The Thesis Committee for Vivek Nath
Certifies that this is the approved version of the following thesis:

Drivers of environmentally-friendly technology adoption: electric vehicle and residential solar PV adoption in California

APPROVED BY
SUPERVISING COMMITTEE:

Supervisor: ____________________
Varun Rai

____
Jay Zarnikau

Drivers of environmentally-friendly technology adoption: electric vehicle and residential solar PV adoption in California

by

Vivek Nath, B.S.EE

Thesis

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degrees of

Master of Science in Energy and Earth Resources

and

Master of Public Affairs

The University of Texas at Austin

May 2016

Dedication

For Nishi

and all who seek to make the world a better place

Acknowledgements

I would like to acknowledge Dr. Varun Rai for all the support he has given me over the last 3 years as my graduate and thesis advisor. I have learnt a lot from him through the course of several research projects and I thank him for placing confidence in me. I would like to thank Dr. Jay Zarnikau for being my thesis reader and for offering valuable feedback for my thesis. I would also like to sincerely thank my peers Ariane Beck, D. Cale Reeves and Scott Robinson for their valuable questions, feedback and support.

I also thank the Graduate School at the University of Texas at Austin and the LBJ School of Public Affairs for their generous financial support.

Finally, I would like to thank my wife and my family for their encouragement and support over the last three years.

Abstract

Drivers of environmentally-friendly technology adoption: electric vehicle and residential solar PV adoption in California

Vivek Nath, M.S.EER/MPAff.

The University of Texas at Austin, 2016

Supervisor: Varun Rai

The use of electric vehicles (EVs) and residential solar photovoltaic (PV) panels is expected to play a role in stabilizing greenhouse gas concentrations in the atmosphere within an acceptable range, to mitigate detrimental climate change impacts. This thesis uses two uniquely rich datasets from the EV and residential solar PV market in California to study the demographic, motivational, social and informational influences on technology adoption decision-making. Rogers' diffusion of innovations theory and the theory of planned behavior (TPB) are extensively used to contextualize the findings.

Several findings aligned with Rogers' generalizations regarding communication channels and characteristics of earlier adopters, and the increasing role of interpersonal communication channels signaled a shift to the early majority. Strong support was also found for the theory of planned behavior through the identification of the role of personal norms, subjective norms, attitude, and perceived behavioral control on intention and, ultimately, behavior. Information channels used by the EV cohort suggest a possible departure from TPB through the role of habitual behavior and attitudinal formation.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Introduction

Anthropogenic greenhouse gas emissions are likely to have caused global warming beginning mid-20th century. About 78% of the greenhouse gas emissions from 1970 to 2010 were contributed by fossil fuel combustion and industrial processes (IPCC, 2014). In response to the need to address the potentially detrimental impacts of climate change, the United Nations put forth the UN Framework Convention on Climate Change (UNFCCC) in 1992 to organize intergovernmental efforts to control greenhouse gas emissions into the atmosphere (Secretariat, 1992). Since then, the efforts to combat the negative impacts of climate change have gained momentum and importance on the global stage. In 2016, the Paris Climate Change Agreement, which promises to reduce greenhouse gas emissions to mitigate potentially threating and irreversible climate change impacts (United Nations, 2015), was signed by 175 countries (United Nations, 2016). The U.S. Environmental Protection Agency's (EPA) Clean Power Plan, proposed in June 2014, requires carbon reductions of 30 percent below 2005 levels by 2030 (U.S. Environmental Protection Agency, 2014). Annual investments in low carbon electricity supply and transportation are expected to be necessary to stabilize greenhouse gas concentrations in the atmosphere within an acceptable range by 2100 (IPCC, 2014). The detrimental ecological impacts of greenhouse gas emissions have been recognized as a major problem by policy makers, business leaders and the public. Renewable energy and alternative fuel vehicles have garnered attention as potentially high impact solutions to reduce greenhouse gas emissions.

In the United States, the transportation sector accounts for 71% of total petroleum use and 33% of the country's total carbon emissions (NREL, 2015). The use of plug-in electric vehicles (referred to as EVs from here on) instead of gasoline internal combustion engine (ICE) vehicles is expected to reduce greenhouse gas emissions produced by the transportation sector. Governments and non-governmental organizations (NGOs) have supported the need to promote electric vehicle adoption through policies, financial support and supportive research and development (Natural Resources Defense Council, 2007; Skerlos, 2010). Battery costs, one of the major contributing factors to the cost of an electric vehicle, have fallen from more than $1,000/kWh in 2008 to $325/kWh in 2013 according to U.S. Department of Energy estimates (NREL, 2015). Electric vehicles are already competitive with traditional ICE cars in terms of consumer satisfaction and price of fuel. An eGallon, the amount of electricity taken to drive an EV the same distance a standard ICE car travels on a gallon of unleaded gasoline, costs only about $1.27, as of late 2014 (U.S. Department of Energy, 2014).

Even though the point-source emissions associated with EVs are relatively lower than ICE vehicles, the emissions associated with the production of electricity required to charge plug-in EVs is largely dependent on the fuel source for electricity. The burning of fossil fuels to generate electricity accounted for the largest source of CO_2 emissions in the US in 2014 (Environmental Protection Agency, 2016). The production of energy from renewable sources of energy such as solar energy would reduce carbon emissions. Solar PV technology adoption at both the residential and utility level can substitute for fossil fuel use and hence reduce emissions. Federal, state and locate incentives have driven down the prices of solar PV systems and have consequently spurred demand (Carley, 2009). From 2000 to 2010, global solar PV deployment increased from 0.26 GW to 16.1 GW (Mints, 2011) with an annual growth rate of more than 40%.

The recent consistent surge in adoption of EV and residential solar PV technologies, which are relatively new compared to competitive technologies in their respective sectors, provides a unique opportunity to study the individual decision-making behind the adoption of these innovative durable, environmentally-friendly and capital-intensive technologies. A better understanding of the decision-making process of adopters can help design demand-centric policies that are intended to meet environmental objectives through technology adoption (Green, 2014; Bollinger, 2012). This study draws from theories of diffusion of innovation proposed by Rogers and, the theory of planned behavior, as well as specific studies on electric vehicle and solar PV technology adoption to contextualize the findings.

1.2 Solar PV and EV Markets

1.2.1 Government Support

Both solar PV and EV markets have been heavily supported by the federal and state governments. In 2009, the US federal government established a national goal of putting one million plug-in vehicles on the road by 2015. Provisions in the American Recovery and Reinvestment Act (ARRA) of 2009 enlarged tax credits for EVs up to $7,500 for each EV. The Department of Energy granted $8 billion in loans in 2009 to Nissan, Ford and Tesla. The modified Zero Emission Vehicle (ZEV) Program in California requires that all major vehicle manufacturers that conduct business in

California offer at least a limited number of ZEVs for sale by 2016. Several other states, including New York, have also adopted these standards (Lane, 2012).

The federal government provides a 30% solar investment tax credit (ITC) for investments in projects that generate electricity using solar energy (Bolinger, 2014). An advanced energy manufacturing tax credit (MTC) supported solar panel manufacturing until reaching its cap of $2.3 billion in 2010. The Department of Energy provided $13.27 billion in loan guarantees, through the Section 1705 loan program, to solar manufacturing and power generation projects. The Section 1603 Treasury Grant program, which expired at the end of 2011, awarded a total of $2.1 billion for solar projects. The Department of Energy runs programs targeted at meeting the goal for solar energy to provide 14% of domestic electricity by 2030 and 27% by 2050 (Platzer, 2012). Local, regional and state government provide financial incentives for solar PV adoption as well. Twenty-nine states, Washington D.C. and three territories, through the Renewable Portfolio Standard (RPS) require that a specified portion of electricity sold in the state comes from renewable sources of energy (National Conference of State Legislatures, 2016; Hagerman, 2016). The California government has stood out for its strong support for solar PV technology since 1974 through policies of upstream investment, market creation, and interface improvement (Taylor, 2008).

