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Factors Affecting Electric Vehicle Adoption Intention

A Comparative Study of Potential Consumers in California and Korea

전기차 수용 의도에 영향을 미치는 요인 연구:
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ABSTRACT

Factors Affecting Electric Vehicle Adoption Intention

A Comparative Study of Potential Consumers in California and Korea

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With respect to the growing interest in environmental protection, attention is being paid to the transportation sector as a main contributor to greenhouse gas emissions. The purpose of this research is to understand the adoption intention of potential electric vehicle (EV) consumers by analyzing the various factors affecting the EV adoption intention, including psychological factors, behavioral factors, and demographic factors, and comparing the results between two regions: California, United States, and Korea. Key psychological factors utilized were

‘environmental concern’, ‘consumer innovativeness’, and ‘motives for car use’. The study analyzed the data collected from 438 respondents in total, from which 202 respondents were from California, United States, and 236 respondents were from Korea. The results show that environmental concern is an important indicator of EV adoption intention for both sample groups, whereas their innovativeness was not found to have significant effect on the adoption intention. EV potential consumers in both regions cited the ‘lack of charging facilities’, ‘high vehicle price’, and ‘short driving range’ as the top three deterrents for considering an EV for their next vehicle option. The study suggests that the managers to focus on delivering marketing messages that fit the characteristics of the consumers in each region, and the government to quickly develop charging infrastructure for the EVs.

Keywords: Electric vehicles, adoption intention, environmental concern, consumer innovativeness, motives for car use

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TABLE OF CONTENTS

I. INTRODUCTION

With increased social interest in environment, more attention is being paid to the transportation sector, which is one of the key contributors to greenhouse gas (GHG) emissions. The International Energy Agency stated that around 15% of total GHGs were generated by transportation sector globally, and the percentage is estimated to increase to almost half of all GHG emissions by 2030 (IEA, 2017).

Given such, several countries are attempting to reduce the emissions by decreasing the use of fossil fuels from the transportation sector. Among several alternative options to the internal combustion engine vehicles (ICEVs), electric vehicles (EVs) are considered as one of the most promising approaches in the sector (Egbue *et al*., 2012; Hawkins *et al*., 2013). Plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) are collectively referred to as EVs, which reduce or has potential to entirely replace the use of fossil fuels in the vehicle through integration with the electric grid. The potential for decarbonization through EVs has been recognized globally, whereby in 2016 fourteen countries in total set national EV deployment targets that will be met between 2020 and 2030. Further efforts for decarbonization in the sector were evidenced by Norway, France, United Kingdom, and India, as they announced the complete ban of petrol and diesel vehicle sales as early as 2030.

At industry level, most automotive manufacturers have launched at least one BEV or PHEV model and some brands have announced that they will have a full line-up only of EVs by the end of this decade (The Guardian, 2017). Due to carbon dioxide regulation tightening up, not only European but Chinese, American, and Japanese manufacturers also have widened investments in EVs and the related technologies, including batteries and lightweight, aerodynamic, and drag-reducing technologies (McKinsey, 2013). At a retail level, the automotive market continues to experience increases in the share of EV sales across nations. Norway remained the global leader in terms of EV market share, with roughly 1 in 3 vehicles being fully electric (EAFO, 2019).

However, in spite of the progress above mentioned, EVs account for only 0.4% of the total global passenger vehicle fleet by the end of 2018 and are yet to displace ICEVs. According to IEA (2019), only five countries had an EV stock share higher than 1% in 2018, even with the ongoing expansion of sales of EVs: Norway (10%), Iceland (3.3%), Netherlands (1.9%), Sweden (1.6%), and China (1.1%). Prior studies have identified critical barriers to the widespread diffusion of EVs. For example, one research reported that the cost of the battery inserted in an EV can be a significant barrier to the EV acceptance. Limitations in battery capacity and vehicle weight are considered as further obstacles to the mass production of EVs. Such limitations have yielded improvements in terms of the technology and engineering-related side of EV diffusion.

Improvements to the technical aspects of EVs have increased the importance of user perspectives on these vehicles. The biggest challenge remaining for the EV industry is to build a market presence and consumer demand despite the dominance of ICEVs for personal vehicle market. Policymakers, industry experts, marketers, and any other stakeholders involved in the process of EV diffusion will need to understand the factors determining consumers' satisfaction with driving EVs, their emotional responses to using EVs, and psychological factors affecting their adoption intentions.

Since the market is in an early stage of its evolution, analyzing the characteristics of the early adopters can provide reliable estimates of the characteristics of the future consumers (Plötz & Gnann, 2013). It is also notable that the early adopters of EVs can affect later adopters through word-of-mouth (Goldenberg *et al*., 2009). Since potential consumers tend to inaccurately predict their interest in products with which they have no experience (Hoeffler, 2003), the role of early adopters should be recognized as critical players in the industry.

Moreover, there is a widespread assumption that EV consumers, regardless of their individual characteristics or geography, will have similar characteristics and behavior (Schneidereit, 2015). However, significant differences in culture, policy, environment, and personal characteristics may result in different patterns in EV adoption across the regions. Therefore, auto manufacturers and governments need to understand what motivates consumers

to purchase an EV and whether early adopters are satisfied with their cars (Rezvani *et al*., 2015), to define the right policies and to develop market-specific marketing campaigns to encourage faster adoption of EVs by consumers and the market in general.

Thus, the current study aims to explore potential consumers' perceptions of EVs by examining their view by comparing the behavior of EV potential adopters in California and Korea. Despite of the selected regions being different in terms of their administrative unit – California as a state and Korea as a country – the comparison between California and Korea is meaningful for several reasons. California is less populated than Korea, as its surface area is nearly four times larger than that of Korea, with about 10 million less people living. California has much longer history of producing and selling EVs than does Korea. California is commonly perceived as a leader on environmentalism, with its high standards for energy efficiency and zealous targets to reduce emissions. Such naturally led the firms to bring more fuel-efficient vehicles and fewer carbon-intensive products to the state. Within the U.S., EV market share is the highest in California, with 177,781 new vehicles sold in 2018. By contrast, EV market in Korea is still very small, although it is now one of the fastest growing markets with government incentives and improved infrastructure encouraging the growth in sales amount. It is only since 2017 that the sales have started to show some meaningful numbers. Sales amount has grown significantly from 61

registrations in 2010 to 23,379 registrations during the first seven months of 2019. Therefore, comparing the two regions will reveal differences between mature and growing markets for EV.

