal
SmartCar	1.225956***	0.111384	11.01	0	Normal
Displacement	0.003562***	0.000267	13.34	0	Normal
Torque	-0.11662***	0.020098	-5.8	0	Normal
Log likelihood = -2151.7257					

※Statistically significant at 0.01***, 0.05***, 0.1*

Table 30 Total SUV group estimation

choice	Mean Coef.	Std. Err.	z	P>z	Distribution
Price	-0.3437***	0.189051	-5.65	0	Log Normal
Fuel Cost	-0.00921***	0.078069	-60.05	0	Log Normal
Type Diesel	-0.59505***	0.124127	-4.79	0	Normal
Type Hybrid	0.204858**	0.097713	2.1	0.036	Normal
Type EV	0.074794	0.106991	0.7	0.485	Normal
Availability	0.024424***	0.002244	10.89	0	Normal
SmartCar	0.63683***	0.085948	7.41	0	Normal
Displacement	0.001066***	0.000302	3.53	0	Normal
Torque	0.40861***	0.059657	6.85	0	Normal
Log likelihood = -1400.8421					

※Statistically significant at 0.01***, 0.05***, 0.1*

Based on the results shown by table 29 and 30 there are some significant difference in the coefficients between the people who chose sedan and the people who chose SUV vehicles. The comparison of log-likelihood of two models suggest that the data set fits the SUV model much better than the sedan model. For the consumers who chose sedan type vehicles, Type Hybrid and Availability variable didn't show significance. For the consumers who chose SUV type vehicles, only the Type EV variable didn't show significance.

Based on the coefficients of the significant variables, the sedan users preferred gasoline over other types of fuel and the lower torque vehicles. On the contrary, the SUV users preferred hybrid fuel type. Although it isn't significant, the coefficient for the EV fuel type is positive unlike the sedan model. The positive sign of the Torque coefficient is understandable because most of the SUV produced in the current market uses diesel fuel type gas that has high torque

compared to other cars. Both models show that people prefer the installment of the SmartCar option. The comparison of the two models show that people who choose SUV and people who choose sedan have different preference for the alternative fuel vehicles.

4.3. Market Simulation

The market simulation is done by applying the simulation tactic proposed by Train in his book. (Train 2009) The coefficients of each consumers (β_n) are drawn from each individuals after the estimation. In the mixed logit model, it is possible to draw the individual coefficients of the attributes that are assumed to have random effect. In order to analyze the market share change and the area of the automobile market that will be affected the most by the alternative fuel vehicles, four body type baselines were set up. Baseline refer to the alternatives that reflect the current market condition. The four body segmentations were organized to represent the top selling models of the Korean automobile market according to the KARI report of 2014. The segments are compact, mid, large, and SUV vehicles. For the first three segments, the β_n 's of the attributes were drawn from the total estimation of the sedan body types. For the SUV segment, the β_n 's of the total data SUV estimation was used. After drawing the β_n 's for every individual, they were put into the equation 10 to produce the choice probability of the alternative. I assumed that there was no no-choice variable, which meant that probability over the alternatives equaled to 1. As a result, the choice probability of each alternative represented the market share within than segment. Table 31 to 34 represent the baseline alternatives of each segments. It is assumed that every consumer can distinguish the different types of vehicle based

on the information provided by them. The information are represented by the different fuel types denoted in the attributes of the vehicle.

Table 31 Compact baseline

Attributes	1	2	3	4	5	6
Price	20	23	40	23	26	43
Fuel Cost	130	100	50	130	100	50
Type Diesel	0	0	0	0	0	0
Type EV	0	0	1	0	0	1
Type Hybrid	0	1	0	0	1	0
Displacement	1591	1591	998	1591	1591	998
Torque	17	15.1	17.2	17	15.1	17.2
SmartCar	0	0	0	1	1	1
Availability	100	100	5	100	100	5

Table 32 Mid baseline

Attributes	1	2	3	4	5	6
Price	28	43	60	31	46	63
Fuel Cost	150	110	50	150	110	50
Type Diesel	0	0	0	0	0	0
Type EV	0	0	1	0	0	1
Type Hybrid	0	1	0	0	1	0
Displacement	1999	2494	2488	1999	2494	2488
Torque	20.5	21.6	23.8	20.5	21.6	23.8
SmartCar	0	0	0	1	1	1
Availability	100	100	5	100	100	5

Table 33 Large baseline

Attributes	1	2	3	4	5	6
Price	30	35	63	33	38	66
Fuel Cost	160	120	50	160	120	50
Type Diesel	0	0	0	0	0	0
Type EV	0	0	1	0	0	1
Type Hybrid	0	1	0	0	1	0
Displacement	2359	2359	2488	2359	2359	2488
Torque	24.6	21	23.8	24.6	21	23.8
SmartCar	0	0	0	1	1	1
Availability	100	100	5	100	100	5

Table 34 SUV baseline

	1	2	3	4	5	6
Price	34	64	45	37	67	48
Fuel Cost	120	100	50	120	100	50
Type Diesel	1	0	0	1	0	0
Type EV	0	0	1	0	0	1
Type Hybrid	0	1	0	0	1	0
Displacement	2199	2494	1995	2199	2494	1995
Torque	45	21	19	45	21	19
SmartCar	0	0	0	1	1	1
Availability	100	100	5	100	100	5

There are six alternatives for every baseline, one of the traditional fuel type vehicle and each of the alternative fuel vehicles (EV and Hybrid). There are three vehicles that doesn't have any smart car option installed, and the same three cars that have the smart car option installed. For the cars that has the smart car option installed, the expected price of installing the smart car option is included into the price of the vehicle. The price of the installing the smart car option is based on the average value of the smart car option price in the survey. The price of the smart car option are 1 million won, 3 million won, and 5 million won, and so the average value of 3 million is used to reflect the average consumer choice of the smart car option. Many of the values for the vehicle specifications are based on some of the most popular traditional and alternative fuel type vehicles in the current market. (Revelt & Train 1998)

4.3.1. Lump Sum

In order to analyze the upcoming automobile market based on the changes of the EV and

HV, it is crucial to reflect the government's supporting policies in the simulations. As described in section 2.2.4, the Korean government is currently practicing various policies that focus on increasing the penetration rate and the market shares of the EV and HVs. Many of the policies that aid this purpose can be categorized into two types of subsidies. The first type is the lump sum type, where a portion of the price or tax is taken off the total cost at the moment of purchasing such vehicles. The second type is the annual incentive type of subsidy. The annual subsidies are usually in the form of annual tax exemption and providing maintenance or fuel cost regularly. In order to analyze which type of policy is the most effective in increasing the consumer preference of the EV and HV, both policies are simulated based on the baseline alternatives. Government policies will be reflected in the baseline alternatives by changing the values of the related attributes. As a result, the changes in the value of the attributes will lead to the shift in the market shares of each vehicles, which will be compared with the market share of the baseline alternatives. This method of analyzing the effect of the government policies in changing the market share was used by Hong et al. where government's subsidy policy on vehicle-to-grid system was evaluated. (Hong et al. 2012)