1.2.2 Price

The federal and state financial incentives make many EVs' retail price comparable to that of their internal combustion engine (ICE) competitors. A comparison of the retail price, however, does not account for ownership costs or savings. A recent analysis of the total cost of ownership by the Electric Power Research Institute found that, in terms of both total lifetime costs and monthly outlay, plug-in EVs are typically within +/- 10% of comparable hybrid or conventional vehicle options. The report also found that the financial savings associated with an all-electric vehicle or battery electric vehicle (BEV) depended on driving behavior, due to the limited range (Davis, 2013). With the cost of lithium batteries in decline, the cost of plug-in EVs is expected to decline as well (Tuttle, 2012).

For residential and small commercial solar PV systems installed in the United States in 2013, roughly 20% were sold for less than $3.90/Watt (W), while a similar percentage were priced above $5.60/W. The primary factors that influence the price of PV systems are their size, ability to track the sun, material composition, use of batteries, integration of panels and method of installation (Gillingham, et al., 2014).

An often-quoted method of comparative assessment for the costs associated with solar PV panels is 'grid parity'. Grid parity refers to the juncture at which the lifetime generation cost of electricity from PV is comparable with the electricity prices for conventional sources on the grid (Yang, 2010). The levelized cost of electricity (LCOE) is often used to gauge the economic feasibility of an energy generation project and is consequently used for considering grid parity of solar PV (Margolis, 2009; Branker, 2011). A recent LCOE report by the California Energy Commission in 2010 (Klein,

2010) demonstrates that solar PV can be less expensive than traditional energy sources in California when considering peak power natural gas plants [1].

1.2.3 Market Supply Structure

Recently, the EV market in the US has grown from having one vehicle model in 2009 to over 25 vehicle models in 2015 (Department of Energy, 2016). Manufacturers that have had a substantive presence in the ICE vehicle market take up a large share of the EV market.

The presence of incumbents may have an impact on the adoption decision-making process due to brand loyalty and habitual behavior. Brand loyalty has been observed to influence car purchases (Mannering, 1985) through repetitive purchases of the same brand vehicle. Brand loyalty plays a larger role in the purchasing decision for 'powerful and prestigious' cars than fuel efficient vehicles, implying a potentially lower influence of brand in the purchase of fuel efficient vehicles (Nayum, 2014).

The role of incumbents is not as influential in the solar PV sector. The influence of installers on product offering and price for a potential adopter is largely local. The higher the density of installers in a local market, the lower the PV system prices in that region (Gillingham, et al., 2014). Figure 1 shows the makeup of US residential solar installers in 2014. As Figure 1 shows, close to half of the installers belong to the All Others group; the total number of installers is on the magnitude of hundreds. However, in

[1] The 'Comparative Costs of California Central Station Electricity Generation' report from 2010 includes a range of cost estimates, projections for variables allowing forward looking values, a range of project types, and considers PV technologies to have a life of 20 years

the electricity sector, households have a long history of depending on electricity utility monopolies to get their electricity. Solar PV installers often have to compete with the 'locked-in' tendencies of consumers whose past interactions regarding electricity have largely been with monopoly suppliers (Fuchs, 2002).

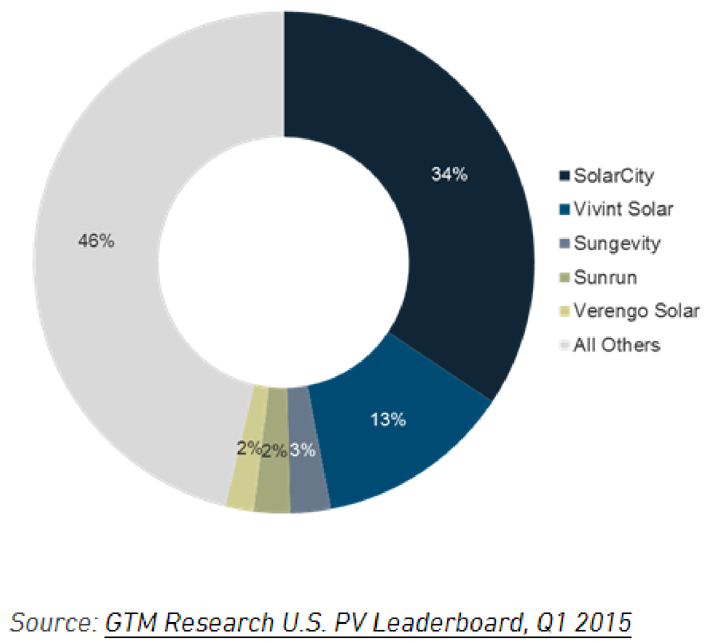

Figure 1. US residential solar installers in 2014 (Green Tech Media, 2016)

1.2.4 Similar technology adoption history

US consumers have a long history of purchasing and using vehicles and this may influence the EV adoption decision-making process. This may impact the perceived costs and benefits of an EV. The reference point of comparison for a potential EV adopter would most likely be an ICE vehicle. Tesla, for instance, developed a business model that emphasized advantages in comparison to high-performance luxury ICE sedans, and successfully found demand for their product (Kley, 2011). The acquisition of a solar PV panel, however, does not have a similar adoption history associated with it in terms of upfront cost, operation, maintenance, aesthetics of the technology and interaction with the primary supplier.

Chapter 2: Foundational Theories

2.1 Foundational Theories

The diffusion and adoption of technology has been the subject of fields of study including management, economics, communications and marketing. Diffusion refers to the process by which members of a social system adopt an innovation (Rogers, 2003). Adoption, on the other hand, refers to the decision of an individual to adopt a technology. While these two concepts are closely related, diffusion refers to a socio-economic phenomenon whereas adoption refers to an individual-level phenomenon.

2.1.1 Rogers' Diffusion of Innovations Theory

Rogers studied extensive social science literature on the adoption and diffusion of innovations to theorize the stages of adoption, characteristics of adopters and the adoption decision-making process. Rogers posited that the diffusion of innovations is comprised of four main elements: innovation, communication channels, time and social system. This study will focus on the aspects of communication channels and time. In order of timing of adoption, Rogers categorized adopters of innovations as innovators, early adopters, early majority, later majority and laggards, and provided precise cutoff thresholds in terms of proportion of adopters for each of these classifications (Rogers, 2003).

Rogers included further descriptions of the characteristics of adopters; innovators are venturesome, technologically competent, wealthy, less risk-averse and tolerant of high uncertainty. Innovators are also proposed to have a higher degree of interest in technological innovation. Early adopters are characterized as catalysts of the innovation diffusion process due to their central role in disseminating information as opinion leaders about the technology through their interpersonal networks. The early majority is ‘deliberate’, seek the opinion of earlier adopters, and take their time to make a decision. The late majority is cautious about innovations, possess relatively scarce resources, and often convinced to adopt through social pressure. Laggards are suspicious of innovations, less wealthy than average, and relatively socially isolated (Rogers, 2003).

Communication channels play a major role in bringing awareness to an innovation and in shaping an individual’s judgment of a technology. Mass media channels, such as radio, television and news websites, enable information regarding an innovation to reach an audience efficiently. Interpersonal channels, which may include family members, coworkers and neighbors, involve a face-to-face exchange and have a higher persuasive influence on a potential adopter’s decision. Rogers proposes that information from mass media channels is more important to earlier adopters than later adopters. Earlier adopters are more likely to evaluate an innovation based on a personal evaluation of costs and benefits or a relatively high interest in technological innovation, whereas later adopters mainly depend on the subjective evaluation of an innovation conveyed by individuals similar to them in socio-economic status, education or other ways (Rogers, 2003). Bass posited a similar theory from the perspective of the individual adopter’s decision-making process; innovators decide to adopt a technology independent of the decisions of others as opposed to imitators whose adoption decision is influenced by the decisions of others (Bass, 1980).

