# How Can We Facilitate the Diffusion of Electric Vehicles in Japan?
## *Consumer Characteristics and Perceived Innovation Attributes*

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Abstract: Electric vehicles (EVs) have significant potential to substantially reduce $CO_2$ emissions from transportation. Researchers have been working around the world to find ways to diffuse the use of this innovation in markets, but only a few such studies have been made in Japan. The aim of this study is to pinpoint potential adopters of EVs and the factors driving or hindering the diffusion of EV use in Japan. An online questionnaire was used to identify consumer characteristics and perceived innovation attributes of EVs among 208 car owners. Two groups of car owners divided by intentions to buy EVs were compared. We found that potential adopters perceive EVs positively and have positive environmental attitudes and are scientifically literate. Our findings also indicate social environment norms can drive the diffusion of EVs while consumers' lack of compatibility with EVs hinders the widespread diffusion of this innovation. Finally we discuss the limitations and implications of this study.

## 1 INTRODUCTION

According to the Intergovernmental Panel on Climate Change (IPCC, 2014), there is no doubt climate warning is progressing. The period from 1983 to 2012 was perhaps the warmest 30-year period of the last 1,400 years, and there is a 95% certainty that humans are the main cause of this. "Cumulative emissions of $CO_2$ largely determine global mean surface warming by the 21st century and beyond" (IPCC, 2014). In Japan, in 2014, transportation was responsible for 16.5% of total $CO_2$ emmisions, and almost 89.6 % of this was from cars according to National Institute for Environmental Studies (NIES, 2016). Thus, the widespread use of environmentally friendly cars, which emit less $CO_2$ than commonly used ICEVs (Interal Combustion Engine Vehicles), is needed. Prime Minister of Japan and His Cabinet (PMJHC], 2014) aim to increase the share of next-generation automobiles, including HVs (Hybrid Vehicles) and EVs (Electric Vehicles), to between 50% and 70% by 2030.

EVs have the least well to wheel CO2 emissions compared to other types of cars according to Japan Automotive Research Institute (JARI, 2011). In this study, vehicles which run only on electricity are called EVs, in contrast to PHVs which are hybrid vehicles that run on both fossil fuels and electricity.

Although EVs were invented before the combustion engine (Situ, 2009), and Nissan, one of Japan's leading automobile companies, launched the world's first "100-percent electric, zero-emission car designed for the mass market", the Nissan Leaf (Nissan, online), in December 2010, as of 2014 there were only 60,000 EVs in Japan according to Next Generation Vehicle Promotion Centre (Nev, 2016), which accounting for only 0.1% of the total number of registered passenger cars calculated from the data of Automobile Inspection & Registration Information Association (AIRIA, 2016).

There still seem to be many barriers to the dissemination of EVs in Japan. In previous studies, battery technology and costs were often mentioned as barriers to the commercialization of EVs (Axsen et al., 2010). Accordingly, many studies looked at how to improve power supply systems, battery capacity, battery chargers, and other infrastructure problems, to lower the net price and improve the usability of the vehicle (METI, 2016; Staats et al., 1997; Yilmaz, M. and Krein, 2013). We believe, however, considering only the technological issues is not enough to encourage widespread use of EVs. Consumer acceptance is key to any technological shift and the long-term success of a new sustainable transport system (Ozaki and Sevastyanova, 2011). Egbue and



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Ona (2012) argued that "it is important to view EVs as part of a socio-technical system in order to break the divide between the technical and the social." The term ''socio-technical'' encompasses not just technological and engineering obstacles, but also cultural, social, political, and economic impediments (Sovacool and Hirsh, 2009). Even though automobile manufacturers and policymakers usually separate technical from social concerns in describing technological development, social barriers can be major obstacles impeding the widespread use of EVs in the mainstream market, even when technological barriers are overcomed (Egbue and Long, 2012; Sovacool and Hirsh, 2009). Therefore, attention needs to be given to what drives consumers to use or not to use EVs.

Many researchers have investigated the topic of who buys what kind of car, such as HVs (Klein, 2007; Oliver and Lee, 2010; Ozaki and Secastyanova, 2011) and biofuel vehicles (Jansson, 2011, Van de Velde et al., 2009). Others have investigated early users of EVs (Egbue and Long, 2012; Hidrue, 2011; Plötz et al., 2014). However, as can be seen in Rezvani's (2015) review of consumer perceptions of electric vehicles, few studies have examined this issue in Japanese society. In 2015, Japan was the third largest automobile market after China and the U.S., according to the official sales statistics data of Organisation Internationale des Constructeurs d'Automobiles (OICA, 2015). Thus, the aim of this paper is to investigate who is most likely to adopt EVs and the factors driving or hindering the diffusion of EV use in Japan by examining the relationship between consumer characteristics and percieved innovation attributes of EVs.

# 2 LITERATURE REVIEW

EVs provide a different driving experience compared to the typical mainstream vehicle, namely ICEs, in terms of propulsion technology, recharging infrastructure and recharging practices. In addition to this, with their remarkable ecological features, EVs meet the definition of eco-innovation given by Kemp and Pearson (2007):

> Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives.

We review previous studies from this perspective, in terms of general ideas of innovation diffusion, particularly as regards eco-innovation.