Another meaningful comparison may come from the attitude of potential consumers towards driving and vehicle ownership in general in the two regions. The motives for driving and vehicle ownership include concepts such as moving from one place to another, expression of social status, expression of environmentalism, and sheer pleasure of driving. The questions for this matter will focus on gathering potential consumers' attitude towards EV adoption.

It is also important to acknowledge the similarity between California and Korea. EV adoption seems to be the strongest in the urban areas in both regions, which are highly populated and are facing severe air pollution (Schlanger, 2017; EACAC, 2019). Consumers in the two regions are comparatively more environmentally concerned, and perceive the issues regarding air pollution, global warming, and GHG emissions as something that affect their lives on a daily basis (PPIC, 2018; The Guardian, 2018). Such make both California and Korea attractive markets for EVs.

Global EV market

There are worldwide initiatives that are intended to help encourage economic development and to gain early market shares in EV technologies, in

addition to advancing environmental goals, such as reducing greenhouse gas emissions. The global electric car fleet exceeded 5.1 million in 2018, nearly doubling the amount of new registrations in 2017 (IEA, 2019). All-electric vehicle, or battery electric vehicles (BEVs) accounted for 64% of the world's EV fleet. China secured its position as world's largest electric market with nearly 1.1 million vehicles sold in 2018, accounting for around 45% of the global electric car stock, and 2.3 million units in total on the road. Europe accounted for 24% with 1.2 million electric cars and the United States accounted for 22% with 1.1 million in 2018.

In line with rapid growth in market interest, various EV related policies were drafted and applied. Key policy developments in 2018 and 2019 include ambitious policies in some countries; for example, Canada outlined a vision for future mobility with zero-emissions vehicles (ZEVs) mandate in Quebec. China's policy developments include the restriction of investment in new ICEV manufacturing facilities, while European Union set minimum requirements for charging infrastructure in new and renovated buildings. Policy supports are being extended worldwide to bridge the cost gap between electric and conventional vehicles and to support the deployment of charging infrastructure. Technology advances are bringing substantial cost reductions in the EV industry. Key enablers for such are developments in battery chemistry and the expansion of production capacity from manufacturing side (IEA, 2019). Private sectors are

also contributing to the electrification of transport through boosting investments. These developments together present a positive outlook for the EV industry and for the environment through lower GHG emissions.

Californian EV market

California is commonly accepted as the largest green market in the United States and the EV market is growing rapidly ever since the state announcement of a goal for low emissions. In 2009, the U.S. Federal Government highlighted electricity as a potential alternative to fossil fuels in the transportation sector and established a national goal of putting one million plug-in electric vehicles (PEVs) on the road by 2015. Since then, the EV and the related industries have gained significant policy support. The modified Zero Emission Vehicle (ZEV) Program in California required all major auto manufacturers that do business in California offer at least a number of ZEVs for sale by 2016 and increase shares of EVs through 2025.

As a result of policy actions, consumer incentives, infrastructure deployment, and information campaigns, a new EV industry have emerged in the United States. The General Motors Corporation and Nissan are the pioneer brands in the industry with their introduction of electric models: a PHEV *Volt* and PEV *Leaf*, respectively. EVs accounted for about 2.1% of light-duty vehicle registrations in 2018 and the most populous metropolitan areas were responsible

for 80% of 2018's total national EV registrations (ICCT, 2019). California accounts for nearly half of the pure EVs sold nationwide, and the sales of new EVs in California went up 63.7% in the first half of 2019 to 51,750 units.

California is leading in the number of public charge points per million population, with top five metropolitan areas with most public charge points being cities in California: San Jose, San Francisco, San Diego, Los Angeles, and Sacramento. Charging infrastructure is critical to support EV market growth, as greater infrastructure deployment at home, workplace, and public locations can extend driving functionality and increase public awareness.

Korean EV market

Korea is among the most advanced automobile-producing countries in the world. The automobile industry is the largest manufacturing industry in Korea, which accounted for nearly 12.3% of all domestic production in 2017. Globally, it is the sixth largest in the world by automobile unit production, and the fifth largest by automobile export volume.

Despite the scale and importance of the industry itself, Korean automakers have been quite passive on investing for the future of the industry, especially when it comes to EVs. The discussion on this matter has only started with the growing concern for air pollution. In Korea, diesel vehicles account for 37% of all registered vehicles, but contribute to 29% of the total fine dust

emissions in the Greater Seoul Metropolitan Area (EACAC, 2019). In attempt to reduce the level of emissions in the city, Seoul has pushed forward various policies and programs in strengthening vehicles emissions restrictions and expanding the use of EV and hydrogen vehicles. Sales have started to show meaningful numbers in 2017 with 18,855 units sold. A total of 59,600 EVs were on the roads by the end of 2018, with nearly 34,000 new vehicles registered in 2018 alone.

Korean government has set a goal to boost the EV production capacity to more than 10% of all vehicle production by 2022, accompanied by the financial support and loan guarantees to major industrial players like Hyundai Motors. The scope of national subsidies for all low-carbon vehicle purchases also increased from 32,000 vehicles in 2018 to 57,000 in 2019, adding to other policy instruments such as rebates on vehicle acquisition taxes, reduced highway tolls and public parking fees.

Research Questions

The Californian and Korean EV markets show contrasts in several perspectives. The empirical data from each market with different maturity level will be used for the analysis. Social, political, and economic backgrounds, market characteristics, and consumer characteristics of the two markets will

result in different consumer behaviors regarding EV adoption intention. This study will explore the following questions:

- *Does EV adoption intention of Korean potential consumers differ from that of Californian?*
- *What psychological factors drive people to adopt EVs?*
- *Do factors affecting EV adoption intention differ between the two groups?*

II. THEORETICAL BACKGROUND

2.1. Vehicle usage

Experience of owning a vehicle is one of the major determinants of the EV adoption intention. As discussed by Schulte *et al*. (2004), the concept of experience includes general life experience, knowledge of related topic, and practical experience with a specific product. For this study, the knowledge on and practical experience with EVs, such as familiarity and past driving experience with EVs, were used. Burgess *et al*. (2013) found that the practical experience as an important factor in transforming the consumer attitude from skeptical to supporting and accepting. Consumers also learn much more about

EVs through practical experience, which changes their preference profoundly. More specifically, Jensen *et al*. (2013) addressed that the consumer preferences related to driving range, cost, battery life, and charging were changed after driving EVs. Therefore, measuring the potential consumers' levels of familiarity and past experience with EVs is critical in understanding how these factors might affect their adoption intention.