Rogers theorizes a five-step innovation decision process: Knowledge, Persuasion, Decision, Implementation, and Confirmation. The potential adopter becomes aware of the innovation during the Knowledge stage, forms a favorable or unfavorable attitude toward the innovation in the Persuasion stage and acts on the adoption or rejection of the innovation in the Decision stage. Following the decision, the adopter implements the new idea and ultimately, decides whether to continue using the new innovation during the Confirmation stage.

2.1.2 Theory of Planned Behavior

A popular and more recent theory of individual decision-making that applies to technology adoption is the theory of planned behavior (Ajzen I. , 1991). The theory states that an individuals' behavior is determined by his/her intentions, which are informed by attitude toward the behavior, subjective norms and perceived behavioral control (PBC). Attitude towards a behavior refers to a person's global positive or negative evaluation of the likely consequences of a behavior (Ajzen & Fishbein, 2000). Subjective norms refer to a person's perception of the expectations of people important to that person, such as family members and friends, to engage in the behavior. PBC refers to a person's perception of her/his ability to perform the behavior, though another interpretation of PBC is the perception of execution of the behavior (Ajzen I. , 1991). These antecedents of behavior can be further moderated by descriptive norms, which are the perception of how others typically behave, and personal norms, which describe self-expectations based on internalized values, and convictions, such as environmental responsibility. Subjective and descriptive norms are both social norms, while personal norms focus exclusively on the evaluation of acts in terms of the individual's own moral worth to the self, whereas other attitudinal concepts refer to evaluations based on material, social and/or psychological payoffs (Schwartz & Howard, Internalized values as motivators of altruism, 1984). Intention refers to an individual's readiness to perform a given behavior and, along with PBC, is the immediate antecedent of behavior.

TPB, with respect to technological adoption, suggests that the decision to adopt a technology is not solely based on utilitarian benefit, but involves other factors including socially influenced standards, self-determined morality and perception of having the skills or resources to acquire the technology.

Several researchers have found support for TPB in pro-environmental decisions. Personal norms have been observed to positively influence environmentally friendly travel modes (Hunecke, 2001) and purchases of pro-environmental food (Wiidegren, 1998). The perceived ease of implementing a behavior has been found to positively affect pro-environmental behavior, suggesting a consequential role for PBC (Loukopoulos, 2004). In a study assessing the comparative contribution of the antecedents of intention and behavior using the TPB framework, personal norms explained pro-environmental behavior more than attitude, subjective norms, and perceived behavioral control (Gärling T. F., 2003).

Chapter 3: Data

3.1 DATA

The data used for this study program data was from the Clean Vehicle Rebate Program (CVRP)[2] in California and the California Solar Initiative (CSI)[3], as well as survey data from Northern California for the solar PV sector and from the state of California for the EV sector.

The electric vehicle dataset was collected as a part of the California Plug-In Electric Vehicle Owner Survey [4]. This longitudinal survey was sent to vehicle owners across California who had received a rebate through the state's Clean Vehicle Rebate Project. Surveys were administered via an email campaign. This study uses data obtained from a survey covering CVRP applications received in the time frame of September 2012 to December 2013. Surveys included responses from 6,515 EV owners. The survey collected information on the adopter's decision-making process, information channels and demographic background. This information was matched with program information from the CVRP which included individuals' rebate application details, vehicle make and model, purchase price, monthly payment, whether the vehicle was bought or leased, and time of purchase.

---

[2] The California Clean Vehicle Rebate Project (CVRP) promotes clean vehicle adoption in California by offering rebates of up to $6,500 for the purchase or lease of new, eligible zero-emission vehicles, including electric, plug-in hybrid electric and fuel cell vehicles

[3] The California Solar Initiative is the solar rebate program for California consumers that are customers of investor-owned utilities. The program offers different incentive levels based on the performance of their solar panels (http://www.gosolarcalifornia.ca.gov/about/csi.php)

[4] The Plug-in Electric Vehicle (PEV) Owner Survey is a long-term collaborative research project managed by Center for Sustainable Energy's (CSE), in coordination with the California Air Resources Board (ARB), researchers at UT Austin's Lyndon B. Johnson School of Public Affairs and the UC Davis Institute of Transportation Studies

The residential solar PV dataset consists of survey information from similar surveys that were sent to residential solar PV adopters in Northern California. The survey was administered between April and June of 2015 and received 690 responses. The survey instrument collected data on the decision-making process, financial aspects, information channels and demographics. This data was matched to the CSI dataset, which contained system-level details including system size, date of interconnection, total system cost, and rebate received. Most survey respondents were successfully matched to corresponding system-level data in the CSI dataset.

Chapter 4: Methodology

4.1 Methodology

Five streams of analysis were conducted for this study: 1) Demographics, 2) Motivation factors, 3) Information channels, 4) Peer effects and 5) Procurement mechanism. For each of these streams of analysis, detailed analysis was first conducted within the EV and PV segments separately, then the findings were compared using qualitative methods.

The methods used for detailed analysis within the EV and PV sectors separately were determined based on an assessment of the quality of the data available to address the five streams of analysis aforementioned. The descriptive analysis included generation of contingency tables, visual comparisons of variables using graphs, and the comparison of mean, median and proportion metrics, for each stream of analysis. In cases where mean, median or proportion comparisons needed further analysis, tests for equal proportions or means were run. The analysis of peer effects and procurement mechanism in the EV segment required logistic regression models to disentangle the relationships between several key variables that were chosen based on earlier descriptive analysis or contextual value. Variance inflation factor tests were used to check for multicollinearity in all binomial logit regression models. For the peer effects and procurement mechanism sections of the study, findings from descriptive data analysis conducted for this study were supplemented with findings from ‘Overcoming barriers and uncertainties in the adoption of residential solar PV’ (Rai, Reeves, & Margolis, Overcoming barriers and uncertainties in the adoption of residential solar PV, 2016) and a working paper ‘Barriers to Solar PV Adoption in Maturing Markets' (Rai, Reeves, & Margolis, 2016), which utilized the same PV survey and program data as this study. The year of adoption or the cumulative number of solar PV installations, in the PV segment, were included in regression analyses to generate insights regarding the evolution of adopter characteristics, communication channels and decision-making processes. Yearly comparisons were also done using mean/median score graphs for motivation factors and procurement mechanism types.

Findings on attitudinal characteristics, demographics and communication channels were compared to Rogers' innovation diffusion theory generalizations to generate insights regarding stage of adoption and the adoption decision-making process. Rogers' characterization of stages of adoption by precise cumulative adoption cutoff thresholds were not used to characterize adopters due to the lack of sufficient data to estimate cumulative EV and solar PV adoption values. A detailed literature search was conducted on studies concerning values, norms, beliefs, behavior and the theory of planned behavior. Additionally, recent studies on electric vehicle and solar PV markets were also found to provide reference to the results of data analysis. Both the theoretical and technology-specific literature were then used to provide context to the findings in each stream of analysis and relate them to the theory of planned behavior framework. Figure 2 below conveys the relationships explored between sections of the study and the theory of planned behavior.