## 2.1 Diffusion of Innovation Theory

In the area of innovation diffusion, Rogers' (2003) work on a DOI (Diffusion of Innovation) framework has been attracting attention for decades. Rogers (2003) claims that even if a new idea is explicitly advantageous, innovation will still take years to be widely adopted. Consequently an issue for persons who would like to spread their ideas is how they can speed up the adoption of innovation.

In this literature review, we focused on perceived innovation attributes and consumer innovativeness relating to the product diffusion process.

### 2.1.1 Perceived Innovation Attributes

Rogers (1983) proposed five perceived innovation attributes in the individual's innovation decision-making process. Perceived innovation attributes are an important factor in explaining the rate at which an innovation is adopted. He claimed that adoption speed can be explained by the five attributes of relative advantage (e.g. economy, convenience and prestige), compatibility (e.g. values, social system and needs), complexity (difficulty of understanding and use), trialability (the degree to which an innovation may be experimented with), and observability (the degree to which the result of an innovation is visible to others). Later researchers added perceived risk as a sixth factor negatively influencing the rate of adoption (Cox and Rich, 1964). Ostlunds (1974) argues that predicting the rate of adoption from perceived innovation attributes is a far easier statistical task than to predict adoption or non-adoption on a case-by-case basis. Volliks et al. (2002) proposed that if the perceived advantage was minor, a potential adopter often decided to reject an innovation. If the perceived advantage was high, the evaluation process usually continued to perceived compatibility.

Rogers (2003) claims adoption of innovation by individuals is a process composed of five stages beginning with knowledge, persuasion, decision, and implementation and ending with confirmation. The first two stages are essential in understanding adoption behaviour since an individual forms a favorable or unfavorable opinion of an innovation in these stages. In the knowledge stage people interpret an innovation through selective perception which means people interpret the communicated message on

the basis of their norms and beliefs. In the second stage, people decide how to interpret the information on an innovation that is provided. Rogers (2003) asserts that perceptions of relative advantage and compatibility are especially important in this stage.

## 2.2 Consumer Characteristics Relating to Adopter Categories

Perception is a process of choosing information, putting it in order, interpreting it, and from there, forming a meaningful perspective (Kotler et al., 2014).This attitude formation has been found to be highly dependent on the personal characteristics of the potential adopter and on how the attributes of the innovation are perceived (Jansson, 2011). The effect of consumer characteristics on attitude formation toward an innovation is also reported by Rogers (2003). One intriguing idea is that of "innovativeness", the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system. Based on this innovativeness, Rogers (2003) separated consumers into six adopter categories: Innovators, Early Adopters, Early Majorities, Late Majorities, and Laggards. Consumers in each category are thought to share general characteristics unique to their category. Early Adopters are described as those who adopt new innovation and also become opinion leaders. Moore (1991) postulates that Innovators and Early Adaptors are consumers who buy EVs even if no one around them owns an EV. Early Majorities are the mainstream market pragmatists and conservatives who do not try an innovation until others try. In seeking ways to encourage wide use of EVs, understanding both Early Adopters and Early Majorities is important. According to Rogers (2003) socioeconomic status is related to innovativeness, such that Early Adopters have more years of education and higher social status than Late Majorities. Status is indicated by such variables as income, lifestyle, and wealth. Relevant to this, Moore (1991) explains that Early Adopters and Early Majorities share an appreciation for new technology, while Late Majorities tend to dislike using sophisticated technology. Early Adopters are more likely to try new technology if it addresses issues in which they have an interest, while Early Majorities are more conservative and pragmatic than Early Adopters.

Consumer characteristics influence the adoption of an innovation as much as perceived innovation attributes. Below are reviews of consumer characteristics and how they have been measured in the previous studies. The characteristics covered are innovativeness, scientific literacy, money behaviour and income level, and environmental attitude.

### 2.2.1 Innovativeness

While consumer innovativeness is central to discussions among innovation diffusion researchers, there is no real consensus on the meaning of the term (Roehrich, 2004). The concept of innovativeness proposed by Rogers (2003) is "the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than the other members of a system". Midgley and Dowling (1978) described it as "the time taken for an individual to adopt." This concept of innovativeness may have more relevance to situational traits than individual traits because an individual may not adopt an innovation because of insufficient income or because they live in an isolated location. This suggest that innovativeness based on personal trait should be investigated. Midgley and Dowling (1978) conceptualized innovativeness as the degree to which individuals make innovation decisions independently of information conveyed verbally between individual consumers.

Early Adopters are likely to take the risk of an innovation without asking for other peoples' opinions. Instead, they try to gather information on their own. This gathering of data may include vicarious adoption of unfamiliar product concepts and experiencing of unfamiliar consumption situations (Hirschman, 1980). "The innovation-decision process is essentially an information-seeking and information-processing activity in which the individual is motivated to reduce uncertainty about the advantages and the disadvantages of the innovation" (Rogers, 1983). That's why individuals with high innovativeness are thought to have CNS (Consumer Novelty Seeking) characteristics as well. "The CNS measure assesses one's tendency to seek out new product information, whereas the CIJM measure evaluates the degree to which an individual makes new product decisions independently of the communicated experience of others" (Manning et al., 1995). In this study, we took up CIJM (Consumer Independent Judgment Making) and CNS as representtative characteristics of consumer innovativeness.