In this section, the lump sum type of policy is simulated. According to the MOTIE report in 2014, described in section 2, the Korean government is allowing consumers who buy EV or HV to be exempt from excise, education tax, other forms taxation and reduction in bond purchases. For these lump sum policies, each level of exemptions are reduced from the price of the vehicle, because it is the only attribute within the baseline alternative that has the form

of onetime payment. Table 35 below represent the scenario of increasing government subsidies on purchasing the EV and HV. Figures 1 through 4 describe the changes in the market share of each segments based on the shift in the price of the vehicles. The price change are divided into 3 stages to observe the overall shift in the market shares

Table 35 Price changes of the EV and HV based on the lump sum scenario

Segment	Vehicle	Baseline price	1st subsidy 20%	2nd subsidy 40%	3rd subsidy 50%
Compact	EV	40	32	24	20
	HV	23	18	14	12
Mid	EV	60	48	36	30
	HV	43	34	26	22
Large	EV	63	50	38	32
	HV	35	28	21	18
SUV	EV	45	36	27	24
	HV	64	51	38	32

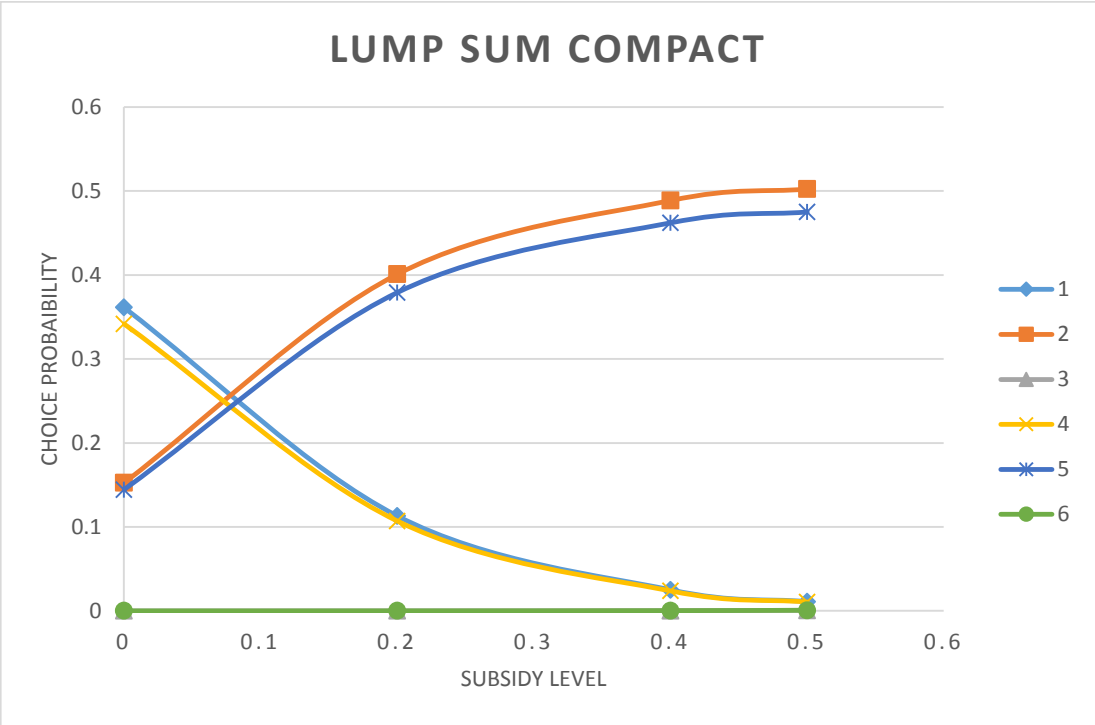

Figure 1 Market share of Compact vehicle

Looking at the changing choice probabilities of each alternatives in figure 1, it is clear to see that alternative 2 and 5 increased the most as the lump sum subsidy increased. Assuming that the policy continued to 50%, the HVs would dominate the compact vehicle segment. On the contrary, the EVs showed little sign of improvement despite the government programs

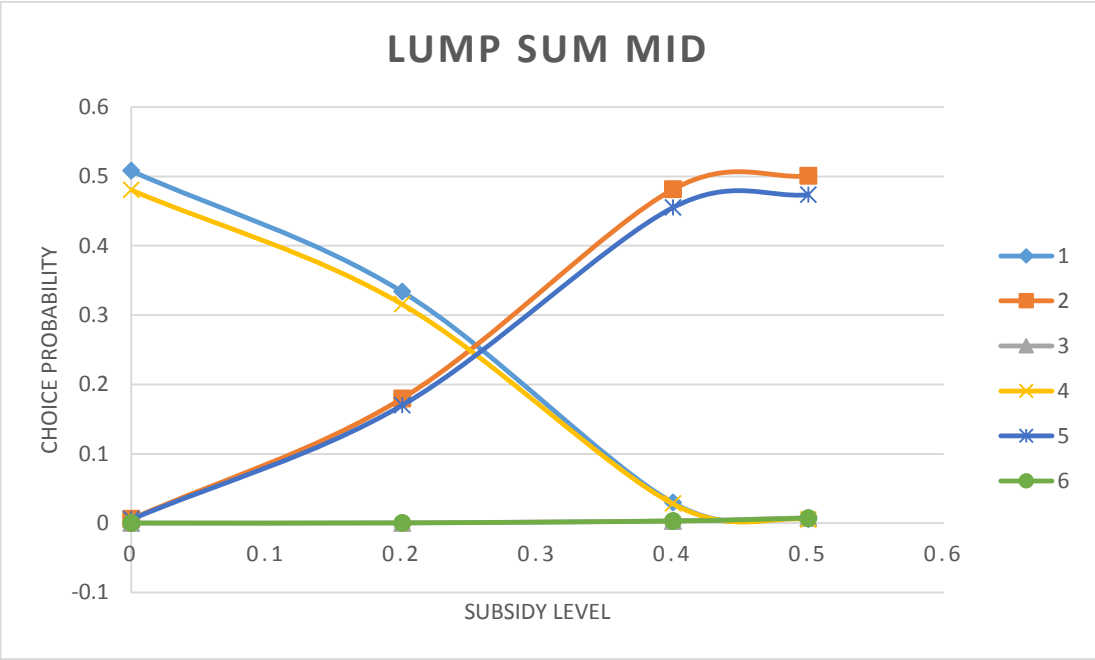

Figure 2 Choice Probability of Mid vehicle

The mid type sedans showed similar pattern of growth in both smart car HV and non-smart car HV. However, the interception point between the traditional gasoline vehicles and the HVs happened only when the government provided about 25% of subsidies. Compared to the interception point of 10% subsidy in the compact vehicle market. The difference between the two segments may be due to the actual price difference between the models. With the average price of the mid vehicle higher than the compact vehicles, people may be less sensitive to the price change of the vehicle.