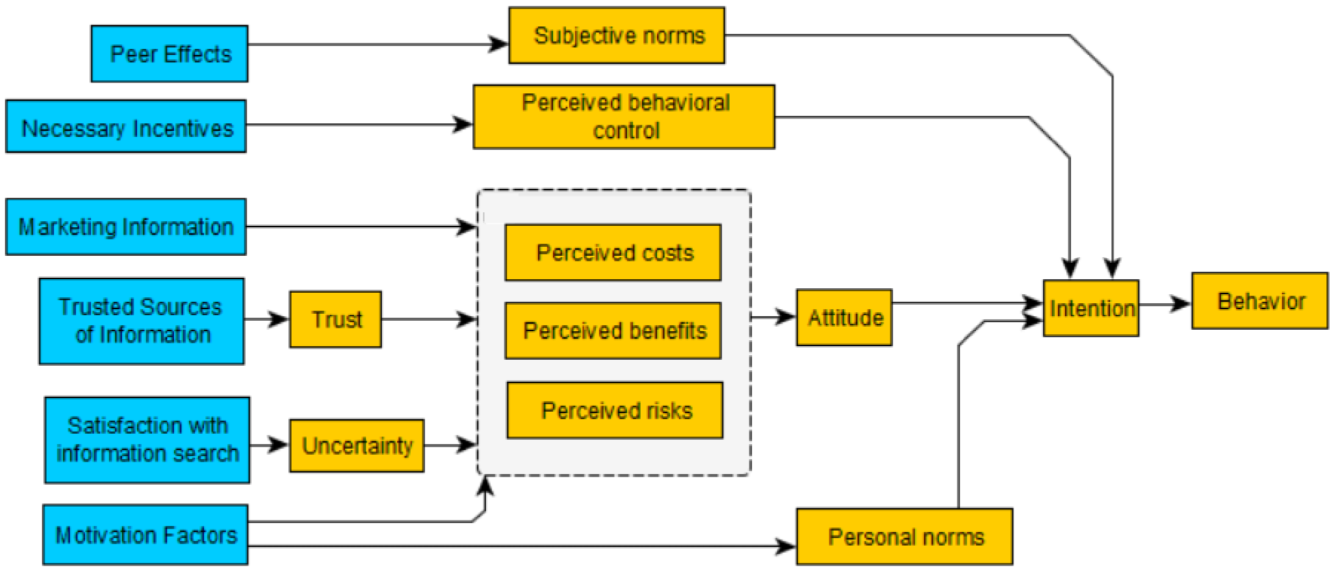

Figure 2. Relationship between sections of this study and the theory of planned behavior framework

Chapter 5: Analysis

5.1 Analysis

This section will provide details of the analysis of demographics, motivation factors, information channels, peer effects and technology procurement mechanism.

5.1.1 Demographics

As shown in Table 1, respondents to both the EV and PV surveys were older relative to the population of California. The response to a question ‘Is there an operating solar photovoltaic (PV) system installed at your residence?’ the EV survey was used to examine potential differences in the median age of those who had already installed solar PV panels and others. No significant difference between their median age and that of the rest of the EV survey respondents was found.

Survey respondents who opted to answer questions regarding education level and household income in both the EV and solar PV studies were relatively highly educated and wealthier in comparison to the population of California. In the EV survey, the median income level associated with Tesla owners was $250,000 - $299,999 which is higher than the median income level of the rest of the EV survey respondents. This suggests that EVs, even at an early stage of adoption, represent a technological variety that caters to groups of different socio-economic statuses. These implications are discussed further in the next section.

Table 1. Descriptive statistics of demographics of survey respondents compared to Californian residents

	EV	**PV**	**Population of California[5]**
Median Household Income	$175,000 - $199,999	$100,000 - $149,999	$61,489
Percent over 25 with at least a BA	84.3	86.7	31.0
Median Age (years)	49	59	35.6

Several studies on electric vehicle adoption and demand have found younger, wealthier, and more highly educated individuals to more likely opt for an electric vehicle (Hidrue, Parsons, Kempton, & Gardner, 2011; Potoglou & Kanaroglou, 2007; Kavalec, 1999; Ziegler, 2012; Zhang, Gensler, & Garcia, 2011; Gallagher & Muehlegger, 2011). Studies on PV adoption have found that wealthier, more highly educated individuals are more likely to adopt solar PV panels, but not necessarily younger individuals (Drury, 2012).

The findings on demographics are in strong agreement with Rogers' characterization of earlier adopters. Rogers' generalized that earlier adopters who have more years of formal education and a higher social status; social status was measured through household income in this study (Rogers, 2003). A cursory analysis revealed no

[5] California demographic data is from US Census Bureau, American Community Survey 2014 estimates (U.S. Census Bureau, 2014)

significant changes in age, education or income level of the respondents over time in both the EV and solar PV groups.

5.1.2 Motivation Factors

The EV survey posed two questions regarding motivational factors behind acquiring an EV. The question, “Which of these factors was the most important reason why you decided to acquire a PEV?”, where PEV referred to plug-in electric vehicle, required respondents to choose one from a selection of factors. The question “How important were each of the following factors in your decision to acquire a PEV?” provided the respondents the choice to rate each factor on a 5-point Likert scale ranging from “Not at all important” to “Extremely important”. The solar PV survey posed a question very similar to the latter in the EV survey.

The top four motivation factors to adopt EVs, in descending order of importance were: 1) saving money on fuel costs, 2) reducing environmental impacts, 3) High Occupancy Vehicle (HOV) lane access, and 4) increased energy independence. The top four motivation factors to install solar PVs, in descending order of importance, were 1) financial evaluation of investment, 2) hedge against electricity rises, 3) reducing environmental impact and 4) decreasing dependence on local utility.

The EV survey asked respondents to rate “How important are each of the following factors in making it possible to acquire a PEV?” The factors listed were 1) Federal Tax Incentives, 2) State Rebate (CVRP), 3) The option to lease a PEV, 4) Access to workplace charging and 5) Other incentive program. The top three rated factors were 1) Federal Tax Incentives, 2) State Rebate (CVRP) and 3) The option to lease a PEV. The ability to acquire is distinct from the motivation to acquire; however, the high value placed on financial costs in the adoption decision is highlighted by the importance of financial incentives provided by the government and manufacturer.

The motivations expressed by respondents affirm the validity of motivational models that move beyond maximizing self-directed utility, as the intent to reduce environmental impacts and increase energy independence has roots in societal or biospheric values. The importance of financial benefits is in agreement with the findings of several studies of both EV and solar PV adopters (Bunch, Bradley, Golob, Kitamura, & Occhiuzzo, 1993; Diamond, 2009; Gallagher & Muehlegger, 2011; Ewing & Sarigöllü, 2000). Interestingly, staying at the frontier of technological innovation or a desire for the newest technology were not among the highly rated motivation factors in either the solar or EV surveys. Based on Rogers' view of the attitudinal characteristics of adopters, the respondents would not be considered innovators, since innovators acquire an innovation based on high technological interest (Rogers, 2003).

5.1.2.1 Theory of Planned Behavior Implications

The top motivation factors reported in both EV and solar PV studies relate to monetary savings/gains. This contrasts with studies that have found financial aspects to be a primary barrier to 'green' adoption (Caird, 2008; Gardner, 2008), indicating that financial incentives present in both solar and EV markets provide potential adopters an uncharacteristic 'green' technology financial proposition. The priority of financial aspects is further highlighted in the EV sector by the high degree of agreement that federal and state tax incentives were needed to accept the decision to acquire the EV. The motivation to save money or gain financial returns is a reflection of the perceived benefits of acquiring an EV or solar PV, which shapes attitude toward the technology positively.

The second highest rated category of motivations behind technology acquisition was related to pro-environmental intentions. From a pro-environmental perspective, the procurement of an EV or solar PV was perceived to reduce greenhouse gas emissions; an outcome that is not readily seen in the immediate future by an adopter and that has benefits that do not solely apply to the adopter. Pro-environmental beliefs, intention and behavior, have been positively associated with social-altruistic and/or biospheric values and negatively associated with egoistic values (De Groot, 2008). Pro-environmental values are often based on an individual's morality, which is the basis of personal norms. Schwartz's moral norm-activation theory of altruism holds that altruistic behavior occurs in response to personal moral norms (Schwartz, Normative explanations of helping behavior: A critique, proposal, and empirical test, 1973). Pro-environmental intentions may also be shaped by social norms of environmentalism subjectively and descriptively. For instance, a study of household energy usage found that both descriptive norms of energy usage and awareness of social approval of environmentally-friendly energy consumption behavior explained pro-environmental household energy consumption behavior (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007). As personal norms have been found to explain pro-environmental behavior more than attitude, subjective norms and perceived behavioral control (Gärling, Fujii, Gärling, & Jakobsson, 2003), the pro-environmental motivation expressed by the survey respondents is assumed to be primarily an expression of personal norms in their decision-making.