### 2.2.2 Scientific Literacy

When consumers are exposed to an innovation, they selectively obtain information on the product, and it is known that their interests, needs, and pre-existing attitudes will affect their opinion of the product (Rogers 1983). When it comes to the adoption of EVs

and their advanced technology, the consumer's background scientific knowledge and attitude toward technology can be affected. In the context of high-tech product diffusion, Earlier Adopters tend to have a better attitude toward technology (Moore, 1991). Previous research on EVs revealed that consumers with a high level of science education are more likely to consider buying an EV (Plötz et al., 2014). In the present study we use scientific literacy instead of the educational factor as a measure of attitudes toward technology.

Saijo and Kawamoto (2008) defined scientific literacy as the "capability of making a social judgment and taking action on issues involving science and technology by linking basic knowledge." Based on this definition, they identified three scales to measure scientific literacy, the individual's interest in science and society, and appreciation of science. (Kawamoto et al., 2013; Saijo and Kawamoto, 2008).

### 2.2.3 Sociodemographics and Money Behaviour

As a general description, Rogers (2003) argued that Early Adopters tend to be of higher social status, have more income, more education, and prestigious jobs, than Late Adopters, but are not so different in age. However, Anable et al. (2011) found that demographic characteristics are insufficient for predicting and understanding the various EV adopter groups. In addition to this, Plötz et al. (2014) found that Early Adopters in Germany are generally middle-aged men with technical professions living in rural or suburban multi-person households. Thus, whether or not sociodemographics are a good predictor of Early Adopters is still in question.

In addition to this, Moore (1991) describes the Early Adopter as the least price-sensitive of any segment of the technology adoption profile. We can assume from this that an Early Adopter consumer, regardless of their income, may not be so cost sensitive. There are two scales used to assess money attitudes: Money Attitude Scale (MAS) (Yamauchi and Templer, 1982) and Money Ethic Scale (MES) (Tang, 1992; Tang, 1995). MES assesses personal attitudes toward money from three sides; an affective component (Good and Evil), a cognitive component (Achievement, Respect, and Freedom/Power), and a behavioural component (Budget). Though the MES was developed and used to evaluate the relationship between money attitude and job satisfaction, we decided to apply its versatile questions to the present study to assess the consumer's economical characteristics.

## 2.3 Environmental Attitudes, Green Consumer Characteristics

Besides the general discussion of diffusion of innovation based on the DOI framework which was first published in 1962 by Rogers (1983), there has recently been much attention paid to the diffusion of green products, in other words eco-innovation. In the period from 1986 to 1989, the rapid diffusion of green products from small specific niches to the mass market was observed (Vandermerwe and Oliff, 1990), and the 1990s would see an increase in environmental concern (Straughan and Roberts, 1999). In recent decades, the concept of a consumer voluntarily engaging (as opposed to being regulated to do so as a result of government policy) in consumer practices that are viewed as 'environmentally friendly' has emerged, and such a consumer is now generically labelled the 'green consumer' (Connolly and Prothero, 2008), and protecting the environment has become an important consideration in human decision-making (Stern, 2000). "As the new millennium draws near, key questions remain unanswered. What is the nature of the ecologically conscious consumer of the future?" (Straughan and Roberts, 1999).

Values, beliefs and norms (VBN theory) have been found to be a useful predictor of environmental behaviour (Jansson, 2010). VBN theory demonstrates a causal chain of personal values, beliefs and personal norms for pro-environmental action (Stern et al., 1999). Stern (2000) postulates four types of causal variables of environmentally significant behaviour, i.e., attitudinal causes, contextual forces, personal capabilities and habit or routine. Among these, attitudinal causes, including personal norms, are suggested to be the strongest predictor. The work of Guagnano et al. (1995) also found that attitudinal variables explain well behaviour in certain situations.

It is generally assumed that personal norms are rooted in values and social norms (Thøgersen, 2002), and that social norms also play a major role in environmental behaviour. A system of social norms specifies what is acceptable and what is not in a social group (Bicchieri, 2005). As human beings are social animals, it is understandable that people conform and change their belief and behaviour when pressured to do so by other groups. Biel and Thøgersen (2007) report that "social norms are often guiding behaviour in specific context." Especially in Japanese society where happiness and loyalty to the group are emphasized more than individual needs (Solomon and Matsui, 2015), the effect of social norms on environmental behaviour would be strong.

Environmental attitude is also thought to be a powerful predictor of ecological behaviour. (Kaiser, 1999). Attitude is different from personal and social norms because it is a positive or negative evaluation or feeling which individuals permanently own against object or thought (Kotler et al., 2014). Attitudes have been found to be predictive of many types of environmentally sensitive behaviour. (Jansson, 2011), and since EVs are representative of eco-innovation, these theories regarding the green consumer will help us to identify potential adopters of EVs.

# 3 METHODOLOGY

## 3.1 Research Questions

In the present study we investigated the perceived innovation attributes of EVs and the consumer characteristics of two groups of consumers. These consumers are identified on the basis of their intention to buy EVs: assertive consumers who intend to buy EVs and passive consumers who do not intend to buy EVs. Three research questions were generated.

RQ.1 How different are perceived innovation attributes of EVs between the two groups of consumers?

RQ.2 How different are consumer characteristics between the two groups of consumers?