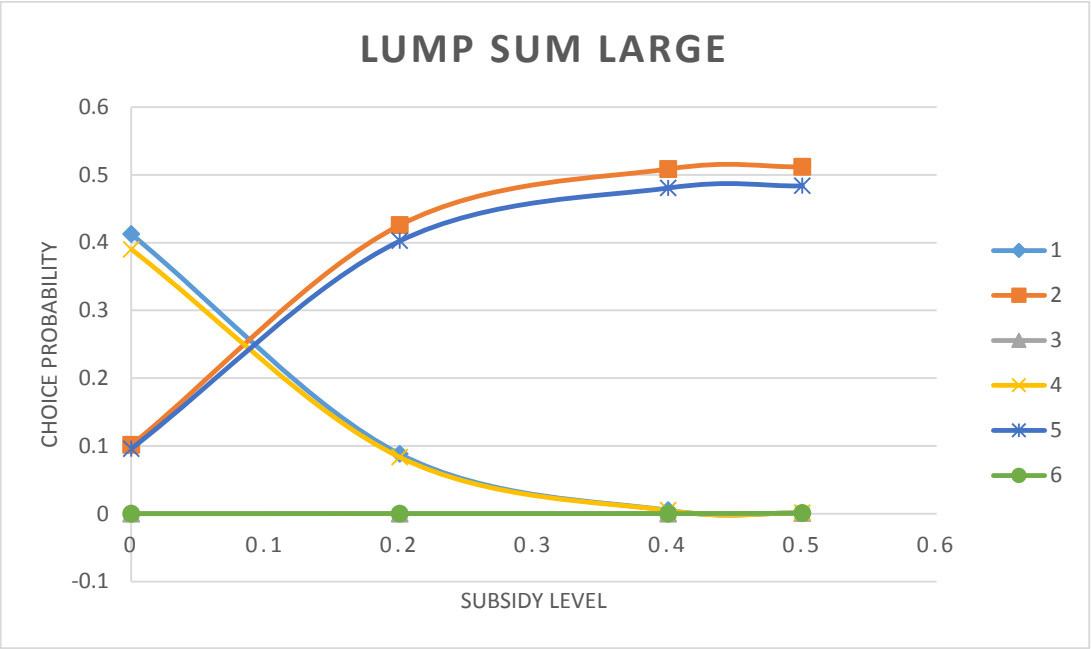

Figure 3 Lump sum Large Vehicle

The changing patterns of the choice probability in the large vehicle segment is very similar to the one shown in the compact vehicle segment. This can be interpreted to mean that consumers who buy compact and large cars are relatively more sensitive to the price change. It is plausible to think so because there are not a lot of alternatives within those two segments compared to the mid segment. With not many variations in the alternatives, a shift in price due to the government subsidies can become one of the key factors in the decision making process.

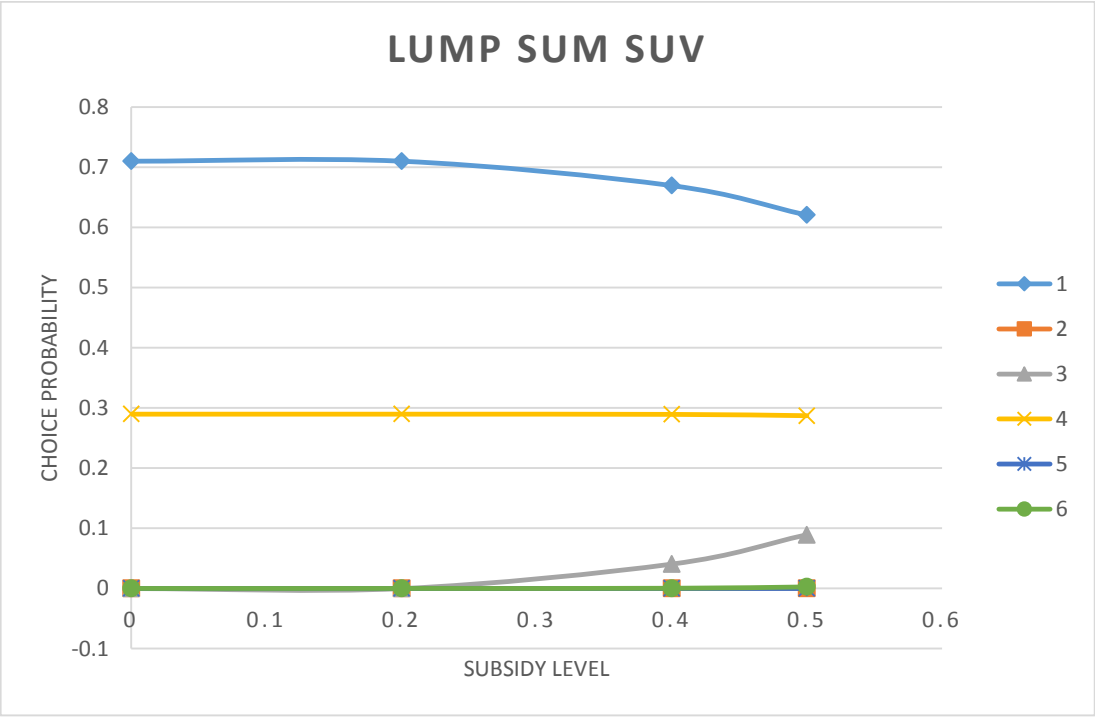

Figure 4 Lump sum SUV

Comparing the choice probabilities of the SUV segment under the lump sum subsidy with other segments, one can see there are not a lot of shift in the overall market shares. In fact, under the lump sum scenario, the HVs dominated the three sedan vehicle segments. In the SUV case, the traditional diesel type vehicles still dominated the market. HV market shares are close to 0. Another key difference between the SUV segment and the other segment is the improving market share of the EVs. When the government subsidy goes up to 50%, the probability of the alternative 1 (diesel SUV) decreases, making up for the rise in the probability of alternative 3 (EV SUV). It may be too much to interpret this pattern as a fact that EV SUVs will replace

diesel SUVs in the future, but it shows promise that a decrease in the EV SUVs drastically improve its market share. Compared to the other vehicle segments, where the choice probability of the EV type alternatives were close to 0, the simulation results show that developing EV SUVs can bring a better chance of success for the government and the automobile firms.

