Overcoming Present Bias to Increase the Adoption of Electric Vehicles

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Abstract:

Although the government-promoted incentivizing policies can increase people's interest in the adoption of electric vehicles (EVs) (Zhang et al., 2011), the efficacy of these policies is often lower than expected (Li et al., 2017). One reason might be that there are many psychological factors that impact people's decision-making process that the existing policies cannot cover (Li et al., 2017). Among these factors, cognitive barriers play a prominent role (Weber, 2017). In particular, present bias leads people to focus on the salient price premium rather than the long-term low operational costs of EVs (Dumortier et al., 2015). Lacking policy actions to overcome this bias, the automaking companies who recognize the problem and implement behavioral methods to solve it can benefit from being the first-movers in the market, creating a huge profit opportunity through increasing sales and penetrating the US market. Partnering with a private automaking company, Nissan, this proposed behavioral intervention aims to address the problem of present bias. The study will be a 2 x 4 online experiment that examines if different time frames and the framing (gain vs. loss) of messaging make a difference in people's willingness to adopt EVs. The author anticipates that presenting information in a shorter time frame and in the loss frame can significantly increase people's willingness to adopt an EV. The following proposal frames the problem within the appropriate context, provides an explanation of the intervention's design, and indicates directions for future research.

1. Motivation

Human behavior is a large causing factor of environmental problems (Steg & Vlek, 2009; Vlek & Steg, 2007). The continuation of high fossil fuel emissions can worsen the global carbon cycle and cause disastrous consequences on nature, creating survival threats for the future generations (Hansen et al., 2013). Research has highlighted the urgent need for changing human behavior to promote environmental sustainability and for policies that could reduce carbon emissions (Schandl et al., 2016).

Transportation is a major contributor to global carbon emissions (Hertwich & Peters, 2009). In the face of climate change, there has been an increase in the interest to replace conventional gasoline vehicles (CVs) with vehicles using alternative fuels, such as electric vehicles (EVs). In the US, the federal and state governments have built monetary and non-monetary incentives to promote EV adoption, such as tax credits, free public charging, free parking, and access to high-occupancy vehicles (HOV) lanes (Jin et al., 2014). Despite the already huge government investment in EVs, the current incentives are limited in their abilities to increase EV adoption. The electric share of new vehicles in the US has only risen from about 0% in 2010 to 2% in 2018 (ICCT, 2019). Following this trend, achieving transport carbon neutrality by 2050 will be very challenging (Schreyer et al., 2020; Milovanoff et al., 2020).

This low adoption rate is concerning not only for policy-makers but also for the traditional automaking industry. Many car companies have transformed from producing CVs only to producing both CVs and EVs. Some car companies have even announced that they will be all-electric in the near future. For example, Volkswagen in 2018 set the goal of producing only EVs after 2026 (Moris, 2018), and Toyota announced in 2017 to stop producing CVs by 2040 (Galeon, 2017). Companies have also invested heavily in developing technologies. In 2022, it is estimated that about 450 new EV models with improved technologies on charging time and driving range will be put in the market (McKinsey, 2020). However, the current slow increase in the EV adoption rate in the US gives the car companies risks of losing profits and potentially failing to make even their investments.

Among all factors that influence consumer intentions to adopt EVs, the high front purchasing cost was found to be one of the most prominent barriers to EV adoption (Weber, 2017; Dumortier et al., 2015).

Due to present bias, people prefer outcomes that are closer to the present even if the more present outcomes are less beneficial than the future outcomes (Kleinberg, Oren, & Raghavan, 2016). When it comes to a purchase decision, consumers rely heavily on the easy-to-rationalize price tags instead of calculating the complicated long-term costs and benefits (Dumortier et al., 2015). Since EVs are not yet cost-competitive with CVs (Danielis et al., 2018), consumers can easily anchor to the high purchase prices of EVs and thus choose CVs without realizing that the low operational cost of EVs can offset much or all of the front premium cost in the long run (Dumortier et al., 2015; Weber, 2017).