RQ.3 What drives or hinders the adoption of EVs most?

In a previous study, Jansson (2011) examined the integrated research of Rogers' (1983) DOI framework from a marketing percepective and VBN theory from the perspective of environmental psychological theory. Using AFVs (alternative fuel vehicles), which run on bio fuel, as the representative of eco-innovation, a postal, mail-in survey using a self-administered questionnaire was conducted in Sweden in the fall of 2008. PCA (principal component analysis) was used to analyse the answers from 642 respondents. With this method Jansson (2011) found a set of factors driving or hindering eco-innovation adoption. In the present study, we used the same method to analyse the responses to the research questions.

## 3.2 Data Sampling

Data used for the present study were as follows:

*Period*: 24 to 25 June 2016
*Type of collecting data*: Online questionnaire through a market research company
*Target*: Car owners aged between 20 and 69 whose opinions were adopted when they bought their current cars.
*Screening*: The lowest household income level was set to be more than 2 million Japanese yen.
*Total sample size*: N = 208

In this paper, electric vehicles (EVs) are defined as passenger cars which only use a battery for propulsion, plug-in hybrid cars (PHVs) are classified as a type of hybrid car (HV) which can run on both fossil fuels and electricity, and clean diesel cars (CDs) are classified as a type of internal combustion engine car (ICE), which runs on only fossil fuels. Firstly, we divided the car owners into four groups: ICE owners who have intentions to buy an EV, ICE owners who do not have intentions to buy an EV, HV owners who have intentions to buy an EV, and HV owners who do not have intentions to buy an EV. However, because of the limited number of samples, we later decided to rebuild into two groups defined only by the intention to buy or not buy an EV.

All 208 samples were used in our analysis because firstly in this online survey, responses with missing answers were not allowed to be sent, and secondly because, after checking whole individual data, no strange answer patterns or outliers were found.

This time, actual EV owners, who are definitely early adopters at this stage, were not selected as a sampling target because of the limited number of EV owners who registered with the research company. This study is still on going and we plan to conduct the survey again with a larger sample size including actual EV owners.

## 3.3 Measures

The questionnaire consists of three parts: innovation perceived attributes, consumer characteristics and standard sociodemographic measures. It was primarily based on Jansson's (2011) original questionnaire and other literature reviews. We translated their questionnaire into Japanese and also modified some of the questions to adjust to EVs and Japanese cultural background. We made repeated translations and had them reviewed by other Japanese native speakers until we had confirmation that the translated version would be easily understood by Japanese people.

As a categorical variable, Assertive/Passive intentions to buy EVs was used. This variable was constructed from one screening question with a five-point Likert scale; "Do you intend to buy an EV?" Those who answered strongly agree and agree were categorized as "assertive consumers", and those who

answered disagree and strongly disagree were categorized as "passive consumers".

The followings are the details of measures. First, the sociodemographics data were examined. Chi-square test was used on quantitative data (i.e. ages) and *t*-test was used on qualitative data such as gender, education level, annual household income, etc.

Second, perceived innovation attributes for EVs were measured using 14 items. Each variable was all measured on a five-point Likert scale. Then they were divided into 6 components, using PCA (principal component analysis) followed by varimax rotation. The PCA on perceived innovation attributes explained the 75.4% total variance. Six subscales, relative advantage, compatibility, complexity, trialability, observability and risk, were made based on the six components and named accordingly by Rogers' (2003) DOI framework. Cronbach's alpha and AVE (average variance extracted) were checked for each component. Six components showed AVE values ranging from 0.50 to 0.74, which are considered to have acceptable validity (Fornell and Larcker, 1981). Meanwhile, the four components, except for complexity and observability, showed acceptable reliability with alpha values ranging from 0.71 to 0.86. Cronbach's alpha for complexity and observability was less than 0.70, meaning that reliability and internal consistency are not enough to be acknowledged as components (Bland, 1997), and therefore these two attributes were not used in the analysis. The subscales' mean difference in the two consumer groups was tested using t-test.

Third, consumer characteristics were measured using 26 items. Each variable was measured on a five-point Likert scale. Then they were divided into 9 components using PCA followed by varimax rotation. The PCA on consumer characteristics explained a 75.4% total variance. Nine subscales, personal environment norm, social environment norm, attitude toward EVs, CIJM, CNS, scientific interest, social interest, scientific appreciating and money behaviour were made based on the PCA result.

Pro-environmental personal norm was measured using 3 questions derived from the works of Janson (2011), Steg et al. (2005) and Stern et al. (1999). Social norm was measured using 4 questions and Attitude toward EVs was measured using 3 questions partially derived from the works of Janson (2011). CNS and CIJM were measured using 3 and 4 questions each, and both scales were developed based on Jansson (2011) and Manning et al. (1995). Scientific interest, social interest and science appreciating were measured using 3, 3 and 4 questions from the work of Kawamoto et al. (2013). Money behaviour was measured using 2 questions from the work of Tang (1995). The nine components showed acceptable reliability with alpha values ranging from 0.81 to 0.94. Seven components showed acceptable AVE values ranging from 0.59 to 0.87, however, scientific interest and social interest showed values of 0.41 and 0.48, below than 0.50 which is considered to have no validity (Fornell and Larcker, 1981). Therefore, these two attributes were not used in the analysis. The subscales' mean difference in the two consumer groups was tested using t-test.