4.3.2. Annual subsidy

In this section the same procedure as the previous section will be performed in order to simulate the market share change when the government policy takes the form of an annual incentive. To reflect the annual incentive provided by the government, the fuel cost of EV and HV will be lowered by 20%, 40% and 50%. This is in line with the government policies that provide new batteries to EV owners. (Hong et al. 2012)

Table 36 Annual subsidy of fuel cost and availability

Segment	Vehicle	Baseline FC	20%	40%	50%
Compact	EV	50	30	10	0
	HV	100	80	60	50
Mid	EV	50	30	10	0
	HV	110	88	66	54
Large	EV	50	30	10	0
	HV	120	96	72	60
SUV	EV	50	30	10	0
	HV	100	80	60	50

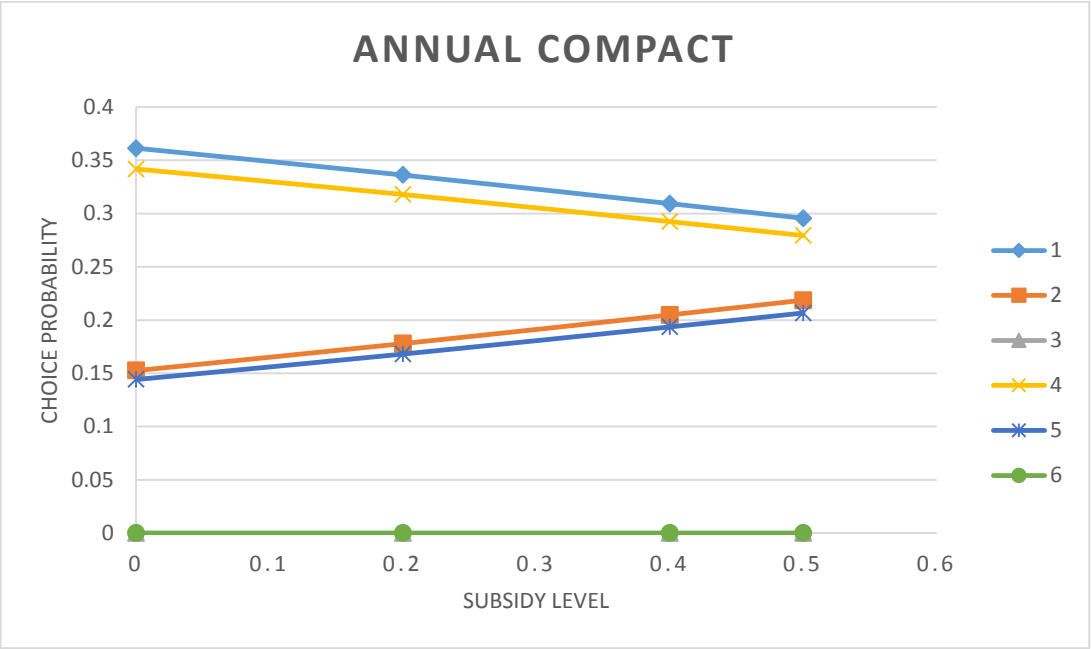

Figure 5 Annual subsidy of Compact vehicle

Compared to the drastic shift of the choice probabilities under the lump sum subsidy, the annual subsidy through the reduction in fuel cost shows gradual increase in the HVs choice probabilities. With almost no changes in the EV choice probabilities, it is evident that the reduction in the fuel cost of the hybrid vehicle will lead to HVs replacing the traditional gasoline type vehicles in the compact segment.

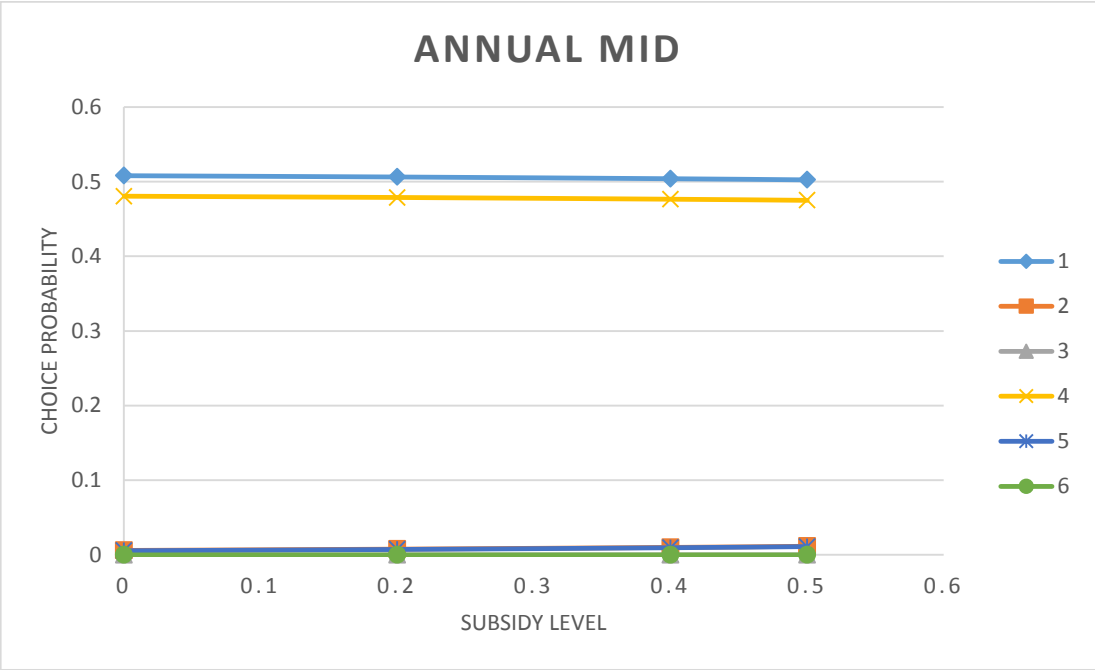

Figure 6 Annual subsidy of Mid vehicle

There are no shift in the choice probabilities in the mid segment. This may be due to the lack of HV or EV alternatives represented in the baseline. Also, consumers who buy mid body type vehicle could be less sensible to the reduction in the fuel cost. It is evident that the mid body segment is the largest automobile market that has the most alternatives. As a result, people may still be reluctant to change their fuel type only based on the fuel cost.

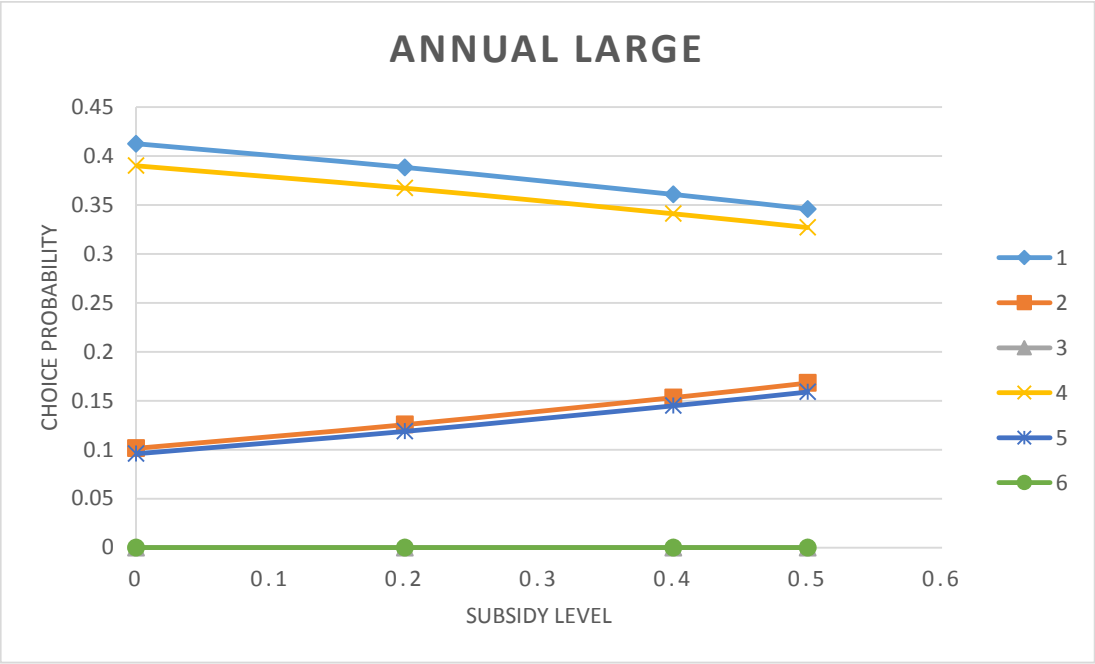

Figure 7 Annual incentive of large vehicle

In the case of the large vehicle segment, the pattern is very similar to the one shown in the compact segment.