To counter this cognitive barrier, it is natural to turn our attention to behavioral interventions, where there is growing empirical evidence that promises highly-beneficial environmental effects (Sunstein & Thaler, 2003) that are both effective and cost-efficient (Benartzi et al., 2017). While the solutions to present bias have been studied in various contexts, there has not been much study in the context of EV adoption. Existing research has confirmed that providing information on the costs and savings of owning an EV can move consumers' decision-making process to a more future-oriented one, but how the information is presented and the traits of the individuals matter. An online study by Dumortier et al. (2015) found out that total cost of ownership disclosure could increase American consumers' interest in electric vehicles, but providing five-year fuel expenditure savings had no effect, possibly because consumers did not know how to relate this information to the salient high purchasing cost of EVs. While Dumortier et al. (2015) only described the fuel cost savings in the gain frame, past research has demonstrated the effectiveness of loss-framed messages on overcoming present bias in different contexts (Bowman et al., 1999; Jenssen et al., 2019; Aytac, 2020). Another study by DellaValle & Zubaryeva (2019) partially confirmed the results of Dumortier et al. (2015): providing information about the vehicles' life-cycle operating costs can increase the likelihood of choosing EVs among consumers in South Tyrol, Italy. However, the effect was limited to individuals with pro-environmental and reciprocal beliefs and those who prefer delayed benefits.

Past research has either used hypothetical car models (Dumortier et al., 2015), which cannot reflect people' preferences on real EVs, or incorporated actual car models but left the effect of customer loyalty to brands or car models uncontrolled (DellaValle & Zubaryeva, 2019). Hoping to resolve both design problems in the current study, the author is going to partner with Nissan to use realistic statistics on Nissan car models and collect data from Nissan customers only to control for the brand effect. Among all potential partners, Nissan is the most suitable car company to partner with due to its popularity and focus on developing the US market. The US is the second largest market of the Nissan EV model, Leaf, with more than 148,000 sold in 10 years since 2010 (Nissan, 2020 December). Additionally, Nissan has announced to introduce its new model, Ariya, an electric crossover SUV, to the US market by the end of 2021 (Nissan, 2020 July). Seeing the US as an important market to explore, Nissan is very likely to partner with the author and support this foundational and worthwhile research, as this research can give Nissan the advantage of being one of the first car companies that can increase the sales of EVs by helping consumers to overcome present bias.

Considering that California takes up almost half of the EV sales in the US (California Energy Commission, 2021), the author proposes to run the intervention in California, US, where the concept of EV adoption is salient and government resources on EV adoption are plenty and accessible. In addition to the federal tax credit, California residents can get up to $1500 for buying or leasing an EV, and low-income residents can get grants or financing assistance through the Clean Vehicle Assistance Program (Clean Vehicle Rebate Project, n.d.). The CA government has also been developing public charging infrastructure. By April 2019, California has the third largest EVs-to-charging-outlets ratio (25.73) across the states, which is way above the country median (11.15) (Evadoption, 2019). In 2020, Governor Gavin Newsom has also announced an investment of $384 billion over the next three years on the electric-vehicle charging and zero-emission vehicle infrastructure to reach one million charging stations (John, 2020). Running the intervention in California can also benefit Nissan, as Nissan's EV model Leaf has the second highest cumulative sales (30,113 cars) from 2010 to 2021 in California, compared to EV models of other car brands that produce a mix of CVs and EVs (California Energy Commission, 2021).

In short, this study aims to examine solutions to present bias in order to increase the adoption of EVs. Inspired by previous research, this research investigates the effect of the time frame and message framing of the fuel costs on people's willingness to adopt EVs. Furthermore, heterogeneity in individuals' traits such as pro-environmental beliefs and economic preferences might also affect people's decisions. Therefore, to isolate the effect of the intervention, major sources of heterogeneity will be controlled. Hoping to get meaningful practical implications out of this study, the author will partner with Nissan and implement the study in California, US.

The paper is divided into five parts. In section 2, I demonstrate the background of the research and introduce the hypotheses. Section 3 presents the experimental design. Section 4 explores data analysis method and expected results. Finally, in section 5, I discuss the limitations and implications of the study and conclude the study.

2. Background

Dumortier et al. (2015) has studied the effect of providing total cost of ownership (TCO) information and five-year fuel expenditure savings on people's intentions to purchase EVs. TCO included information about the initial purchase price, fuel expenses, and other operating cost of the vehicle over the lifetime of the vehicle. Fuel expenditure savings is the delta between the expenditure on gas and electricity given the gas prices and electricity rates in the region and the planned length of use of the vehicle. In the experiment, participants looked at EPA labels of four types of vehicles -- gasoline, conventional hybrid, plug-in hybrid, and battery electric vehicle. Information presented on the labels differ by treatment groups. In the control group, participants saw typical EPA labels with information on fuel economy (the distance a vehicle can travel per unit of fuel used), annual fuel cost, purchasing price, and the Fuel Economy & Greenhouse Gases Rating (among all available vehicles in the market). In treatment group 1, participants saw typical EPA labels plus information on monthly total cost of ownership. In treatment group 2, participants saw the EPA labels shown in treatment group 1 plus information on the 5-year fuel expenditure savings. Then, participants picked their top choice of vehicle for possible purchase and ranked the remaining vehicles based on their preferences.