2.2. Psychological factors

Previous studies have found that psychological factors directly affect the decision whether or not to adopt an EV. Various psychological factors have been shown to affect individual's attitude towards EVs, including environmental concern (Bauer et al., 2014; Carley *et al*., 2013), motives for car use (Schuitema *et al*., 2013), and consumer innovativeness (Morton *et al*., 2016). Environmental concern is assumingly the most frequently researched constructs in terms of the adoption intention of EVs. Many studies have shown that the environmental concern of individuals have a positive effect on the intention to purchase EVs (Bauer *et al*., 2014; Das *et al*., 2011; Heyvaert *et al*., 2015; Jensen et al., 2013; Wang *et al*., 2017). Individuals who are environmentally sensitive or those of whom identified themselves as environmentally friendly person would be more likely to adopt EVs (Barbarossa *et al*., 2017). Individuals with more environmental concern exhibited greater preference and usage satisfaction from

EVs (Jensen *et al*., 2013). Moreover, early adopters of EVs are more environmentally conscious than others (Hardman *et al*., 2016).

Motives for one's use and ownership of cars can have many different underlying motives. Perception of cars is generally associated with instrumental, affective, and symbolic attributes (Steg, 2005). An instrumental or functional motive refers to the perception of cars nothing more than as a means of transportation. An affective or hedonic motive refers to the joy and fun one feels from driving a car. A symbolic motive is associated with perceived qualities such as wealth and social status. Several studies found that hedonic and symbolic motives are valid predictors of preferences towards EVs (Ozaki & Sevastyanova, 2011; Schuitema *et al*., 2013). Others found that instrumental attributes are largely important for the adoption of EVs and that individual's pro-environmental self-identity has a positive effect on the perception of EVs (Schuitema *et al*., 2013; Peters *et al*., 2011; Ozaki & Sevastyanova, 2011).

Innovativeness is defined as the degree to which an individual is earlier in adopting new ideas than the average member of his or her social system (Rogers & Shoemaker, 1971). Consumers with high level of innovativeness are characterized by willingness to adopt innovative concepts and things (Ho & Wu, 2011). Studies have shown that innovativeness significantly affect the preferences for EVs (Morton *et al*., 2016). Other studies on innovations have revealed that innovative consumers usually provide other consumers information

and suggestions regarding new products, and their opinions are generally accepted by other consumers (Ho & Wu, 2011). Such makes innovative consumers as the most important target group in the diffusion process of a new product. Therefore, identifying consumers with high levels of innovativeness can help in predicting the acceptability of EVs in the market and creating the word-of-mouth effect among potential consumers of EVs.

2.3. Demographic factors

Previous studies have included individual's demographic factors as significant determinants of EV adoption, where common indicators include age, gender, education, income level, and love of technology. The literature, however, is mixed on which of these characteristics matter the most and sometimes differs on the sign of the effect.

An individual's age can influence mobility patterns and preferences for EVs. Younger people, in general, accounted for more EV usage (Nayum et al., 2016), across nations. A study (Sovacool *et al*., 2018) on the relationship between EV adoption intention and age in Nordic areas has shown that the EV interest is the highest for the 25-34 age group, which also peaked in terms of EV experience. Over-65 age group, however, was willing to pay more for electric mobility, even though they had relatively little EV experience, low EV ownership rate, and EV interest.

Over the past several decades, research has tended to prove that mobility (and electric mobility) gendered (Sovacool *et al*., 2018). In Nordic areas, a consistent 13-15% point difference of men and women having experience with an EV was found, although the EV dispersion rate differed highly across countries (Kester *et al*., 2018). However, a survey in China found that gender was only a limited explanatory factor in explaining preferences for EVs (Yang et al., 2017).

Although far less discussed than the relationship between gender and EV adoption, several studies have shown that higher level of education makes an individual more likely to purchase an EV or be more "EV-oriented" (Carley *et al*., 2013; Hackbarth & Madlener, 2013). In Sweden, high level of education is prominent among the early adopters of EVs (Vassileva & Campillo, 2017). In Norway, the drivers of EVs tend to have higher education than non-adopters and they reported as being highly motivated by environmental issues (McKinsey, 2014).

2.4. Other factors affecting EV adoption intention

Other than the psychological and demographic factors affecting the EV adoption intention, several other measures could also affect the EV adoption intention among potential consumers across regions. Measures of perceived level of technological advancement, perceived convenience, and perceived fun

from driving an EV could be interesting factors that may explain the adoption intention measure. Out of the listed, there are plenty of studies on the relationship between the convenience and adoption intention of product or service that require some degree of additional effort. Follows and Jobber (2000) identified that convenience related factors such as charging auto batteries that increase one's effort required would influence consumer adoption intention or behavior negatively. They also stated that these factors are the deterrents for the development of adoption intention for green practices. Other studies specifically addressing the EV adoption found that the lack of supporting infrastructure may hinder consumer acceptance of full EVs (Wouk, 1995). As adoption of EV requires additional effort, especially in terms of locating the charging station and time spent for charging, measuring how perceived level of convenience affects the adoption intention of potential consumers of EVs.

III. METHODOLOGY

In current study, levels of environmental concern of Californian and Korean potential consumers of EVs will be compared and the impact of environmental concern on their EV adoption intention will be analyzed with motives for car use mediating the relationship between environmental concern

and EV adoption intention. Similarly, levels of innovativeness of Californian and Korean potential consumers will be compared and the impact of innovativeness on EV adoption intention with respect to the motives for car use will then be analyzed. Data on demographic factors will be used as factor moderating the relationship between the motives for car use and adoption intention.