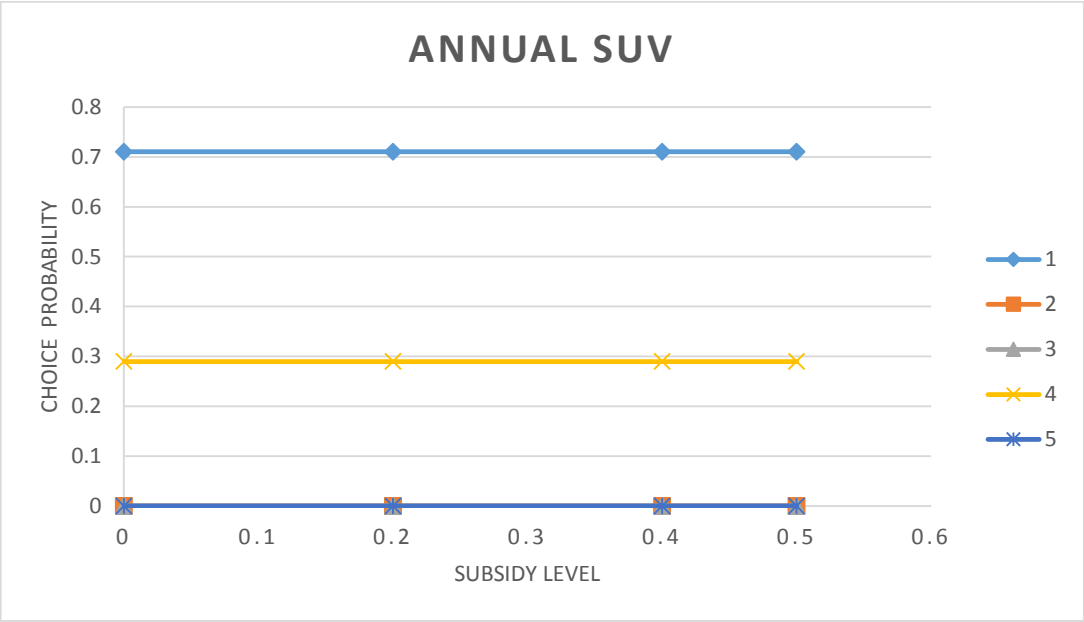

Figure 8 Annual subsidy of SUV

The pattern shown in the SUV segment is similar to the one shown in the mid segment, with no significant changes in the choice probabilities of any alternatives.

4.3.3. Availability

The availability of electric charging station is one of the key factors that determine the diffusion of the EVs. Currently, the availability of the EV charging station is 5% relative to the gas stations that can be used by gasoline, diesel, and hybrid vehicles. In order to analyze the changes in the consumer's choice probability when the availability of these charging stations increased, the ratio was set to increase by 20%, 40%, and 50%. However, the results of the simulation didn't show any real significant increases in the choice probability of the EVs. This

may have been due to the lack of EV vehicles characteristics that could have been affected by the availability of the charging stations.

5. Discussion and conclusion

This paper aimed to investigate the effect of the increasing HVs and EVs in the automobile market by using the consumer preference analysis. Sections 2 and 3 outlined the background of the present research and reviewed t relevant studies in the field. Based on the global automobile market trends and the government and firms' policies concerning the upcoming alternative fuel vehicles, it is evident that EV and HV will become t new dominant products of the automobile industry. Korean government has proposed various policies to increase the diffusion of these two vehicles by managing public transportation system and providing different types of subsidies. As a result, this paper used the mixed logit model to estimate the stated preference data and the revealed preference data on the consumer preference of different vehicles. Furthermore, based on the estimated coefficients from the mixed logit model, the market shares of each type of vehicles were calculated in different segments of the vehicle market. The market simulation was based on the applications of different types of government subsidy policies and improved infrastructures of the alternative fuel vehicles.

Previous studies that forecasted the diffusion of the alternative fuel vehicles mainly used stated preference or other types of survey data in order to make an analysis. Reports from institutions such as the KIET (Lee 2013) and KEIT (Son 2014) simulated the automobile market based on these stated preference data. The analysis carried out in this paper is different from previous studies in that it used both revealed preference and stated preference data to simulate the market shares of the EVs and HVs. Also, combined data were divided into two

parts, SUV and Sedan, to investigate how consumer preferences changed with the body type of the vehicles. In the market simulation stage, the simulation investigated the changes in the choice probabilities of the alternatives based on the changes in the subsidy provided by the government. The alternatives were separated based on the fuel type and reflected the actual alternatives consumers considered in the market. In addition, consumer preferences for the smart car option were also analyzed during the estimation and simulation processes.

The results of the analysis suggest that people currently still prefer the traditional fuel type gasoline and diesel. With all infrastructure and monetary systems designed based on traditional vehicles, the government must provide appropriate incentives and make a suitable form of investment in order to increase the market shares of the EVs and HVs. The results of the simulation suggest that the government will instantly increase the market shares of the HV by providing lump sum subsidies. On the other hand, the annual incentive type of subsidies will gradually increase the market share of the HVs. Compared to the HVs, the market share of EVs will increase only in the SUV segment under the lump sum policies. While this may be true, the results of the simulation based on the increasing infrastructure of EV indicate however that there are other important attributes that need be controlled in order to more accurately analyze consumer preferences of EVs. Although many of the key attributes were used in the analysis, we still lacked the necessary attributes to fully estimate consumer preferences. Also, the model fit improved when the data were divided into the SUV and sedan segments, which may have altered the results of the EV simulations.

Based on the interpretation of the results, it can be stated with certainty that the Korean government will increase the market shares of the HV without investing in any further infrastructure. Furthermore, the results indicate that the most promising market segment for the EVs is the SUV segment.