The results of the study provided insights on how the time frame of the information presented can impact people's preference for EV adoption. While presenting monthly TCO was found to shift people's preference to EVs, providing 5-year cost expenditure savings had no effect, possibly because participants could not relate the 5-year savings to the presently salient price premium. This speculation is supported by other research: a recent meta-analysis of present-bias estimation indicated that the time delay between the "current" time period and the issue of the reward could impact how present-biased people were (Imai et al, 2021). In other words, the time frame of a message can make a difference in how people perceive the delayed rewards.

It is important to note that in the study, the fuel cost savings were presented in the gain frame (e.g. "You save $8,955 in fuel costs over 5 years"). Research that studied present bias in other contexts has demonstrated that leveraging loss aversion, framing the message in a loss frame can make a difference in people's preference for delayed rewards. Loss-framed health messages were more effective at encouraging people to do preventive activities that give people long-term benefits, such as screening (Jenssen et al., 2019). Loss-framed messages could also reduce people's temptation to overspend and increase future savings (Bowman et al., 1999; Aytac, 2020). Given that loss-framed messages were found effective to reduce people' present bias in different contexts, it would be interesting to investigate if loss-framed messages can influence EV consumer's purchasing decisions.

Also important to consider was the limitation of the study's experimental design. Instead of using statistics on actual vehicles, the study used "generic" models with hypothetical statistics calculated based on many assumptions. Thus, the participants' preferences on the generic models may not reflect their preferences on the actual models. In contrast, DellaValle & Zubaryeva (2019) incorporated statistics of actual car models into hypothetical purchasing scenarios. In the baseline treatment, participants were shown a scenario in which information about price and technical characteristics was provided. In the *salience* treatment, participants were also presented with the vehicles' life-cycle operating costs to make the EVs' future cost savings salient. While the study found that presenting this additional information could increase people's willingness to adopt EVs, the researchers highlighted that the effect was mainly attributed to individual traits including pro-environmental beliefs and time and risk preferences. Research has also found other demographic factors that can impact people's intentions to adopt EVs, including individual factors (age, gender, income, education, and transport habits) and family factors (numbers of vehicles in the family) (Li et al., 2017). To isolate the effect of the intervention, it is necessary to control for these major heterogeneous factors.

Additionally, although DellaValle & Zubaryeva (2019) used actual car models, it failed to control for the impact of brand or model loyalty that consumers might have. In the scenarios, brand names were listed under the pictures of the car models, potentially biasing the participants' decision-making process.

Inspired by the intersection of previous research, the current study investigates if using different time frames and framing of the message of the fuel expenditure savings can make a difference in consumers' intentions to adopt EVs. In order to control for the influence of customer loyalty on consumers' decisions and reflect people's preferences for actual car models, the author will partner with Nissan and run the study in California. Given that research studying present bias in contexts other than EV adoption have demonstrated the effectiveness of loss-framed messaging, and that consumers are better at rationalizing more-present rewards, the hypotheses are as follows:

H1*: Using loss-framed messaging can increase people's intention to purchase an EV more than using gain-framed messaging.*

H2*: Describing rewards in a shorter time frame can increase people's intention to purchase an EV more than in a longer time frame.*

3. Experimental Design

3.1 Participants

While the experiment will be conducted online, participants will be recruited offline through Nissan dealers to ensure only people who are interested in purchasing a new Nissan vehicle participate in the study. When people visit the stores, Nissan staff members will provide the customers with the website link to the online experiment. The staff members will also inform them of the opportunity to have a 10% chance of getting a $100 coupon in return if they complete the study within 5 days. Participants will give their contact information to the staff members if they agree to participate.

In total, 450 participants will be recruited. Participants will be limited to Nissan customers in California, US to ensure all participants have the same general context of the scenarios presented. Participants also have to have a valid driver's license and must be at least 18 years old.

3.2 Procedure

The link provided by Nissan staff members will guild participants to an online Qualtrics survey. Participants will complete the survey in private, and all responses will be anonymous.

The procedure of this study is adopted from Dumortier et al. (2015). Participants will first select their preferred type of vehicle, a car or a SUV. This step aims to screen out people who intend to buy other types of vehicle, such as a van or sports car. Then, participants will be introduced to the terms used in the coming scenarios to describe the features of a vehicle, including fuel economy (MPG and MPGe), total cost of ownership, fuel expenditure, and fuel expenditure savings.