All analyses were conducted on IBM SPSS Statistics 23.

# 4 RESULT

Firstly, before looking into differences in the extracted components, we analysed the sociodemographic data of the two consumer groups. Then the two consumer groups' components' means and standard deviations were checked.

## 4.1 Sociodemographics

Sociodemographics are often considered to be one of the main factors affecting consumer decision making, and are often used as a tool to segment consumer categories. In Table 1, sample descriptions and sociodemographic variables are explained. Recent studies suggest, however, that the consumer characteristics tested below are not a strong enough factor to segment green consumers (Straughan and Roberts, 1999). Meanwhile, in the area of EV consumer studies, some recent studies use demographics to explain consumer adoption of EVs (Plötz, 2014) while others deny the importance of demographics (Anable et al., 2011). To understand the effect sociodemographics have on the intention of buying EVs, the Chi-square test is used for numerical data (i.e. ages) and t-test were used for categorical data such as gender, number of persons in the household and annual driving distance. However, as shown in Table 1, there were no statistically significant differences between these two consumer groups in any of the sociodemographic data.

## 4.2 Perceived Innovation Attributes

In Table 2, mean, standard deviation, communality, Cronbach's alpha and AVE values for six components resulting from PCA on perceived innovation attributes of EVs are shown to investigate the difference between how the two consumer groups

of assertive and passive perceive EVs. We compared the mean difference of 4 subscales based on PCA. Table 3 shows mean, standard deviation, difference and the result of t-test on the subscales of perceived innovation attributes. There were significant differences in relative advantage, compatibility and trialability in the two consumer groups ($p < 0.001$). Meanwhile, no significant difference was apparent in perceived risk ($p > 0.05$). The biggest difference was compatibility, followed by trialability and relative advantage.

### 4.3 Consumer Characteristics

In Tables 4 and 5, mean, standard deviation, communality, Cronbach's alpha and AVE values for 9 components resulting from PCA on consumer characteristics of EVs are shown. To investigate the different characteristics of the two assertive and passive consumer groups, we compared the mean difference of 7 subscales based on PCA. Table 6 shows mean, standard deviation, difference and the result of t-test on the subscales of consumer characteristics. There were significant differences in pro-environmental social norm, attitude toward EVs, CNS, CIJM ($p < 0.001$), scientific appreciating ($p < 0.01$) and pro-environmental personal norm ($p < 0.05$). Meanwhile, no significant difference was apparent in money behaviour ($p > 0.05$). The biggest difference was seen in pro-environmental social norm followed by CNS, CIJM, attitude toward EVs, science appreciating and personal environment norm.

## 5 CONCLUSION AND FUTURE RESEARCH

The present study attempted to examine mind-set factors which will identify the differences of consumer groups and which will drive or hinder the widespread diffusion of electric vehicles in Japan by applying psychological research and a diffusion of innovation framework. Several important conclusions are derived from the findings in this study. First, assertive consumers are more likely than passive consumers to perceive EVs as more advantageous than other cars using different kinds of propulsions. Second, assertive consumers felt more compatibility with EVs than passive consumers. Third, assertive consumers generally showed a higher level of consumer characteristics marking them as Early Adaptors of eco-innovation as described in previous studies.

Table 1: Sociodemographic variables (N=208).

| Sociodemographic | | Assertive Consumers | Passive Consumers | p |
|---|---|---|---|---|
| Gender | Female | 26.9% | 26.9% | n.s. |
| | Male | 73.1% | 73.1% | |
| Number of persons in household | Single | 11.5% | 6.7% | n.s. |
| | 2 | 27.9% | 28.8% | |
| | 3 | 32.7% | 33.7% | |
| | >4 | 27.9% | 30.8% | |
| Children in household | Yes | 71.2% | 71.2% | n.s. |
| | No | 28.8% | 28.8% | |
| Educational background | (Junior) High school | 17.3% | 21.2% | n.s. |
| | Vocational college/Junior college | 17.3% | 26.0% | |
| | Bachelor | 61.5% | 48.1% | |
| | Master | 3.8% | 4.8% | |
| Age of car owner | Mean (SD) | 51.3 (10.5) | 51.7 (9.1) | n.s. |
| Annual household income in millions of JPY | 2-4 | 15.4% | 16.3% | n.s. |
| | 4-6 | 26.9% | 23.1% | |
| | 6-8 | 14.4% | 24.0% | |
| | 8-10 | 20.2% | 15.4% | |
| | >10 | 20.2% | 21.2% | |
| House type | Solitary | 59.6% | 64.4% | n.s. |
| | Condominium | 40.4% | 35.6% | |
| Number of cars in household | 1 | 63.5% | 59.6% | n.s. |
| | 2 | 27.9% | 28.8% | |
| | >3 | 8.6% | 11.6% | |
| Annual driving distance, km | <3,000 | 13.5% | 15.5% | n.s. |
| | 3,000-5,000 | 13.5% | 20.2% | |
| | 5,000-10,000 | 35.6% | 33.7% | |
| | 10,000-15,000 | 22.1% | 10.6% | |
| | >15,000 | 13.5% | 16.3% | |
| | Don't know | 1.9% | 3.8% | |

n.s. = not significant ($p>0.05$)