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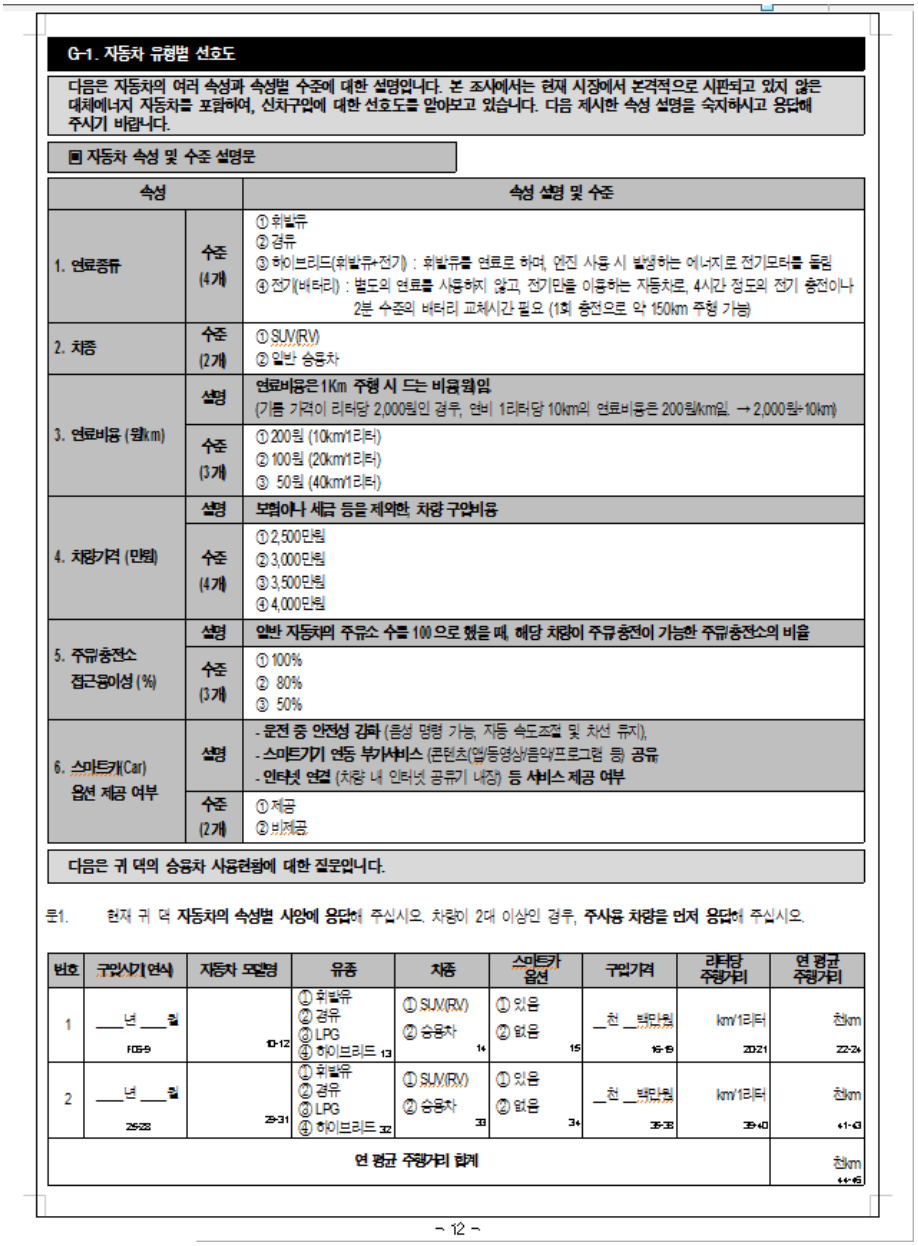
Appendix: Survey on smart-device usage (2010)



G-1. 자동차 유형별 선호도

다음은 자동차의 여러 속성과 속성별 수준에 대한 설명입니다. 본 조사에서는 현재 시장에서 본격적으로 시판되고 있지 않은 대체에너지 자동차를 포함하여, 신차구입에 대한 선호도를 알아보고 있습니다. 다음 제시한 속성 설명을 숙지하시고 응답해 주시기 바랍니다.

▣ 자동차 속성 및 수준 설명문

속성		속성 설명 및 수준
1. 연료종류	수준 (4개)	① 휘발유 ② 경유 ③ 하이브리드(휘발유+전기) : 휘발유를 연료로 하며, 엔진 사용 시 발생하는 에너지로 전기모터를 돌림 ④ 전기(배터리) : 별도의 연료를 사용하지 않고, 전기만을 이용하는 자동차로, 4시간 정도의 전기 충전이나 2분 수준의 배터리 교체시간 필요 (1회 충전으로 약 150km 주행 가능)
2. 차종	수준 (2개)	① SUV(RV) ② 일반 승용차
3. 연료비용 (원/km)	설명	**연료비용은 1Km 주행 시 드는 비용임.** (기름 가격이 리터당 2,000원인 경우, 연비 1리터당 10km의 연료비용은 200원/km임. → 2,000원÷10km)
	수준 (3개)	① 200원 (10km/1리터) ② 100원 (20km/1리터) ③ 50원 (40km/1리터)
4. 차량가격 (만원)	설명	**보험이나 세금 등을 제외한, 차량 구입비용**
	수준 (4개)	① 2,500만원 ② 3,000만원 ③ 3,500만원 ④ 4,000만원
5. 주유/충전소 접근용이성 (%)	설명	**일반 자동차의 주유소 수를 100으로 했을 때, 해당 차량이 주유/충전이 가능한 주유/충전소의 비율**
	수준 (3개)	① 100% ② 80% ③ 50%
6. 스마트카(Car) 옵션 제공 여부	설명	- **운전 중 안전성 강화** (음성 명령 가능, 자동 속도조절 및 차선 유지), - **스마트기기 연동 부가서비스** (콘텐츠(앱/동영상/음악/프로그램 등) **공유** - **인터넷 연결** (차량 내 인터넷 공유기 내장) **등 서비스 제공 여부**
	수준 (2개)	① 제공 ② 비제공

다음은 귀 댁의 승용차 사용현황에 대한 질문입니다.

문1. 현재 귀 댁 **자동차의 속성별 사양에 응답**해 주십시오. 차량이 2대 이상인 경우, **주사용 차량을 먼저 응답**해 주십시오.

번호	구입시기(연식)	자동차 모델명	유종	차종	스마트카 옵션	구입가격	리터당 주행거리	연 평균 주행거리
1	____년 ____월		① 휘발유 ② 경유 ③ LPG ④ 하이브리드	① SUV(RV) ② 승용차	① 있음 ② 없음	_천 _백만원	km/1리터	천km
	F05-9	10-12	13	14	15	16-19	20-21	22-24
2	____년 ____월		① 휘발유 ② 경유 ③ LPG ④ 하이브리드	① SUV(RV) ② 승용차	① 있음 ② 없음	_천 _백만원	km/1리터	천km
	25-28	29-31	32	33	34	35-38	39-40	41-43
연 평균 주행거리 합계								천km
								44-46

다음은 자동차 유형별 선호도에 대한 질문입니다.

지금부터 앞에서 설명드린 6가지의 자동차 속성을 조합하여 구성한 **4개의 자동차 유형이 동시에 제시**됩니다.

귀하께서는 **제시한 4개 유형의 자동차 중**...