Participants will be randomly assigned to one of eight treatment groups: two message framings (gain vs. loss) and four time frames (monthly, annually, 5-year, and 10-year) describing the fuel expenditure savings (Table 1). Participants will proceed to read a hypothetical scenario of Joe purchasing a Nissan vehicle. Instead of using "you" (i.e., the participants themselves as the character in the scenario), the study will use an imaginary character, which can help eliminate participants' potential social desirability bias to "look good" (Biccheri et al., 2014). The content of the scenario depends on which treatment group the participant is assigned to and the participant's preferred type of the vehicle. The details of the scenarios are described in section 3.3.

After reading the vignette, participants will answer a question: "*On a scale of 1 to 5, how likely do you think Joe will purchase the electric vehicle?*"

		Message Framing	
		Gain Frame	**Loss Frame**
Time Frame	**Monthly**	*T1*	*T5*
	Annually	*T2*	*T6*
	Five-Year	*T3*	*T7*
	Ten-Year	*T4*	*T8*

Table 1 *– 2 x 4 Study Design*

Then, participants will complete questionnaires that measure their individual traits. They will complete the 19-item Environment Attitudes Scale (Heyl et al., 2013) that assesses participants' attitudes toward protecting the environment, the 7-item future time orientation dimension of the Stanford Time Perspective Inventory (Zimbardo & Boyd, 1999), and the four-item Risk Averseness Scale that measures a consumer's degree to avoid taking risks in life (Burton et al., 1998). From 1 (strongly disagree) to 7 (strongly agree), participants need to rate their levels of agreement with the items listed in each scale.

Lastly, participants will report their demographic information including age, gender, income, education, transport habits, and the number of vehicles in the family. This information may also be used by Nissan to better understand their customers. After participants respond to all questions, they will be thanked and debriefed.

3.3 Scenarios

All participants will read a story of Joe, who is a person suggestively similar to the participant, purchasing a vehicle from a Nissan dealer. Participants will be introduced to two vehicle models of Nissan that Joe is interested in, a CV and an EV. The car models presented correspond to the participant's preference of the car type. If the participant chooses an SUV in the beginning of the survey, in the scenario, Joe will choose between the conventional SUV model Rogue and the electric SUV model Ariya.

If the participant chooses to purchase a car, in the scenario, Joe will choose between the conventional car model Altima and the electric car model Leaf[1].

Statistics on the car models will be presented. Participants in all treatments will see information on the technical features of the two vehicles, (fuel economy, range, cargo space, and horsepower), price of the vehicles, yearly total cost of ownership over 5 years, and an introduction of the monetary and non-monetary government incentives of purchasing an EV in California. The information on fuel expenditure savings will be presented differently based on the treatment group. The gain-framed messaging will be "*Compared to driving the conventional vehicle, driving the electric vehicle will save Joe x amount of money on fuel expenditure*," and the loss-framed messaging will be "*Compared to driving the electric vehicle, driving the conventional vehicle will make Joe lose x amount of money on fuel expenditure*." Differing by time frame, the statistics on fuel expenditure savings will be described in the monthly, annually, 5-year, or 10-year unit. For example, the message in T2 (gain frame x annually) will be "*Compared to driving the conventional vehicle, driving the electric vehicle will save Joe x amount of money on fuel expenditure every year."* For an example of the full scenario, please see Appendix I.

4. Analysis

To test the hypotheses, the Mann-Whitney U test (non-parametric test) will be used to compare means between conditions. The study measures participants' ratings of the likelihood of Joe purchasing the EV (Rating), and the dependent variable will be the average of the Rating for each treatment. The independent variable will be the different treatments. Other factors measured in the study will be controlled.

The author predicts that the shorter the time frame of the savings, the higher the participants' intentions to adopt an EV. Thus, it is expected to see the pattern of the Rating among treatments to be *T1 > T2 > T3 > T4*. Additionally, the author predicts that using loss-frame messaging is more effective at

[1] Rogue and Altima are both top selling Nissan vehicles in the US (Nissan, December 2020). Leaf is the only Nissan electric car model currently available, and Ariya is a new model that will enter the US market by the end of 2021.

increasing participants' intentions to adopt an EV than using gain-framed messaging. Thus, it is expected to see the Rating among treatments that incorporate the loss-framed message on fuel expenditure saving to be significantly higher than the Rating among treatments that use the gain-framed message.