3.1. Sample and Data Collection

Given that the Korean EV market is much smaller than that of California, the study recruited the potential consumers of EVs instead of EV owners to make the comparison between the two regions fair. For data collection, an online survey was conducted for each region. For California, an online survey was conducted using the marketing research company "Survey Monkey", which is one of the most popular online survey platforms in the United States. Total of 202 respondents participated in the survey and the data was collected between November 27 to November 30, 2019. The sample in California consisted of 100 men (M_{age} = 51.14) and 102 women (M_{age} = 57.71).

For Korea, the identical online survey used for California, simply translated to Korean, was conducted using the marketing research company "Embrain", which is one of the most popular market research firms with more than 6.4 million panel members from various demographic backgrounds. Total of 236 respondents participated in the survey and the data was collected between

November 25 to November 28, 2019. The sample in Korea consisted of 105 men (M_{age} = 39.72) and 131 women (M_{age} = 35.34).

To test a proposed model, the questionnaire was developed and distributed randomly via a web-based study. Survey questions were drafted in two languages – English and Korean – and the questions were kept the same between the regions. One sample requirement was identified for the survey development. As the purpose of this research is to understand the potential EV consumers focusing on the factors affecting EV adoption intention, drivers who hold a valid driver's license become the target respondents for the survey. The first section of the survey was designed for the screening purposes, which included a question incorporating the sampling requirement. Participants were provided, upon the beginning of the questionnaire, a brief description of the survey, so they can be equally informed about the purpose of the survey before answering questions. They were then asked a series of questions regarding general vehicle usage behavior, vehicle attributes of interest, motives for car use, psychological factors, EV awareness, general attitude towards EVs, technical factors for EV adoption, and demographic information.

3.2. Operationalization

Most of the key variables in this study were operationalized using existing validated scales or measures, slightly adapted from what was reported

in previous literature, to address the factors influencing an intention to adopt EVs. Items used to measure constructs are shown in Table 1 below.

The measure for *Environmental concern* was adapted from existing scales, including environmental consciousness, environmental consumption, and environmental behavior (Stern *et al*., 1999; Chu *et al*., 2019). *Consumer innovativeness* also was adapted from previous studies (Kim *et al*., 2014; Morton *et al*., 2016).

Table 1
Constructs and measurement items

Constructs	Items	Scale
Environmental concern	I am concerned about global warming.	7-point Likert scale (1: not at all, 7: very much) Cronbach's alpha = 0.88
	I decreased disposable product consumption for environment.	
	I increased recycled product consumption for environment.	
	I prefer products made by environmentally friendly companies.	
	I am willing to pay more for environmentally friendly products and services.	
Motives for car use	(Functional)	7-point Likert scale (1: not at all, 7: very much)
	For me, a car is just a means of transportation.	
	I wouldn't have purchased a car if I didn't need one.	
	(Symbolic)	
	A car provides prestige.	
	One can know a person by looking at his or her car.	
	(Affective)	
	I like to drive just for fun.	
	I feel free and independent when I drive.	
Consumer innovativeness	My peers ask me for advice when purchasing a new product.	7-point Likert scale (1: not at all, 7: very much)
	I consider myself more adventurous than my peers.	
	I enjoy trying out new ideas.	

	I consider myself as creative and original when I think or act.	
	I like to try out new high-tech products before others.	Cronbach's alpha = 0.78
Image of EV usage	Electric cars would show my social status.	7-point Likert scale (1: not at all, 7: very much)
	I would feel proud when people see me driving an electric car.	
	Electric car would better fit my lifestyle than the combustion engine vehicles do.	Cronbach's alpha = 0.83
	Owning an electric car would show others that I'm environmentally- aware.	
	Owning an electric car would tell others that I'm tech-savvy.	
Factors affecting EV adoption intention	(Single-item measure)	7-point Likert scale (1: not at all, 7: very much)
	Range	
	Battery life	
	Charging time	
	Charging infrastructure	
	Saving the environment	
	Economic benefits	
	Technology and innovativeness	
	Pleasure of driving	
	Others' interest in purchasing an electric car and how others think of me	
Adoption intention	I am planning on getting an EV for next vehicle.	7-point Likert scale (1: not at all, 7: very much)

The factor of *Motives for car use* was measured using items adapted from previous research (Schuitema et al., 2013). A varimax-rotation factor analysis was conducted on the 6 items in total, and the results allowed for the classification of six items into three factors: instrumental, symbolic, and affective (Table 2). The average of the two items per each factor was taken as a variable in the study for analysis purposes.

Table 2
Factor Analysis

Items		Component		
		1	2	3
Functional	For me, a car is just a means of transportation.	0.03	-0.08	**0.54**
	I wouldn't have purchased a car if I didn't need one.	-0.18	-0.02	**0.64**
Symbolic	A car provides prestige.	0.12	**0.37**	-0.08
	One can know a person by looking at his or her car.	-0.13	**0.99**	0.01
Affective	I like to drive just for fun.	**0.87**	-0.10	-0.20
	I feel free and independent when I drive.	**0.73**	0.17	0.01

The *Image of EV usage* was adopted from previous studies (Schuitema *et al*., 2013; Noppers *et al*., 2015). For *Adoption intention*, a single-item measure using a 7-point Likert scale was used.

Cronbach's alpha scores were 0.88 for *Environmental concern*, 0.78 for *Consumer innovativeness*, and 0.83 for *Image of EV usage*, indicating that the items are internally consistent (Bland & Altman, 1997). All constructs used for the study showed good reliability in terms of the Cronbach's alpha scores, as scores of 0.7 to 0.8 are regarded as satisfactory (Table 1).