① **구매의향**이 있는 자동차 (중복응답)

※ 제시한 4개의 자동차중, 구매의향이 없는 경우, **"비선택" 응답란에 O표**

② **(구매의향 자동차가 2개 이상인 경우)** 그 중, **가장 선호**하는 자동차

③ **(구매의향 자동차에 6. 스마트카 옵션이 있는 경우) 실제로 사용 의향**이 있는 스마트카 옵션 모두 (중복응답)

④ **(구매의향 자동차에 모두에 대해)** 문5.의 연평균 주행거리(총합계)를 **구매의향 자동차 각각에 어느 정도씩 배분할지**를 응답해 주시면 됩니다.

※ 단, 제시한 6개의 자동차 속성 이외의 **모든 다른 속성은 동일한 것으로 가정**하고 응답해 주십시오.

▣ 자동차 유형별 선호도 응답 예시

▣ 자동차 선호도 질문 1

구분		자동차 A	자동차 B	자동차 C	자동차 D	비선택
자동차 속성	1. 연료종류	휘발유	경유	하이브리드	전기(배터리)	현재 보유한 주사용 자동차 유지/ 선호 자동차 없음
	2. 차종	SUV(RV)	승용차	승용차	SUV(RV)	
	3. 연료비용 (원/km)	50	200	200	50	
	4. 차량가격 (만원)	4,000	4,000	2,500	2,500	
	5. 주유/충전소 접근용이성 (%)	100	50	100	50	
	6. 스마트카(Car) 옵션	비제공	비제공	제공	제공	
① 구매의향 자동차 (중복응답 ; O표)			O	O	O	
② 가장 선호 자동차 (하나만 ; O표)				O		
③ 사용의향 스마트카 옵션	1) 다른 스마트기기와 연결					
	2) 음성명령기능 ✓			O	O	
	3) 자동주행기능					
	4) 차량 내 인터넷 사용 ✓			O	O	
	5) 차량용 애플리케이션(앱) 사용 ✓			O	O	
④ 구매의향 자동차 연 주행거리 배분계획		천km	15천km	30 천km	5 천km	천km

총주행거리 50천km

①**구매의향**이 있는 자동차 (중복응답)
※ 제시한 4개의 자동차중, 구매의향이 없는 경우, "**비선택**" **응답란에 O표**
②**(구매의향 자동차가 2개 이상인 경우)** 그 중, **가장 선호**하는 자동차
③**(구매의향 자동차에 6. 스마트카 옵션이 있는 경우) 실제로 사용 의향**이 있는 스마트카 옵션 모두 (중복응답)
④**(구매의향 자동차에 모두에 대해)** 문5.의 연평균 주행거리(총합계)**를 구매의향 자동차 각각에 어느 정도씩 배분할지**를 응답해 주십시오.

■ 자동차 선호도 질문 1

구분		자동차 A	자동차 B	자동차 C	자동차 D	비선택
자동차 속성	1. 연료종류	휘발유	경유	하이브리드	전기(배터리)	현재 보유한 주사용 자동차 유지/선호 자동차 없음
	2. 차종	승용차	SUV(RV)	SUV(RV)	승용차	
	3. 연료비용 (원/km)	50	50	100	100	
	4. 차량가격 (만원)	2,500	4,000	4,000	3,500	
	5. 주유/충전소 접근용이성 (%)	50	80	50	100	
	6. 스마트카(Car) 옵션	비제공	제공	제공	비제공	
① 구매의향 자동차 (중복응답 ; O표)		47	48	49	50	51
② 가장 선호 자동차 (하나만 ; O표)	52					
③ 사용의향 스마트카 옵션	1) 다른 스마트기기와 연결		53	58		
	2) 음성명령기능		54	59		
	3) 자동주행기능		55	60		
	4) 차량 내 인터넷 사용		56	61		
	5) 차량용 애플리케이션(앱) 사용		57	62		
④ 구매의향 자동차 연 주행거리 배분계획		천km 63-65	천km 66-68	천km 69-71	천km 72-74	천km 75-77

■ 자동차 선호도 질문 2

구분		자동차 A	자동차 B	자동차 C	자동차 D	비선택
자동차 속성	1. 연료종류	휘발유	경유	하이브리드	전기(배터리)	현재 보유한 주사용 자동차 유지/선호 자동차 없음
	2. 차종	승용차	SUV(RV)	SUV(RV)	승용차	
	3. 연료비용 (원/km)	100	100	50	50	
	4. 차량가격 (만원)	3,000	2,500	3,500	4,000	
	5. 주유/충전소 접근용이성 (%)	50	80	50	80	
	6. 스마트카(Car) 옵션	제공	비제공	비제공	제공	
① 구매의향 자동차 (중복응답 ; O표)		FD6	7	8	9	10
② 가장 선호 자동차 (하나만 ; O표)	11					
③ 사용의향 스마트카 옵션	1) 다른 스마트기기와 연결	12			17	
	2) 음성명령기능	13			18	
	3) 자동주행기능	14			19	
	4) 차량 내 인터넷 사용	15			20	
	5) 차량용 애플리케이션(앱) 사용	16			21	
④ 구매의향 자동차 연 주행거리 배분계획		천km 22-24	천km 25-27	천km 28-30	천km 31-33	천km 34-36

G-2. 스마트카(Car) 옵션 유형별 선호도

이번에는 스마트카(Car) 옵션의 여러 속성과 속성별 수준에 대한 설명입니다. 다음 제시한 속성 설명을 잘 읽어 주시기 바랍니다.

▣ 스마트카(Car) 옵션 속성 및 수준 설명문

속성		속성 설명 및 수준
1. 옵션가격	설명	자동차에 스마트 기능을 옵션으로 추가하기 위해 지불해야 하는 금액
	수준 (3개	① 100만원 ② 300만원 ③ 500만원
2. 다른 기기와 연결	수준 (2개	① 연결 가능 : 스마트폰, 태블릿PC, 스마트 가전과 같은 스마트기기를 유선/무선으로 차량과 연결 기기에 저장된 동영상/음악을 차량 내 화면/스피커를 통해 자유롭게 재생이 가능 차량 정비내역이나 운행정보 등도 스마트 기기에 기록/저장이 가능 또한, 차량 내에서 가정 내의 가전제품, 보안 장비 등을 원격으로 제어 할 수 있음 ② 연결 불가능 : 차량 내에서 스마트 기기 콘텐츠 및 스마트가전을 원격으로 조정할 수 없음
3. 음성명령 기능	수준 (2개	① 음성명령 가능 : 운전과 관련 없는 일반적인 조작을 음성명령으로 제어 가능 ② 음성명령 불가능 : 운전과 관련 없는 일반적인 조작을 현재와 같이 수동으로 제어
4. 자동주행기능	수준 (3개	① 차선유지 + 자동속도 조절 : 고속도로/직진 도로에서 차선을 지키며 일정한 속도로 자동주행 가능 차나 장애물이 전방에 존재할 시 자동으로 속도를 줄여 충돌을 방지 오직 직진 주행만 가능 ② 자동속도 조절 : 일정한 속도로 자동주행이 가능하며 차나 장애물이 전방에 존재할 시 자동으로 속도를 줄여 충돌을 방지함. 그러나 차선이탈을 방지하기 위한 핸들조작은 사용자가 직접 해야 함. ③ 고정속도 유지 : 가속페달을 밟고 있지 않아도 일정한 속도로 운행이 가능함. (크루즈 컨트롤 가능) 단 전방에 다른 차나 장애물이 있을 시에는 사용자가 수동으로 브레이크를 작동해야 함.
5. 인터넷 연결	수준 (2개	① 상시연결 : 차량이 3G나 4G를 통해 항상 인터넷과 연결되어 있음. 이를 통해 태블릿PC나 노트북을 이용한 인터넷의 자유로운 사용이 가능함. ② 연결불가 : 차량 내에서 3G나 4G와 같은 별도의 통신 기능을 이용불가
6. 애플리케이션(앱) 제공범위	수준 (3개	① 스마트폰용 애플리케이션(앱) + 스마트카(Car)용 애플리케이션(앱) 동시 제공 스마트폰용 애플리케이션(앱)과 함께, 주차장의 빈 공간, 사고 및 사건내역, 교통상황 등이 제공되는 스마트자동차 전용 애플리케이션(앱) 별도로 이용 가능 ② 스마트폰용 애플리케이션(앱)만 제공 ③ 별도의 애플리케이션(앱) 사용 불가