5. Discussion and Limitations

Despite that the federal and state governments have developed large monetary and non-monetary incentives, the current EV adoption rate is very low. Increasing EV adoption is an urgent goal for both the government to reach carbon neutrality by 2050 and the automaking companies to cover their significant investments on developing EVs and make profits. Among all factors, the high upfront cost is one of the largest barriers to EV adoption. Due to present bias, even though the cost premium can be offset by the low operational costs in the long run, consumers can easily focus on the salience price tags only and choose CVs. Hoping to solve the behavioral problem of present bias, this research aims to investigate how to incorporate different messaging techniques to increase consumers' intentions to adopt EVs. The author anticipates that using a shorter time frame and using a loss frame to describe the fuel expenditure savings of EV can lead to more consumers hoping to adopt EVs. The author hopes that by introducing fuel expenditure savings in different forms, the long-term benefits of owning an EV can be more salient to consumers so that they are less likely to be anchored by the upfront cost premium.

This proposed study has several academic and practical implications. Firstly, it contributes to the lacking research on the solutions to present bias in the context of EV adoption. Secondly, the experimental design of this research overcomes some key limitations of past empirical studies. Instead of using hypothetical statistics like Dumortier et al. (2015) or leaving the effect of customer loyalty uncontrolled like DellaValle & Zubaryeva (2019), the current study uses real Nissan car models and explores the preferences of Nissan customers only to prevent the confounding impact of brand. Thirdly, this study provides valuable insights to every automaking company. With the well-known barrier of high upfront costs and the still developing market of EV, setting the proper prices for the vehicles can be challenging. This study gives companies a new angle of increasing consumers' willingness to adopt EVs through changing people's perceptions on the price of EVs instead of changing the price itself. More importantly, it explores the use of different messaging techniques that are cheap and easy to implement.

This proposed study also has limitations. Firstly, similar to previous studies, due to the constraints of online experiments, this study can only explore people's willingness to adopt EVs instead of their actual purchasing decisions. Because of the possible intention-action gap (Frederiks et al., 2015), these messaging techniques may have a weaker ability to influence consumers' decisions than what's indicated in the results of this study. Secondly, the hypothetical scenarios used in the study may not reflect the real process of purchasing a vehicle. There are other factors that influence consumers' decisions, such as car appearance, accessories available, advertisements, and the characteristics of the dealers. Thirdly, this study has a limited generalizability as it is restricted to one car company in one region. Due to the wide variation of car models among companies and different government policies and people's pro-environmental attitudes among regions, the findings of this study will not be readily applicable to dissimilar car companies or regions.

While present bias is a cognitive trap that people often fall into, research has found solutions to present bias in one context may not apply to another context (Imai et al, 2021). Furthermore, since EV is a developing market, current solutions to present bias may not apply to the future situation. Thus, it is necessary for researchers to keep exploring the solutions to present bias as well as other behavioral problems in the specific context of EV adoption. Additional research would also be required to explore what messaging techniques could be effective in various contexts. Lastly, it would be interesting for future researchers to conduct field experiments to examine consumers' actual decisions made.

Appendix I

This is an example of Treatment 4 (gain frame x ten-year) in the study.

A person like you, Joe, wants to buy a Nissan vehicle. Now, Joe is at a Nissan car store, trying to look for a car model that he likes. After looking for a while, two models stood out to Joe. One is an electric car, Leaf, and the other is a conventional car, Altima. A staff handed Joe a table that compares Leaf with Rogue as follow[2]:

	Altima	**Leaf**
Price	\$24,350	\$31,670
Fuel economy	Up to 28 MPG City / 39 MPG Highway	Up to 123 MPGe City / 99 MPGe Highway
Range	518 miles	150 - 226 miles
Cargo space	15.4 cu. ft.	30 cu. ft.
Horse Power	182-236 hp	141 - 214 hp
Yearly total cost of ownership over 5 years	\$7177	\$8747

Joe is aware that if he buys Leaf, he could get an additional \$2000 rebate from the CA government. Joe will also get HOV lane access, which could save Joe a lot of time spent on the road.

Seeing Joe hesitating, the staff told Joe another piece of information: **given the average electricity rates and gas prices in California in 2021, compared to driving the conventional vehicle, driving the electric vehicle can save Joe \$12,730 on fuel expenditures over 10 years.**

After 10 minutes of thinking, Joe has made up his mind on which vehicle to choose, the conventional model Altima or the electric model Leaf.

[2] The statistics came from the official Nissan website (www.nissanusa.com), the California's Clean Vehicle Rebate Project (https://cleanvehiclerebate.org), and Edmunds, an American online resource for automotive information (www.edmunds.com)

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