The third most frequently rated primary motivation factor of EV adopters was HOV lane access. HOV lane access has the potential to provide drivers several benefits including less travel time (Li, 2007), greater travel time reliability (Burris, 2007), reduced travel cost, reduced level of stress (Washington State Department of Transportation, 2007), and greater enjoyment of the journey (Li, 2007; Wang, 2012). The HOV lane access incentive plays a role in the attitudinal formation preceding the intention to adopt an EV by providing a perceived benefit to the adopter.

The motivation to increase energy independence likely originated from concerns about national security from dependence on foreign oil (Steel, 2015). Concerns about national security are informed by a desire to benefit residents or citizens of the nation, possibly altruistic in nature. The intention to adopt technology for improving national security supports the role of personal norms, expressed through altruistic behavior, in the intention to procure an EV or solar PV panel.

The motivation to decrease dependence on the local utility has multiple probable origins. Reducing dependence on the local utility may be perceived as a method of protection against electricity price changes. The demands on a local utility may not be fulfilled solely by the provision of electricity at an agreeable rate. A study of electricity consumers in 22 countries found that they expect utilities to cater to other demands such as energy independence and renewable energy uptake, but lack trust in utilities to follow through (Accenture, 2010). Other reasons that may have led to a lack of trust in the local utility are data privacy concerns (New York Times, 2011). A lack of trust is a probable motivator to reduce dependence on the local utility. The motivation for decreased utility dependence, thus, has a probable influence on attitude through perceived benefits from reduced electricity cost considerations and has probable roots in personal norms through pro-environmentalism. Personal norms may also be expressed as altruism through the dissatisfaction with utilities in promoting energy independence.

The EV survey respondents highly valued the role of federal and state incentives, as well as the option to lease, in making it possible for them to acquire EVs. This suggests an influential role for PBC in the EV adopter's decision-making process, as the rebate incentives reduced the requisite financial resources for the adopters to acquire EVs and enhanced the adopters' perception of their behavioral control over the adoption decision.

To summarize, the most frequently reported primary motivations behind purchasing both solar PV panels and EVs suggest the role of attitude, personal norms, and subjective norms in the shaping of intentions and behaviors in accordance with TPB. Personal norms and subjective norms were largely explained by the respondents' high level of stated pro-environmental intentions and recent studies confirming the role of personal norms and subjective norms in promoting pro-environmental intentions. PBC was observed to play a role in the EV adopters' decision-making process.

5.1.2.2 Technology-driven motivations

The relatively low degree of interest in technological innovation would place a majority of the survey respondents out of the 'innovators' category per Rogers' theory. Interestingly, the motivation factors of Tesla owners were more indicative of technological interest than non-Tesla owners, as indicated in Table 2. Pearson's chi square test for independence was conducted on the count data used to generate the proportions in Table 2. The result (χ^2 (df = 2, N = 1119) = 134.8, p ~ 0) indicates a significant difference in response rates between the two groups.

Table 2. Proportion of EV owners that rated factor as most important factor in decision to acquire an EV

	Desire for newest technology	**Vehicle performance**	**Supporting diffusion of EV technology**
Tesla owner	15.4%	20.9%	8.5%
Non-Tesla owners	3.6%	1.8%	4.7%

The difference in technology-driven motivations between Tesla owners and other EV owners may be hypothesized to be due to the technological differences between Tesla vehicle models and other EVs as well as comparable ICE vehicles. A comparative study of the technological attributes of vehicles revealed Tesla EVs to compare favorably to both EV and incumbent ICE counterparts with respect to core vehicle attributes including acceleration, speed and looks (Hardman, 2015). The Tesla Model S, which comprised all but one of the Tesla EVs owned by the EV survey respondents, has won awards including car of the year by a popular automotive magazine (2013 Motor Trend Car of the Year: Tesla Model S, 2012). The high relative performance of the Tesla EVs supports the hypothesis that comparative technological advantage is responsible for the difference in technology-driven motivations between Tesla owners and other EV owners. An alternative hypothesis is that the difference in technology-driven motivations was driven by the difference in demographic attributes; Tesla owners were considerably wealthier than other EV owners in the survey. Do wealthier adopters in the survey express a higher technological interest, regardless of the make of the EV they acquired? Or were adopters with higher technological interest, all household income equal, more likely to choose a Tesla than other EV makes?

A logistic regression analysis was conducted to determine if the degree of technology-driven motivation was higher for Tesla owners in the survey, controlling for the effects of age and household income. The development of the dependent variable of this regression analysis consisted of two steps. Firstly, an arithmetic average of the level of importance (expressed in a 5-point scale Likert survey item) of the three technology-driven motivations listed in Table 2 was calculated for each survey respondent. Then, the calculated average was dichotomized such that responses with an average of 4 or greater out of 5 were assigned a value of 1, and all other responses were assigned a value of 0. The dichotomized variable for technology-driven motivation level was regressed using a binomial logit model against three variables: 1) a binary variable indicating whether the make of the vehicle was Tesla, 2) age, 3) household income level and 4) year of adoption. The results of this analysis indicated that the odds of Tesla owners having a high technology-driven motivation level were 4.25 times the odds of non-Tesla owners having a high technology-driven motivation level, controlling for the effects of age and household income level (See Appendix for results). Thus, the first hypothesis that the higher technology-driven motivation level of Tesla owners was due to technological attributes seems more likely than the alternative hypothesis that postulated differences in household income caused the difference in technology-driven motivation levels.

Additionally, the technological interest expressed seems to be explained largely by performance of the technology rather than the innovativeness associated with the use of an electric drive rather than a combustion engine. If technological interest solely arose from the substitution of a combustion engine by an electric drive, a similar degree of technological interest may have been expected for Tesla and non-Tesla owners.

5.1.2.3 Stated Motivation Factors over Time

Figures 3 and 4 below show the mean rating of motivational factors in the solar and PV surveys, by year of adoption. In both cases, there are no significant discernible shifts in adoption motivations over time, indicating that the stage of adopters, as characterized by Rogers', has not transitioned significantly.