3.3. Statistical methods used for analysis

To test whether the coefficients in the two linear regressions on different datasets are equal, the Chow Test was performed. Chow Test examines whether parameters of one group of the data are equal to those of other groups. If the null hypothesis, $\alpha_1 = \alpha_2$ and $\beta_1 = \beta_2$, is rejected than the two groups have different

slopes and intercepts. To test the differences in adoption intention of EV between groups t-tests were conducted. For the test of independence of variables, Pearson's chi-squared test ($\chi 2$) was conducted. Differences in psychological variables were tested using an analysis of covariance (ANCOVA), as ANCOVA ensures better precision when compared to other statistical methods in that it reduces error caused by covariates, such as age, income, and level of education. These variables should be controlled for, as they may be related with the independent variables. All three covariates mentioned were used as they differed between two sample groups. Motives for car use variables was divided by factor analysis for the grouping of measurement items purposes. For a comparison of EV adoption intention between the two regions, an ANCOVA was used, with age, income, and education level as covariates. Determinants of adoption intention were examined through multiple regression analyses. All of these statistical analyses mentioned were performed via statistical software SPSS Statistics 23.

IV. RESULTS

4.1. Vehicle usage and attributes of interest

First, variables related to the general vehicle usage behavior were analyzed for the two regions (Table 3). For the question that asked how long a respondent has had the driver's license, the most frequent answer was 'more than 10 years' for both regions. The ratio for 'more than 10 years' and the rest of the answer choices were 83.2% and 16.8%, respectively, for Californian respondents, suggesting that getting a driver's license and personal vehicles are, or at least used to be, a must.

Next, the vehicle attributes that the consumers value the most when choosing a car were analyzed for the two regions (Table 4). Total of ten different attributes were presented and the respondents were asked to choose the most important vehicle attribute for themselves when choosing a car to purchase. For Californian respondents, 'fuel efficiency' turned out to be the most important attribute with 52 counts (25.7%), followed by 'safety (16.8%)', 'maintenance and service (14.9%)', and 'price (12.9%)'. For Korean respondents, the most important vehicle attribute was 'safety' with 48 counts (20.3%), closely followed by 'fuel efficiency (19.1%)' and 'price (17.4%)'.

Table 3
Vehicle usage

	No experience	Less than a year	1 – 3 years	3 – 5 years	5 – 10 years	More than 10 years
Californian	8(4.0%)	2(1.0%)	4(2.0%)	10(5.0%)	10(5.0%)	**168(83.2%)**
Korean	46(19.5%)	27(11.4%)	28(11.9%)	22(9.3%)	25(10.6%)	**88(37.3%)**

Note: Frequency (Percentage)

Table 4
Vehicle attributes of interest

	Brand	Comfort	Design	Engine	Fuel efficiency	Maintenance and service	Performance	Price	Safety	Space
California n	14(6.9%)	8(4.0%)	6(3.0%)	0(0.0%)	**52(25.7%)**	30(14.9%)	24(11.9%)	26(12.9%)	34(16.8%)	8(4.0%)
Korean	19(8.1%)	12(5.1%)	23(9.7%)	2(0.8%)	45(19.1%)	22(9.3%)	17(7.2%)	41(17.4%)	**48(20.3%)**	7(3.0%)

Note: Frequency (Percentage)

Respondents were then asked about their previous experience with electric cars, either directly through rental or test drives, or indirectly through electric public transportation, such as taxis and buses (Table 5). While most frequently chosen option was 'no experience' for both regions (California = 35.7%, Korea = 58.1%), significantly more respondents reported to have direct experience with EVs in California (46.5%) than in Korea (16.1%). Such difference in the level of experience between the two groups goes along with the level of maturity of EV market in each region, in that California has longer history of EV sales than in Korea which allows for more exposure of the technology among the general public.

Finally, respondents were asked whether they are familiar with EVs (Table 6). The ratio of respondents who reported to have no familiarity at all with the EVs was significantly lower for Korean respondents (5.1%) when compared to Californian respondents (14.9%). More Californian respondents answered that they are not only familiar but also knowledgeable about the

technology behind the operation of EVs than the Korean respondents did (19.8% Californian vs. 11.9% Korean).

Table 5
Previous experience with EVs

	Direct (e.g. test drive, etc.)	Indirect (e.g. taxi, bus, etc.)	No experience
Californian	72 (46.5%)	36(17.8%)	94(35.7%)
Korean	38(16.1%)	61(25.8%)	137(58.1%)

Note: Frequency (Percentage)

Table 6
Familiarity with EVs

	Not at all familiar	Heard about EVs	Familiar with EVs	Understand technology behind EVs
Californian	30(14.9%)	46(22.8%)	86(42.6%)	40(19.8%)
Korean	12(5.1%)	96(40.7%)	100(42.4%)	28(11.9%)

Note: Frequency (Percentage)

4.2. Psychological factors

First, the similarity between the models was tested using the Chow Test. The null hypothesis identified for the current study was the following:

$$H_0: \alpha_1 = \alpha_2, \beta_1 = \beta_2$$

The α_i and β_i are the constants for intercept and slope of each model. The *p*-value (<0.0001) was small enough to reject the null hypothesis above. *F* value obtained was 8.797 with 6 and 426 degrees of freedom, while the *F* critical value is close to 2.802. Because the computed *F* value exceeds the tabulated critical value, the

null hypotheses was rejected. This result indicates that at least one of the estimated regression coefficients is different. The result can be further extended to explain that the models for California and Korea are systematically different, which shows that the potential consumers of EVs in each region are affected by different factors or different combinations of factors.

The difference in for the measure *Environmental concern* between the two regions were analyzed using an ANCOVA with age, income, and education level as covariates. Age, income, and education level were selected as covariates as they differed between the two regions and therefore should have been controlled for when performing analyses between main variables. Table 7 compares the mean values of psychological factors between the two regional groups in the study. Results showed that the level of environmental concern did not significantly differ between groups ($M_{California}$ = 5.15 vs. M_{Korea} = 4.76, $F(1,436) = 2.874$, $p > 0.05$, $\eta_p^2 = 0.007$).

Next, an ANCOVA with with age, income, and education level as covariates was conducted to examine whether there is a difference in *Consumer innovativeness* between the two regions. As a result, there was no significant difference observed in consumer innovativeness between two groups ($M_{California}$ = 3.86 vs. M_{Korea} = 4.13, $F(1,436) = 0.006$, $p > 0.10$)

Third, the differences in the *Motives for car use* were analyzed between the two groups. In both groups, affective motives were higher than the functional

and symbolic motives. Functional motives were higher than symbolic motives for Californian respondents, while the opposite applied to the Korean respondents. An ANCOVA analysis with age, income, and education level as covariates showed that respondents in Korea showed significantly higher symbolic motives ($M_{California}$ = 2.99 vs. M_{Korea} = 3.89, $F(1,436) = 25.644$, $p < 0.001$, $\eta_p^2 = 0.056$) and lower affective motives ($M_{California}$ = 4.52 vs. M_{Korea} = 4.18, $F(1,436) = 8.330$, $p < 0.05$, $\eta_p^2 = 0.019$) than those in California. No difference in functional motives was observed.