Table 2: Principal components and scale reliability for perceived innovation attributes (N=208).

| Perceived innovation attributes | Mean | SD | Component | | | | | | Communality |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | |
| ***Relative advantage*** [a] | | | | | | | | | |
| EVs are excellent cars using state-of the-art technology. | 3.84 | 0.858 | .824 | | | | | | 0.763 |
| To use EVs would decrease my fossil carbon dioxide emissions. | 3.92 | 0.999 | .815 | | | | | | 0.721 |
| There are more financial advantages for me if I purchase and use EVs than using ICEs or HVs. | 3.33 | 1.104 | .599 | | | | | | 0.631 |
| ***Compatibility*** [a] | | | | | | | | | |
| As long as my usage of cars, the length of time to recharge EVs are acceptable. | 2.77 | 1.184 | | .834 | | | | | 0.819 |
| The range of EVs' cruising distance is enough for my usage of cars. | 2.84 | 1.260 | | .732 | | | | | 0.701 |
| There are rechargers for EVs close to me. | 2.57 | 1.230 | | .724 | | | | | 0.689 |
| ***Complexity*** [a] | | | | | | | | | |
| It is hard to drive EVs. | 2.48 | 1.031 | | | .871 | | | | 0.812 |
| It is difficult to maintain EVs compared to other cars. | 3.42 | 1.042 | | | .758 | | | | 0.722 |
| ***Trialability*** [a] | | | | | | | | | |
| Before I decide to buy EVs, it is possible to try comfortableness by riding in someone else's EV. | 2.57 | 1.230 | | | | .834 | | | 0.824 |
| Before I decide to buy EVs, it is possible to test drive EVs. | 3.01 | 1.210 | | .501 | | .648 | | | 0.784 |
| ***Observability*** [a] | | | | | | | | | |
| EVs visually stand out. | 3.06 | 1.039 | | | | | .908 | | 0.897 |
| By riding an EV, I can show that I care about the environment. | 2.80 | 1.152 | | | | | .542 | | 0.727 |
| ***Risk*** [a] | | | | | | | | | |
| To buy an EV means a financial risk for me. | 3.56 | 0.882 | | | | | | .898 | 0.826 |
| EVs are risky since there are concerns such as a battery malfunction. | 3.61 | 0.867 | | | | | | .823 | 0.777 |
| *Cronbach's alpha* | | | 0.71 | 0.82 | 0.61 | 0.73 | 0.64 | 0.76 | |
| *AVE* | | | 0.57 | 0.50 | 0.67 | 0.58 | 0.56 | 0.74 | |
| *Percentage of variance explained* | | | 14.8 | 17.8 | 10.7 | 11.8 | 9.2 | 12.2 | |

Assertive consumers N = 104, Passive consumers N = 102.
Scale: a…1, strongly disagree… 5, strongly agree
Principal component analysis; Varimax rotation with Kaiser Normalization; loading less than 0.50 are not shown.
Total variance explained 76.4%; KMO = 0.813; Bartlett's test chi-sq. = 1060.622 (df = 171, p = 0.000)

Table 3: Subscales of perceived innovation attributes and differences between 2 consumers groups (N=208).

| Perceived innovation attributes | Assertive consumers | | Passive consumers | | Δ | P |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | |
| Relative advantage | 3.97 | 0.68 | 3.43 | 0.80 | 0.54 | 0.000 |
| Compatibility | 3.17 | 0.97 | 2.28 | 0.92 | 0.89 | 0.000 |
| Complexity | - | - | - | - | - | - |
| Trialability | 3.22 | 0.97 | 2.37 | 1.02 | 0.85 | 0.000 |
| Observability | - | - | - | - | - | - |
| Risk | 3.55 | 0.74 | 3.62 | 0.81 | -0.07 | n.s. |

n.s. = not significant (p>0.05)
Δ = Mean (Assertive consumers) – Mean (Passive consumers)

Table 4: Principal components and scale reliability for scientific literacy and money behaviour (N=208).

| Consumer characteristics | Mean | SD | Component | | | | Communality |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | |
| ***Scientific interest*** [a] | | | | | | | |
| I am knowledgeable of science and technology. | 2.92 | 1.047 | .711 | | | | 0.789 |
| I am good at grasping a commonality among things. | 3.22 | 0.953 | .614 | | | | 0.709 |
| I wish to know more about science and technology. | 3.40 | 1.054 | .587 | | | | 0.742 |
| ***Social interest*** [a] | | | | | | | |
| I am interested in the issue of welfare. | 3.02 | 0.963 | | .800 | | | 0.810 |
| I am interested in the issue of culture. | 3.33 | 0.963 | | .605 | | | 0.701 |
| I am interested in the issue of local society. | 3.16 | 0.916 | | .581 | | | 0.732 |
| ***Science appreciating*** [a] | | | | | | | |
| Scientific findings and technological developments enrich human society | 3.60 | 0.896 | | | .829 | | 0.837 |
| I trust scientists and engineers | 3.69 | 0.807 | | | .821 | | 0.803 |
| I hope scientific thinking prevails more in the society | 3.55 | 0.861 | | | .782 | | 0.800 |
| I am interested in the issue of economy | 3.49 | 0.983 | | | .628 | | 0.678 |
| ***Money behaviour*** [a] | | | | | | | |
| I use my money very carefully. | 3.59 | 0.864 | | | | .897 | 0.872 |
| I budget my money very well. | 3.55 | 0.986 | | | | .880 | 0.871 |
| *Cronbach's alpha* | | | 0.81 | 0.81 | 0.87 | 0.86 | |
| *AVE* | | | 0.41 | 0.48 | 059 | 0.87 | |
| *Percentage of variance explained* | | | 5.2 | 5.6 | 10.2 | 5.5 | |