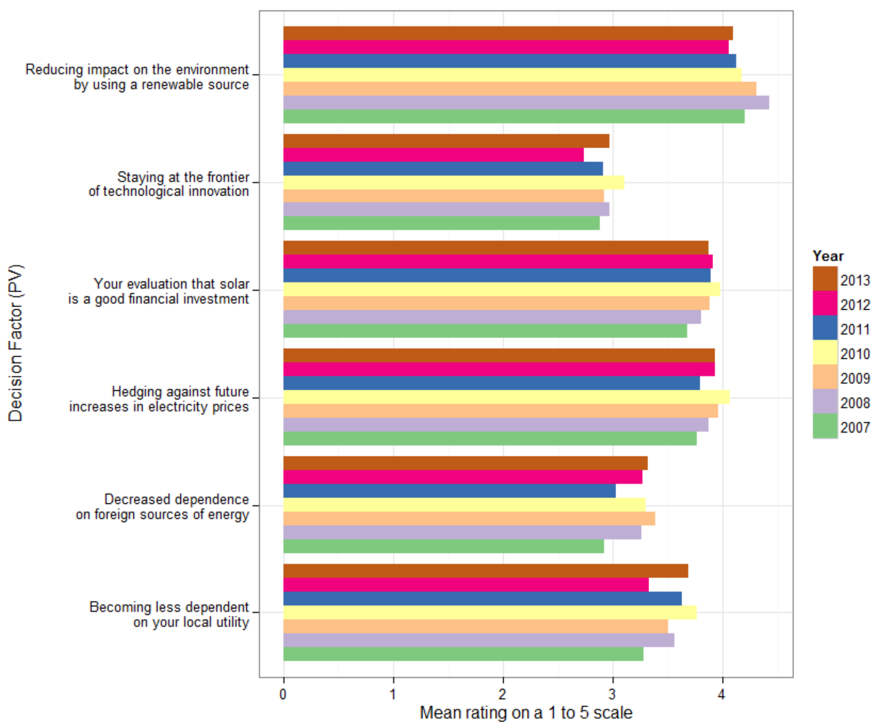

Figure 3. Importance of decision factors by year for PV survey respondents

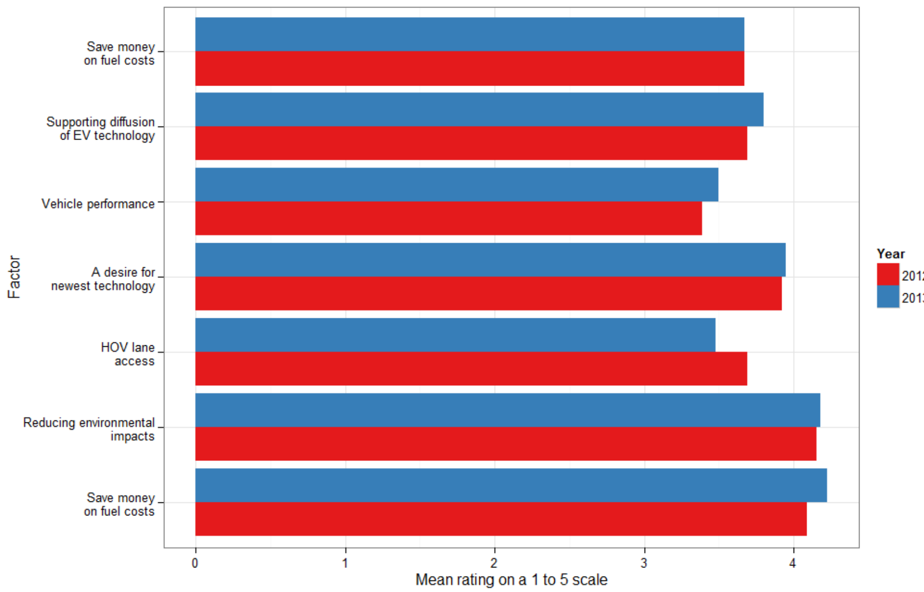

Figure 4. Importance of decision factors by year for EV survey respondents

5.1.3 Information Channels

5.1.3.1 Marketing Medium

In the EV survey, Manufacturer websites, Technology blogs, Referral by a friend/family and Print ads (newspaper, magazines, etc.) were reported as the most commonly received modes of marketing messages. A similar question in the solar survey revealed Door-to-door, Print ads and Radio/TV ads as the most commonly received marketing media. The most commonly reported marketing source was solar companies. Referrals were not widely reported as a marketing medium in the solar PV survey.

The use of door-to-door marketing, as reported in the PV survey, is reflective of the local reach of installers, as compared to the larger scale reach of manufacturers in the EV sector. Moreover, the reporting of manufacturer websites and technology blogs in the EV survey shows that adopters pro-actively accessed the domains that presented them with marketing messages, rather than having received these messages through printed, radio/TV media, or in-person interactions at their residences. This suggests a possible role of habit in the EV sector as potential vehicle buyers seek purchase-relevant information, based on past buying experiences with other vehicles, by accessing specific websites. In other words, past experiences with searching for information regarding vehicles seems to have influenced, their sources for information on EVs, It is plausible that habitual information search behavior is accompanied by habitual information analysis leading to the formation of attitudes regarding EVs using habitual processes. A study on a habit and information search found that with an increase of habit strength, the depth of pre-decisional information search and choice option information search decreased (Verplanken, 1997). Extrapolating this finding points to habitual decision-making processes when evaluating information on EVs. TPB does not include habit as a factor that determines behavior and thus may not provide a comprehensive explanation of adopter behavior in the EV sector.

The proportion of EV survey respondents who reported receiving marketing messages through a referral from a friend/family members increased from 2012 (22.4%) to 2013 (28.8%). A two-sample test for equality of proportions revealed that these proportions were significantly different (χ^2 (df = 1, N = 6510) = 21.5, p ~ 0). The increased presence of referrals with time indicates that a higher proportion of the adopters' social network owned or had positive experiences with electric vehicles and were willing to persuade other potential adopters. This also suggests that manufacturers have improved their effectiveness of increasing adoption through referral programs. A potential reason for the success of

Tesla's referral programs is their associated financial incentive. A Tesla Model S referral program, for instance, offered owners $1,000 toward service for providing a referral to a new Model S consumer, while giving the referral recipient a $1,000 discount on the vehicle purchase (DrivingSales News, 2016).

In both the solar PV and EV studies, marketing information was most likely obtained through mass media channels and the marketing sources were likely to be manufacturers or established third-party institutions (technology blogs).

5.1.3.2 Trusted Sources of Information

"How important was information from the *source* in your decision to acquire *technology?*" was asked in both the EV and PV surveys, wherein respondents were asked to rate on a 5-point Likert scale the importance of information from various sources. *Source* refers to source of information and *technology* refers to EV or solar PV depending on the survey. In the EV survey, adopters' median response to the value of information from manufacturers was 'very important', and the median response to the value of information from online discussion forums, family members and friends, stories in the media, blogs, and drive expos was 'moderately important'. In the solar PV survey, the median responses indicated that information from solar installers was considered 'very important', from online resources was considered 'moderately important', and from family was considered 'not very important'. The median response for the value of information from utilities was 'not very important'.

The high value placed on information from manufacturers and installers in the EV and PV surveys, respectively, suggest a high degree of trust in the knowledge of the technology provider that would benefit the adoption decision. The technology provider's perceived comparative advantage to other actors shows a high level of product and pricing expertise. Brand loyalty may also have positively influenced the trust placed in the manufacturer (Mannering, 1985). The role of trust in TPB is in allowing for another individual/organization to have a higher degree of influence in determining the adopter's perceived costs, benefits, and risks of the adoption decision; in other words, forming the attitude towards the technology.

The higher level of trust in information from the manufacturers correlates to the decision-making process of earlier adopters in Rogers' framework. According to Rogers, early adopters decreased uncertainty about a new idea by adopting it and then passing a subjective evaluation of the innovation to peers, consequently activating later adopters to accept the innovation (Rogers, 2003). Given the lower relative trust expressed in peers' information, the survey respondents were earlier adopters (either innovators or early adopters).

5.1.3.3 Satisfaction with information gathered

Both the EV and PV surveys asked respondents how much they agreed or disagreed with their understanding of the following aspects after they completed their information search: performance, maintenance and operation, and warranty and financial aspects of the purchase. A lack of satisfaction with their information search indicated a higher degree of uncertainty due to the ambiguous nature of determining outcomes without adequate, relevant information. Perceived uncertainty can influence attitude through shaping the perceived risks associated with the behavior. Perceived uncertainty can influence perceived behavioral control; uncertainty about a potential loss because of the behavior could lead to a person feeling less control over their behavior (Quintal, 2010).

The median rating of each of the responses regarding satisfaction after information search completion in the PV survey as well as the EV survey was ‘Agree’ (a 4 out of 5 on the Likert scale item in the survey). The high degree of satisfaction with the information on operational, financial, and performance aspects of the technology suggests that respondents had productive interactions with the technology developers or installers, who, as mentioned earlier, are highly trusted to address their information gaps. The ‘moderately important’ level of trust expressed in online resources as sources of information in both surveys points to them having potentially provided useful technological and financial information to the survey respondents.