Then the *Image related to EV usage* factors were analyzed between the two groups using an ANCOVA with age, income, and education level as covariates (Table 8). The findings show that Korean respondents have higher level of interest in showing others their social status through EV usage ($M_{California}$ = 2.51 vs. M_{Korea} = 3.66, $F(1,436) = 25.492$, $p < 0.001$, $\eta_p^2 = 0.056$) when compared to those in California. Korean respondents have higher level of interest in showing others their environmental awareness ($M_{California}$ = 3.99 vs. M_{Korea} = 4.48, $F(1,436) = 12.892$, $p < 0.05$, $\eta_p^2 = 0.011$) than those in California. Findings indicate that Korean respondents also prefer expressing their tech-savviness through EV usage ($M_{California}$ = 2.93 vs. M_{Korea} = 4.17, $F(1,436) = 33.122$, $p < 0.001$, $\eta_p^2 = 0.071$) than those in California. There was no significant difference between the regions observed for 'perceived fitness level of EVs to the lifestyle compared to ICEVs' factor. Thus, it can be understood that the Korean potential

consumers of EVs are more conscious of their image as EV adopters in both environmental and social ways than Californian potential consumers.

Table 7
Mean of psychological factors

	Environmental Concern	Consumer innovativeness	Motives for car use		
			Functional	Symbolic	Affective
Californian	5.15(1.58)	3.86(1.37)	3.42(1.74)	2.99(1.39)	4.52(1.81)
Korean	4.76(1.01)	4.13(1.15)	3.54(1.44)	3.89(1.33)	4.18(1.53)
F (Significance)	2.874(0.091)	0.006(0.936)	0.040(0.842)	25.644(<0.0001)	8.330(0.004)

Note: Frequency (Standard deviation)

Table 8
Perceived image related to EV usage

	EV would show my social status.	EV would better fit my lifestyle than the ICEVs do.	Owning an EV would show others that I'm environmentally aware person.	Owning an EV would tell others that I'm a tech-savvy person.
Californian	2.51(1.66)	3.50(2.10)	3.99(1.96)	2.93(1.79)
Korean	3.66(1.39)	4.11(1.31)	4.48(1.34)	4.17(1.44)
F (Significance)	25.492(<0.0001)	2.240(0.135)	4.709(0.031)	33.122(<0.0001)

Note: Mean (Standard deviation)

4.3. Factors affecting EV adoption intention

Factors that may affect the EV adoption intention were analyzed and compared between the groups. First, differences in reasons for purchasing an EV between the groups were examined (Table 9). Respondents in each region were asked to choose the most important factor that attracts them to choose an EV as

their own car. Both Californian and Korean respondents showed the highest degree of importance for ‘vehicle prices and maintenance cost’, each by 30.6% and 49.6%. For Californian respondents, factor for ‘environment protection (29.6%)’ followed closely as the second highest. For Korean respondents, however, the first-place factor nearly doubled the second option, ‘tax benefits and government subsidies’ (49.6% vs. 25.4%).

Table 9
Factors for EV adoption intention

	Tax benefits and gov’t subsidies	Vehicle prices and maintenance cost	Other benefits (e.g. parking, discounts)	Environment protection	Innovative technology	Engine power and performance	Myself as an environmentally friendly consumer	Other
Californian	18(8.9%)	**62(30.6%)**	2(1.0%)	60(29.6%)	22(10.8%)	8(4.0%)	9(4.5%)	22(10.8%)
Korean	60(25.4%)	**117(49.6%)**	13(5.5%)	29(12.3%)	5(2.1%)	9(3.8%)	2(0.8%)	1(0.4%)

Note: Frequency (Percentage)

Next, differences in potential reasons against purchasing an EV between the groups were examined (Table 10). The respondents in each region were asked to choose the most important factor that pushes them away from choosing an EV. The largest portion of Californian respondents reported ‘expensive vehicle prices (29.7%)’ as the most important, while Korean respondents chose ‘lack of charging facilities (47.0%)’ as the most important issue that hinders them from choosing an EV as their own car.

The findings in this section indicate that economic factor can work both as positive and negative factors for EV adoption, especially among potential consumers in California. Korean respondents' interest in the readiness of charging infrastructure conforms to the results of study done by Lee (2017), who identified the shortage of charging infrastructure as the most important reason that stops Korean automotive consumers from choosing an EV as their next vehicle.

Table 10
Factors against EV adoption intention

	Lack of charging facilities	Short driving range	Concern for safety	Concern for maintenance	Concern for engine power and performance	Limited vehicle options	Expensive vehicle prices	Other
California n	48(23.8%)	44(21.8%)	14(6.9%)	4(2.0%)	20(9.9%)	4(2.0%)	**60(29.7%)**	8(4.0%)
Korean	**111(47.0%)**	33(14.0%)	23(9.7%)	18(7.6%)	12(5.1%)	8(3.4%)	30(12.7%)	1(0.4%)

Note: Frequency (Percentage)

A linear regression of the pooled data from the two regions was conducted to analyze factors that affect the adoption intention of EVs. Factors examined were reasons for potential EV adoption and demographic and behavioral variables included in the survey. All four adoption reason variables were included, while only the factors that exhibited higher correlations with the

dependent variable and had no multicollinearity issue (Appendix 4) were included for the examination.

Table 11 shows that environmental reasons (β = 0.266, p <0.001), reputational reasons (β = 04.668, p <0.000), income (β = 0.151, p <0.001), familiarity with EVs (β = 0.269, p <0.001) are the factors that could significantly affect one's EV adoption intention. Interestingly, economic reasons show only a marginally significant effect (β = 0.108, p <0.10) on the adoption intention, apart from expectations. Perceived fun factor showed a negative effect (β = -0.140, p <0.05) on adoption intention. The overall model fit was significant (F = 15.925; p < 0.001; R^2 = 0.272).