Table 5: Principal components and scale reliability for norm, attitude and innovativeness (N=208).

| Consumer characteristics | Mean | SD | Component | | | | | Communality |
|---|---|---|---|---|---|---|---|---|
| | | | 5 | 6 | 7 | 8 | 9 | |
| ***Pro-environmental personal norm*** [a] | | | | | | | | |
| I feel a moral obligation to conserve fossil fuels such as gasoline and kerosene no matter what other people do. | 3.75 | .961 | .875 | | | | | 0.812 |
| People like me should do everything they can do to decrease their use of fossil fuels such as gasoline. | 3.64 | .873 | .828 | | | | | 0.832 |
| Personally, I feel that I should not travel by car which has bad fuel efficiency. | 3.76 | .948 | .702 | | | | | 0.694 |
| ***Pro-environmental social norm*** [a] | | | | | | | | |
| People surrounding me think that I should replace my car with a so-called environmentally friendly car. | 2.98 | 1.094 | | .881 | | | | 0.872 |
| People surrounding me think that I should conserve fossil fuels such as gasoline. | 3.10 | 1.045 | | .851 | | | | 0.845 |
| People surrounding me think that I should travel by car as little as possible. | 2.91 | 1.064 | | .836 | | | | 0.872 |
| People surrounding me think that I should drive a car that runs on a different propulsion from fossil combustion such as EVs and HVs. | 3.00 | 1.088 | | .823 | | | | 0.817 |
| ***Attitude toward EVs*** [a] | | | | | | | | |
| Cars which run on electricity are classified as environmentally friendly. | 3.72 | 0.933 | | | .875 | | | 0.854 |
| Cars which run on only electricity are more environmentally friendly than HVs which run on both electricity and fossil fuels. | 3.58 | 0.318 | | | .845 | | | 0.807 |
| Cars which partially run on electricity are more environmenttally friendly than cars which run on only fossil fuels. | 3.72 | 0.749 | | | .755 | | | 0.707 |
| ***Consumer independent judgement making*** [b] | | | | | | | | |
| When I buy a new product or service, I often ask acquaintances with experience of the product/service for advice. | 2.60 | 0.749 | | | | .887 | | |
| When I'm interested in buying a new product/service, I usually trust the opinions of friends who have used the product/services | 2.64 | 0.918 | | | | .874 | | |
| Before buying a product from a new brand/manufacturer, I usually ask someone with experience of the brand/manufacturer for advice. | 2.69 | 0.933 | | | | .868 | | |
| ***Consumer novelty seeking*** [a] | | | | | | | | |
| I continuously look for new products and brands/manufacturers. | 2.90 | 1.127 | | | | | .838 | |
| I continuously look for new experiences from new products. | 2.94 | 1.068 | | | | | .827 | |
| I like to visit places where I'm exposed to information about new products and brands. | 3.13 | 1.047 | | | | | .796. | |
| I like newspapers and magazines that inform me about new brands. | 3.21 | 1.112 | | | | | .788 | |
| *Cronbach's alpha* | | | 0.81 | 0.94 | 0.85 | 0.93 | 0.92 | |
| *AVE values* | | | 0.65 | 0.72 | 0.68 | 0.77 | 0.66 | |
| *Percentage of variance explained* | | | 6.5 | 10.8 | 7.0 | 8.0 | 10.4 | |

Assertive consumers N = 104, Passive consumers N = 102.
Scale: a…1, strongly disagree… 5, strongly agree, b…1, strongly agree… 5, strongly disagree,
Principal component analysis; Varimax rotation with Kaiser Normalization; loading less than 0.50 are not shown.
Total variance explained 80.6.1%; KMO = 0.871; Bartlett's test chi-sq. = 4352.661 (df = 406 p = 0.000)

These characteristics include pro-environmental personal norm, pro-environmental social norm, attitude toward EVs, CNS and science appreciating. Fourth, contrary to expectations based on the literature, passive consumers showed a high level of CIJM. Fifth, there were no significant differences in money behaviour and perceived risk. Last, huge gaps were found in compatibility and pro-environmental social norm between assertive consumers and passive consumers.

## 5.1 Discussion

In contrast to consumer novelty seeking (CNS), consumer independent judgment making (CIJM) was not high in assertive consumers. If they are Early Adopters of EVs, this implies different behaviour from the usual Early Adopter pattern. Rogers (2003) characterized Early Adopters as opinion leaders, meaning they can form their own opinions. Early Majorities, in contrast, are rarely opinion leaders and are often deliberate in their decision making.