5.1.4 Peer Effects

Apart from the trusted sources of information, which was explored earlier, the role of peer effects was examined using data from other survey questions in both the EV and solar surveys. These questions varied between the two surveys. This section uses responses that were most relevant to understanding the individual decision-making process and applies different methodologies for the EV and solar PV data due to the differences in types of data available.

Peer effects are classified into two categories: active effects, which involve interpersonal interaction, and passive effects, which only include exposure to others who own the technology.

Adopters are categorized into two groups: 1) passive interpersonal exposure to information regarding EVs, i.e., those who had access to coworkers and neighbors who owned EVs but did not talk to them about EVs and 2) active interpersonal exposure to information regarding EVs, i.e., those who talked to others about EVs.

5.1.4.1 Case 1: Electric Vehicles

The value of information from various sources was compared across the following binary factors: the presence of a neighbor who owned an EV, the presence of a coworker who owned an EV, whether the adopter contacted anyone regarding their EV purchase and whether the adopter contacted a neighbor regarding their EV purchase. There were no significant differences in the value placed on any of the sources of information between respondents who had passive exposure to information and those who had no interpersonal exposure. Adopters with active interpersonal exposure to information valued information from peers significantly higher with an observable correlation to the peers they had communicated with. Respondents who had communicated with neighbors relatively valued information from neighbors higher than those who did not. Those who had communicated with others who were not neighbors valued information from others including family and friends more than those who did not contact anyone.

There are four main variables in the EV surveys that provide insight into peer effects: 1) the number of coworkers who owned EVs, 2) the number of EVs in the owners' neighborhood, 3) the number of EV owners contacted, and 4) the number of EV owners contacted from their neighborhood. First, each of these four peer variables was dichotomized to indicate the presence or absence of EVs or communication with EV owners. For example, the dichotomized variable for the number of EV owners contacted is 1 when the number of EV owners contacted was reported as 1 or greater, and 0 otherwise. Next, logit regression models were run to determine the influence of age, income, and year of adoption on each of the four dichotomized peer effects variables. The influence of peers on 16 different survey responses including motivational factors, trusted sources of information, marketing medium received, and post information search satisfaction was assessed using logit regression models, controlling for age, income, and year of adoption (See Appendix). A summary of the findings regarding peer effects from logistic regression analyses is shown in Table 3.

Table 3. Summary of findings from logistic regression analysis of peer effects

Peer Effect Type	**Relationships with variables in Column 3**	**Variables**
Communication with EV owners	Positive	Reception of marketing messages through referrals Importance of information from neighbors, family members and friends
	Negative	Importance of information from the manufacturer
Presence of EVs in neighborhood	Positive	Post information-search satisfaction with understanding of performance, operation, and maintenance, and warranty aspects of procuring an EV Motivation to acquire an EV to reduce environmental impacts

Each of the four peer variables was positively correlated to the year of adoption, indicating a higher likelihood of having access to EV owners as well as communication with EV owners from one year to the next. The prevalence of communication with EV owners was found to be positively related to the likelihood of receiving marketing messages through referrals, valuing information from neighbors, family members and friends, and was negatively associated with the likelihood of trusting information from the manufacturer. The presence of EVs in the neighborhood, controlling for communication with EV owners, was positively related to the perceived satisfaction with the information search regarding performance, operation, maintenance and warranty aspects of an EV. The presence of EVs in the neighborhood, controlling for communication with EV owners, was also positively related with the role of motivation to reduce environmental impacts in the product purchase decision.

Both passive and active peer effects were observed in the EV sample. The passive effects suggest that seeing EVs in the neighborhood provided information that decreased uncertainty associated with the vehicle purchase and improved satisfaction with both technical and financial (warranty) aspects. The positive relationship between the presence of passive effects and the motivation to reduce environmental impacts suggests two possibilities: 1) respondents who had EVs in their neighborhood lived in like-minded environmentally friendly neighborhoods, or 2) seeing EVs in their neighborhood increased their motivation to reduce environmental impacts. In either of these two possibilities, the adopter may have been influenced by subjective norms persistent in his/her neighborhood.

Active peer effects were related to the value placed on information channels. The higher level of trust associated with those who respondents interacted with is likely indicative of respondents seeking information from trusted EV owners. The negative association between communication with EV owners and trust in manufacturers supports Rogers' rationale behind the use of communication channels. Respondents who sought information from EV owners most likely trusted the subjective evaluation of the EV owners more than the respondents who did not interact with other EV owners. Similarly, respondents who did not interact with EV owners placed greater value on information received directly from the experts, in this case, the manufacturers, than those who communicated with EV owners, suggesting that they were willing to act on information without requiring assistance or assurance from their interpersonal networks. The higher likelihood of interpersonal interaction with EV owners over time, along with the fact that interpersonal interaction is positively associated with trust of the person/group they interacted with, also supports Rogers' generalizations that later adopters rely more on interpersonal communication channels for their innovation decisions.

5.1.4.2 Case 2: Solar PV

A question in the solar PV survey asked, "What situations or events prompted your initial interest in installing a solar system?" (These events are referred to as spark events.) The respondents were provided with options (multiple options could be selected) including 1) a conversation with a friend, coworker or family member who had solar panels, 2) seeing a neighbor install solar panels, and 3) a conversation with a neighbor who had solar panels.

Of all the respondents, 22.8% mentioned 1) a conversation with a friend, coworker or family member who had solar panels. Of respondents who had at least one PV system in their neighborhood, 14.7% mentioned 2) seeing a neighbor install solar panels, and 14.9% mentioned 3) a conversation with a neighbor who had solar panels. Thus, both active and passive effects were stated as factors that prompted interest in acquiring the technology.

The rest of this section uses relevant results from the 'Barriers to Solar PV Adoption in Maturing Markets' working paper. Logit regression models were run to determine the influence of peers controlling for year of adoption and number of a cumulative installations in the solar PV study. Cumulative installations were measured as the cumulative installations of residential solar PV in California prior to the interconnection date of the observed adoption as recorded in publicly available CSI data. Cumulative installations were found to be significantly and positively associated with likelihood of a conversation with a neighbor being a spark event. However, conditional on having at least one system in the neighborhood, the neighbor spark event conversation was only significantly associated with cumulative installations. Overall, this indicates that neighborhood peer effects in neighborhoods with at least one solar PV system already installed increase in association with cumulative installations. The likelihood of reporting 2) seeing a neighbor with a solar PV system as a spark event, with the neighborhood having at least one solar PV system, was not associated with cumulative installations. Thus, the likelihood of passive peer effect 2) seeing neighbor install spark event) for an individual adopter was not influenced by cumulative number of installations, whereas active peer effect 3) a conversation with a neighbor who had solar panels was positively associated with the cumulative number of installations. As the cumulative number of installations in California is an indicator of the stage of adoption, it can be concluded that later adopters will be more positively influenced by interpersonal communication to adopt a solar PV panel than earlier adopters. Thus, Rogers' generalization that later adopters rely more on the subjective evaluation of earlier adopters in their innovation-decision process is supported in the PV sector.

5.1.4.3 Summary of Peer Effects

Assuming year of adoption in the EV study and cumulative installations in the solar PV study are indicators of stage of adoption, later stages of adoption are associated with a higher degree of influence of interpersonal communication. In the case of EVs, interpersonal communication was observed to influence the value placed on sources of information and the likelihood of receiving marketing media through referral. In the solar PV study, interpersonal communication was found to influence interest in procuring a solar PV system, and this influence increased proportionally with cumulative installations.