Table 11
Factors affecting adoption intention (Pooled data of two regions, N = 438)

Independent variables	Unstandardized coefficients		Standardized coefficients		Sig.
	B	Std. Error	β	*t*	
Constant	3.927	1.200		3.272	0.001
Environmental reasons	0.704	0.128	0.266	5.483	**<0.0001**
Economic reasons	0.316	0.183	0.108	1.729	**0.085**
Innovativeness	-0.138	0.166	-0.053	-0.831	0.406
Technical reasons	-0.257	0.230	-0.068	-1.119	0.264
Reputational reasons	0.550	0.117	0.252	4.720	**<0.0001**
Perceived convenience	0.226	0.236	0.062	0.958	0.339
Perceived fun	-0.342	0.134	-0.140	-2.544	**0.011**
Income	0.723	0.221	0.151	3.275	**0.001**
Familiarity with EVs	1.315	0.229	0.269	5.748	**<0.0001**
Past experience with EVs	-0.105	0.180	-0.026	-0.584	0.560

Note: Dependent variable: adoption intention. Model fit F = 15.925; R^2 = 0.272

Next, the separate by-country analyses were performed via linear regression, to examine the differences of the adoption intention between the two regions (Table 12). Results show that for Californian respondents, environmental reasons (β = 0.357, p <0.001), reputational reasons (β = 0.155, p <0.05), and familiarity with EVs (β = 0.390, p<0.001) were the variables with significance. No other negatively significant or marginally significant factors were identified for this group. For Korean respondents, environmental reasons (β = 0.171, p <0.05), income (β = 0.187, p <0.05), familiarity with EVs (β = 0.200, p <0.05), and past experience with EVs (β = 0.167, p <0.05) turned out to significantly explain the adoption intention of Korean respondents. The reputational reasons were not significant for Korean potential consumers, and both groups disregarded have economic reasons as important to the adoption intention. Unlike what was expected, perceived level of convenience and fun did not have significant impact on adoption intentions of respondents from both regions. As in Table 12, the overall model fit for each region was significant in both of the cases.

Table 12
Factors affecting adoption intention by country

Independent variables	California			Korea		
	β	*t*	Sig.	*β*	*t*	Sig.
Constant		1.616	0.108		2.978	0.003
Environmental reasons	0.357	5.377	**<0.0001**	0.171	2.138	**0.034**
Economic reasons	0.068	0.769	0.443	0.121	1.303	0.194

Innovativeness	-0.068	-0.782	0.435	-0.069	-0.740	0.460
Technical reasons	0.089	1.082	0.281	-0.107	-1.032	0.303
Reputational reasons	0.155	2.216	**0.028**	0.001	0.013	0.990
Perceived convenience	-0.068	-0.766	0.444	0.075	0.708	0.480
Perceived fun	-0.113	-1.498	0.136	0.005	0.053	0.958
Income	0.077	1.183	0.238	0.187	2.661	**0.008**
Familiarity with EVs	0.390	5.821	**<0.0001**	0.200	3.012	**0.003**
Past experience with EVs	-0.059	-0.949	0.344	0.167	2.750	**0.006**
Model fit *F*	10.227			6.186		
Sig.	**<0.0001**			**<0.0001**		
R^2	0.349			0.216		

Note: Dependent variable: adoption intention. β is standardized coefficient.

V. DISCUSSION

5.1. Vehicle usage

Californian and Korean respondents showed differences in their vehicle usage behavior and experience or knowledge on electric vehicles. Although more Californian respondents had direct or indirect experience with the EVs, respondents from both regions expressed neutral to positive thoughts on how EVs would fit their lifestyles better than the ICEVs. In terms of the familiarity with EVs, the percentage of respondents reported to have no familiarity with the

EVs were much smaller for Korean respondents (5.1%), while about 14.9% of the Californian respondents reported to have no knowledge about EVs.

Time passed since respondent's got the driver's license differed between regions, as majority of Californian respondents (83.2%) answered that they have had the driver's license for more than 10 years, while only 37.3% of the Korean respondents answered the same. Such difference comes from the difference in average age of each group; Californian group was about 10 years older than the Korean group, with slight difference occurring when gender factor is added (Appendix 1, 2).

5.2. Psychological factors

The results of the study show that the psychological determinants of respondents or potential consumers of EVs in California and Korea are different. The self-reported level of environmental concern was higher for Californian respondents, but there was no significance observed when the reasons for purchasing an EV were analyzed. The reason why Californian respondents' interest for the environmental protection is higher than that of Korean can be inferred from the higher public awareness of the environmental issue and the maturity of the political actions regarding the environmental issue. Political and public focus on the environmental issues, such as alternative energy sources and pollution, has long been one of the most important issues in California, while it

is only been a couple of years since the discussions on the same matter started in Korea.

5.3. Demographic factors

Income turned out to be one of the most significant factors that affect the adoption intention for Korean respondents, while Californian respondents were not at all affected by it. Given that Californian respondents perceived economic reasons factor very indifferently, we can assume that the respondents in California are not so much influenced by money, but by other attributes such as how environmentally friendly the vehicles are or how others perceive them as EV owners. In the same way, we can assume that more affluent the Korean potential consumers are, the higher the preference they show on EVs, as found by the analyses discussed above. Given such, EV firms attempting to enter South Korean auto market could specifically target wealthier demographic cohorts as their main consumer group to maximize the efficiency in their marketing activities.

Other demographic measures such as age and education level were disregarded from the analyses as they did not exhibit significance to any of the groups.

5.4. Factors affecting EV adoption intention

Adoption intention was higher among Korean respondents than among Californian respondents. The study presented that the most important factor for determining one's adoption intention was degree of environmental concern the respondents had.

With regard to the main factors and other additional factors, economic reasons, environmental reasons, and reputational reasons were deemed as most important determinants of adoption intention in the pooled sample of 438 respondents. Such is in line with the previous findings that identified the price and incentives (Gallagher & Muehlegger, 2011), pro-environmental attitude (Jensen et al., 2013; Schuitema et al., 2013), others' view of me (Schuitema et al., 2013) as being important to EV preference. It was revealed that the lack of charging facilities was a major deterrent of EV adoption intention.