If we consider the assertive consumer to be of the Early Majority, the discrepancies of CNS and CIJM are understandable. Since these consumers are quite deliberate, they like to seek new information to take into consideration. This view is also supported by the higher social pro-environmental personal norm of this type of consumer, meaning they are generally more affected by the opinion of others. In addition to this, assertive consumers had a high level of scientific literacy, which is in line with the Early Adopter and

Table 6: Subscales of consumer characteristic attributes and differences between 2 consumer groups (N=208).

| Consumer characteristics | | Assertive consumers | | Passive consumers | | Δ | P |
|---|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | | |
| Green Consumer | Pro-environmental personal norm | 3.83 | 0.77 | 3.60 | 0.79 | 0.23 | 0.034 |
| Attitudinal Factors | Pro-environmental social norm | 3.38 | 0.85 | 2.62 | 0.96 | 0.76 | 0.000 |
| | Attitude towards EVs | 3.91 | 0.67 | 3.53 | 0.80 | 0.38 | 0.000 |
| Innovativeness | Consumer independent judgment making | 2.42 | 0.78 | 2.87 | 0.96 | -0.45 | 0.000 |
| | Consumer novelty seeking | 3.37 | 0.89 | 2.72 | 0.95 | 0.65 | 0.000 |
| Scientific Literacy | Scientific interest | - | - | - | - | - | - |
| | Social interest | - | - | - | - | - | - |
| | Science appreciating | 3.71 | 0.67 | 3.44 | 0.80 | 0.27 | 0.009 |
| Money behaviour | Money behaviour | 3.65 | 0.83 | 3.49 | 0.90 | 0.16 | n.s |

n.s. = not significant ($p>0.05$)
Δ = Mean (Assertive consumers) – Mean (Passive consumers)

Early Majority types according to Moore's (1991) description.

Thus to think of these consumers as Early Majorities waiting for someone else's opinions to push their decision making is reasonable. We conclude that these consumers are closer in type to the Early Majority than the Early Adopter. This result suggests the biggest difference between Early Adopters and Early Majorities may be CIJM. In addition, this data supports the suggestion made by Moore (1991) that Early Majorities are unlikely to make the actual decision to buy. To know the real characteristics of Early Adopters we need to investigate actual EV adopters.

## 5.2 Implications

Findings from our study suggest the necessity of environmental consciousness promotion by the government. The biggest difference in consumer characteristics found in our study between assertive and passive consumers was pro-environmental social norm. Consumers who had assertive intentions to buy EVs felt more pressure from the people surrounding them. Additionally, since assertive consumers were found to be less willing to make their own judgments, as indicated by their low level of CIJM, we suggest that these consumers would react positively to imposed pressure to buy EVs. Moreover, according to the results of the World Wide Views conducted in 2015 by the Japan Science and Technology Agency (JST, 2015), Japanese people tend to think that the government has more responsibility to deal with climate change than citizens, which was opposite of the results in the rest of the world. Therefore, it would be pointless for manufactures to appeal directly to these people regarding the EV's ecological features. Social pressure is thought to be important to make passive consumers buy EVs, and social pressure can come from an atmosphere of environment consciousness. We suggest the government should make a major effort to promote EVs through the media so as to generate peer pressure.

Take the example of "cool-biz," a campaign launched by the Ministry of the Environment (MOE) to encourage business people to wear cool and comfortable clothes to work so that offices could be kept at the more energy-efficient temperature of around 28 degrees C (MOE, 2005). Before this campaign, Japanese office workers were implicitly obliged to wear formal suits even under the glistening sun. Sampei and Aoyagi-Usui (2009) found evidence that the increase in newspaper coverage of global warming correlated with an increase in public concern about the issue. In the first four years of the cool-biz campaign, the rate of setting air conditioner temperatures higher rose from 32.5% to 61.8% (MOE, 2012). EVs are a high involvement product and the adoption of cool biz and the adoption of EVs are in quite different contexts. Still, this provides an example of how the Japanese people can be persuaded to change their habits by governmental promotion.

## 5.3 Limitations and Future Study

Like all studies, our study contains some notable limitations.

First, the present study is only an exploratory study of non-EV owners. We investigated perceived innovation attributes and consumer characteristics of two different groups of consumers based on their intentions to buy EVs in the future. However, it is important to note that our objective was to examine actual drivers and obstacles to the widespread dissemination of EVs. Considering that having the intention to buy an EV and actually buying an EV are different phases of decision making, there is likely to be a huge difference between actual adopters and assertive consumers. In our next study, therefore, we will also investigate actual EV owners as well.

Second is the cultural gap of understanding reflected in the questionnaire. In this study, all perceived innovation attributes and consumer characteristic scales were introduced from previous studies. Because

of different cultural background, some variables, such as complexity and observability are not extracted properly.

Third is the biggest limitation of small sampling size. We could only gather 208 samples using a third party agent. To fully explain and adopt the statistical method, a larger sample size is required.

Fourth, tangible and real estate limits were not well considered. As we noted above, compatibility is a major factor in having intentions to buy EVs. EVs require a recharging station. However, in this study the relationship between the tangible location of EV rechargers and consumer residential areas was not considered.

Still, despite these limitations, this study does give some idea of the drivers and obstacles to stimulating intentions to buy EVs. Future studies can explore some of the issues identified in this study with a larger and more representative sample of car owners, namely EV owners. By investigating this group we should be able to elaborate on the differences between Early Adopters, Early Majorities and Late Majorities in the case of EVs. These findings will provide us with the seeds to knowing what kind of information should be communicated to consumers in the different adoption stages of diffusing innovation.

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