다음은 스마트카(Car) 옵션 유형별 선호도에 대한 질문입니다.

지금부터 앞에서 설명드린 6가지의 스마트카(Car) 옵션 속성을 조합하여 구성한 **4개의 스마트카(Car) 옵션이 동시에 제시**됩니다.
귀하께서는 제시된 4개의 스마트카(Car) 옵션 중, **선호하는 순서대로 1위에서 4위까지 순위를 응답**해 주시면 됩니다.
※ 단, 제시한 6개의 스마트카(Car) 옵션 속성 이외의 **모든 다른 속성은 동일한 것으로 가정**하고 응답해 주십시오.

문2-1. 다음 제시된 4개의 스마트카(Car) 옵션 중 **귀하께서 선호하는 순서대로 순위를 응답**해 주십시오.

▣ **스마트카(Car) 옵션 선호순위 질문 1** : 스마트카(Car) 옵션 A~스마트카(Car) 옵션 D 등 4개 중, **선호하는 순서대로 순위를 응답**해 주십시오.

스마트카(Car) 옵션 속성 구분	스마트카 옵션 A	스마트카 옵션 B	스마트카 옵션 C	스마트카 옵션 D
1. 옵션가격	500만원	300만원	100만원	100만원
2. 다른 기기와의 연결	연결 가능	연결 불가능	연결 가능	연결 불가능
3. 음성명령 기능	음성명령 가능	음성명령 가능	음성명령 불가능	음성명령 가능
4. 자동주행 기능	차선유지 +자동속도조절	자동속도조절	자동속도조절	차선유지 +자동속도조절
5. 인터넷 연결성	연결 불가	연결 불가	연결 불가	상시 연결
6. 애플리케이션(앱) 제공범위	스마트폰용+스마트카용 애플리케이션(앱) 제공	스마트폰용 애플리케이션(앱)만 제공	스마트폰용+스마트카용 애플리케이션(앱) 제공	비제공
응답란 : 1위~4위 순위응답	위 37	위 38	위 39	위 40

▣ **스마트카(Car) 옵션 선호순위 질문 2** : 스마트카(Car) 옵션 E~스마트카(Car) 옵션 H 등 4개 중, **선호하는 순서대로 순위를 응답**해 주십시오.

스마트카(Car) 옵션 속성 구분	스마트카 옵션 E	스마트카 옵션 F	스마트카 옵션 G	스마트카 옵션 H
1. 옵션가격	500만원	300만원	100만원	100만원
2. 다른 기기와의 연결	연결 가능	연결 가능	연결 불가능	연결 가능
3. 음성명령 기능	음성명령 불가능	음성명령 불가능	음성명령 가능	음성명령 불가능
4. 자동주행 기능	고정속도유지	차선유지 +자동속도조절	고정속도유지	고정속도유지
5. 인터넷 연결성	상시 연결	상시 연결	상시 연결	연결 불가
6. 애플리케이션(앱) 제공범위	스마트폰용 애플리케이션(앱)만 제공	비제공	스마트폰용+스마트카용 애플리케이션(앱) 제공	비제공
응답란 : 1위~4위 순위응답	위 41	위 42	위 43	위 44

문2-2. 귀하께서는 향후 선택하신 유형의 스마트카(Car) 옵션을 **실제로 구매하실 의향**이 있으십니까?
45

1. 예 (있다) 2. 아니오(없다) → **다음 페이지로 가십시오.**

▼

문2-2-1. 그럼, 앞에서 평가하신 스마트카(Car) 옵션 A~스마트카(Car) 옵션 H 등 8개의 스마트카 옵션 중 **실제로 무엇을 구매**하시겠습니까? 앞에서 평가하신 스마트카(Car) 옵션 선호도 질문1~2에서 **가장 선호한다고 응답하신 스마트카 옵션 2개 중 하나를 응답**해 주십시오.
46 47

1. 스마트카 옵션 A 2. 스마트카 옵션 B 3. 스마트카 옵션 C 4. 스마트카 옵션 D
5. 스마트카 옵션 E 6. 스마트카 옵션 F 7. 스마트카 옵션 G 8. 스마트카 옵션 H
9. 구매의향 스마트카 옵션 없음

초 록

21 세기에 들어서서 환경보존은 모든 정부와 산업체에서 중심주제로 부각되어 왔다. 이러한 추세의 일환으로 환경우호적인 자동차를 생산하는 것은 환경보존에 있어서 가장 유망한 방법 중의 하나가 될 수 있을 것이다. 자동차 산업 마케팅이 성공적으로 변환되기 위해서는 정부의 정책적인 지지뿐 만 아니라 적절한 종류의 대체연료 자동차를 생산하기 위한 회사의 연구개발 노력이 뒷받침되어야 한다. 본 연구에서는 한국 마케팅을 기반으로 고객의 선호도 변화를 대한 자동차 마케팅에서 증대되는 대체연료 자동차의 효과를 알아보기 위하여 현시선호(revealed preference)와 진술선호(stated preference) 자료를 분석하는데 혼합로짓추정법을 적용하였다. 추정결과를 바탕으로, 변화하고 있는 자동차 마케팅의 분배양상을 예측하기 위하여 다양한 정부정책을 모의실험으로 생성하였다. 본 연구결과에서는 어떤 대체연료 자동차를 고객들이 가장 선호하고 있으며 이러한 자동차가 실제로 보급될 때 마케팅이 어떻게 변화할 것인지를 보여줄 것이다. 이러한 분석을 통해 정부는 어떤 종류의 정책을 펼쳤을 때 가장 빠르게 전기차와 하이브리드차를 확산할 수 있는지, 또는 어떤 종류의 차량을 지원해야 되는지 알 수 있을 것이다.

주요어: 친환경 자동차, 자동차 시장, 혼합로짓모형, 진술선호, 현시선호, 전기차, 선호분석

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