5.5. Limitations and future research

This study has several limitations that need to be addressed. First, the sampling method can be improved. As there was no sampling requirement to filter the specific area (e.g. respondents should live within 25 kilometers from the center of Seoul) within California or Korea, results of this study cannot be generalized to address the overall characteristics of potential EV consumers in either region. Segmenting each region in three or more tiers depending on the

level of urbanization – for example, urban, suburban, and rural – could be an effective way to understand difference in consumer characteristics and market needs. Second, the targets of the survey can be differed. This study is based on the responses from the potential consumers of EVs in each region, not from the actual consumers of EVs. Therefore, the findings of the study are only meaningful in terms of understanding the key psychological, behavioral, and demographic factors that affect each region differently. A comparison between the actual early adopters of EVs in California and Korea or a comparative study between the potential consumers and early adopters in each region could provide interesting insights in terms of identifying the factors that actually led to and affected the EV consumers' decision-making process.

VI. CONCLUSION

The implications from the study are as following. This study provides a general market insight that can help the firms that do their businesses globally, as it addresses the newest consumer perspectives from California and Korea, which are each a more mature market and an emerging market for EVs, respectively. For example, as Korean consumers' interests lie in economic reasons and their choices are highly influenced by their income level, marketers

should narrow down their target consumer group to more affluent ones and deliver the marketing message accordingly. On the other hand, emphasizing the positive image that the drivers can get from driving an EV, for example, through tech-savviness, may improve the sales in Californian EV market as the potential consumers consider reputational reasons as important for developing an EV adoption intention. For the policymakers, this study delivers an important message regarding the development of charging infrastructure. With respect to the worldwide interest in reducing greenhouse gas emissions and growing consumer demand for more charging facilities, government-led investments in the expansion of the charging infrastructure as a means of preparing for the EV era may be the key to increase EV adoption rates.

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VIII. APPENDICES

Appendix 1. Demographic profile of Californian respondents

Demographics		Frequency (Fixed value)	Percentage
Gender	Male	100	49.5
	Female	102	50.5
Average age	Male	(51.14)	-
	Female	(57.70)	-
Education level	Below high school	10	4.9
	Undergraduate	46	22.8
	Bachelor's degree	78	38.6
	Graduate degree	68	33.7
Employment status	Employed by a company	64	31.7
	Self-employed	22	10.9
	Out of work	10	4.9
	A homemaker	12	5.9
	A student	10	4.9
	Military	6	3.0
	Retired	62	30.8
	Unable to work	6	3.0
	Other	10	4.9
Monthly income	Less than $2,000	50	24.8
	$2,001 – $5,000	50	24.8
	$5,001 – $10,000	44	21.7
	More than $10,001	58	28.7
Residence type	Apartment	42	20.8
	House	160	79.2
Total		202	100.0

Appendix 2. Demographic profile of Korean respondents

Demographics		Frequency (Fixed value)	Percentage
Gender	Male	105	44.5
	Female	131	55.5
Average age	Male	(39.72)	-
	Female	(35.34)	-
Education level	Below high school	26	11.0
	Undergraduate	23	9.7
	Bachelor's degree	168	71.2
	Graduate degree	19	8.1
Employment status	Employed by a company	148	62.7
	Self-employed	12	5.1
	Out of work	8	3.4
	A homemaker	28	11.9
	A student	26	11.0
	Military	0	0.0
	Retired	5	2.1
	Unable to work	0	0.0
	Other	9	3.8
Monthly income	Less than $2,000	88	37.3
	$2,001 – $5,000	119	50.4
	$5,001 – $10,000	25	10.6
	More than $10,001	4	1.7
Residence type	Apartment	169	71.6
	House	67	28.4
Total		236	100.0

Appendix 3. Correlation Matrix

	1	2	3	4	5	6	7	8
1. Environmental reasons	1							
2. Economic reasons	0.536**	1						
3. Technical reasons	0.370**	0.625**	1					
4. Reputational reasons	0.035	0.229**	0.546**	1				
5. Income	0.079	-0.07	-0.051	-0.264**	1			
6. Familiarity with EVs	0.142**	0.075	0.138**	0.032	0.102*	1		
7. Past experience with EVs	0.081	0.026	0.170**	-0.006	0.213**	0.383**	1	
8. Environmental reasons	1	0.536**	0.370**	0.035	0.079	0.142**	0.081	1

Note: * significance at 0.05; ** significance at 0.01

국문 초록

환경 문제에 대한 관심이 증대되면서 온실 가스 배출의 주요 원인으로 자동차 시장이 대두되고 있다. 본 연구의 목적은 가스 배출을 저감시키는 측면에서 전기차를 내연기관을 대체할 친환경 자동차의 핵심으로 삼고, 소비자의 전기차 수용 의도에 영향을 미치는 주요 심리적, 행동적, 인구통계학적 요인을 분석해 미국 캘리포니아와 한국의 응답 간 비교를 하는데 있다. 주요 심리적 요인으로는 '환경에 대한 염려', '소비자의 혁신성', '자동차 사용 동기' 등이 포함되었다. 캘리포니아 응답자 202 명과 한국 응답자 236 명의 응답자를 합해 총 438 명의 응답자로부터 얻은 데이터를 분석하였다. 연구 결과, '환경에 대한 염려' 요인이 전기차 수용 의도를 예측하는데 매우 중요한 지표인 반면, '소비자의 혁신성'은 수용 의도에 유의미한 영향을 미치지 않음을 확인하였다. 두 지역 모두에서 '충전 시설 부족', '높은 전기차 가격', '짧은 주행거리'가 전기차 구매를 망설이게 하는 가장 주요 요인으로 나타났다. 본 연구를 바탕으로 전기차 시장의 활성화를 위해서는 각 지역의 소비자 특성에 맞는 마케팅 메시지를 전달해야 하고, 정부 차원에서 전기차를 위한 충전 인프라를 빠르게 구축해야 한다는 시사점을 제공하였다.

주요어: 전기차, 수용 의도, 환경에 대한 염려, 소비자의 혁신성, 자동차 사용 동기

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