5.1.5 Procurement Mechanism

Leasing has been shown to relieve perceived burdens of ownership through an alleviation of perceived financial and technological risk (Schaefers, Lawson, & Kukar-Kinney, 2015). Technological risk may arise from unfamiliarity due to lack of experience with the technology and the rapidly changing landscape of technology options (Tylock, 2012). Non-monetary costs including expectations of rapid technological change and information barriers can lead to high discount rates for financial returns from innovation adoption (Rai & Sigrin, Diffusion of environmentally-friendly energy technologies: buy versus lease differences in residential PV markets, 2013; Hassett, 1993; Howarth, 1995). Researchers have recommended leasing as an option to address the problem of high discount rates (Coughlin, 2009; Drury, 2012).

The automotive sector has a long history of leasing. On the average, 25% of all new car sales in the US in 2013 were leases (Edmunds, 2013). By transferring the risk associated with maintenance, operation and ownership of a vehicle to a third party, leasing provides an avenue to reduce technological risk as well as uncertain financial ramifications of the use of this technology. Due to the clause that a leased vehicle may be returned to the manufacturer at the end of the lease term, previous studies have found that leasing, can lead to moral hazard, wherein maintenance expenditures on leased cars are below socially efficient levels (Johnson, 2014; Schneider, 2010).

In the residential solar PV market, two types of third-party ownership (TPO) mechanisms have been used in the US over the past couple of years – lease and solar power purchase agreement (PPA). In a solar lease, the customer is responsible for a monthly payment that does not depend on the PV system's energy production. In a solar PPA the customer pays per unit kilowatt-hour (kWh) of generation. In both TPO mechanisms, customers typically pay a one-time upfront down payment. The financial implications of entering the variety of solar TPO options is outside of the scope of this study; however, recent studies suggest that leasing provides a higher net present value than ownership (Rai & Sigrin, Diffusion of environmentally-friendly energy technologies: buy versus lease differences in residential PV markets, 2013), and PPA contracts cost more than leases (Davidson, 2015).

Overall, the proportions of solar PV survey respondents who chose to buy, lease or enter PPAs were 70%, 23%, and 3% respectively. The proportions of EV survey respondents who chose to buy and lease were 52.6% and 47.4% respectively. As Figure 5 shows, the proportions of buyers in both the EV and PV cohort decline with time. In the last few years of solar PV adoption, the proportion of PPAs increases sharply, whereas the proportion of leasers reaches its highest point in 2012.

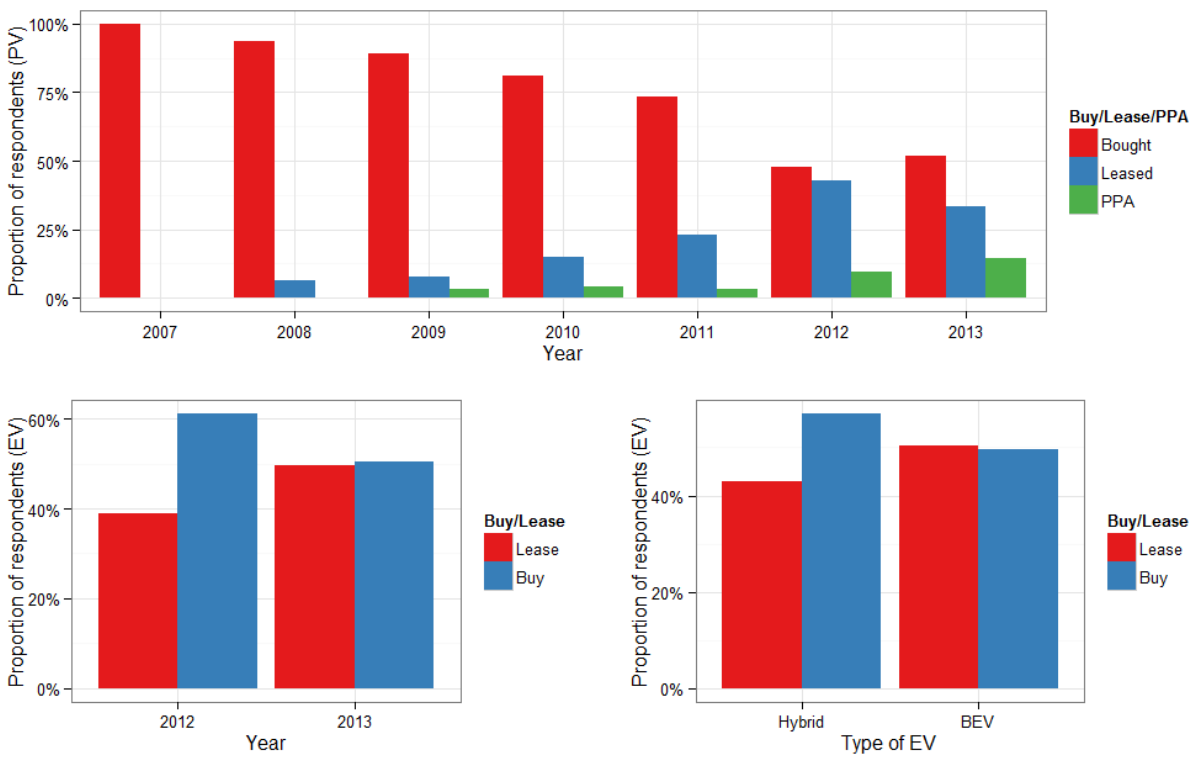

Figure 5. Proportions of survey respondents by procurement mechanism, year, and type of electric vehicle

The bottom right chart in Figure 5 displays the proportion of EV survey respondents who bought or leased their vehicles, by hybrid and battery electric vehicle (BEV) types. Respondents who acquired hybrid electric vehicles leased 43% of the time, compared to 50.4% of respondents who acquired BEVs. A two-sample test for equality of proportions revealed that these proportions were significantly different (χ^2 (df = 1, N = 6510) = 34.3, p ~ 0) This difference in leasing proportions is possibly due to varied levels of technological uncertainty. Hybrid electric vehicles use both an internal combustion engine as well as an electric motor for propulsion, whereas BEVs only use an electric motor. The partial reliance on a familiar engine for propulsion can result in reduced technological uncertainty in the adoption decision-making process for respondents who acquired hybrids in comparison to those who acquired BEVs. As leasing helps alleviate risk associated with technological uncertainty, the higher proportion of leasing observed in BEV owners is expected due to higher degree of unfamiliarity with the technology underlying BEVs.

5.1.5.1 Case 1: Electric Vehicles

The EV surveys, unlike the solar PV surveys in this study, did not contain specific questions regarding the factors behind the choice of method of acquisition. However, the program data from CVRP provided information on the respondents' chosen method of acquisition, overall purchase price (including interest and principal when applicable) and monthly payment. The survey data provides comparable factors to those evaluated in the solar surveys. The prioritization of saving money on fuel as a motivation to adopt an EV is used as a proxy variable to gauge the value of financial aspects in the adoption decision-making process. The reported satisfaction with information acquired on O&M of the vehicle is used as an indicator comparable to O&M concerns in the solar survey. In addition, variables were included indicating the reported satisfaction with information acquired on warranty, performance and financial aspects in the models.

A set of logistic regression models with the decision to buy or lease being the dependent variable were run to determine the primary drivers behind the acquisition-method decision. These models controlled for age, household income and vehicle make. A series of models were run to additively insert variables including purchase price, monthly payment, prioritization of reducing environmental impact, prioritization of saving money on fuel, O&M information satisfaction, and the presence of active and passive peer influences (See Appendix). Variance inflation factor tests were conducted for all models to check for multicollinearity. These tests consistently indicated only a significant relationship between the purchase price and vehicle make. The level of satisfaction with information obtained on performance, warranty and financial aspects had no significant influence on the respondents' choice to buy or lease the vehicle. A higher purchase price and lower monthly payments were associated with a higher likelihood of leasing. A higher prioritization of saving money on fuel was also positively associated with the likelihood of leasing. This suggests that a priority of saving money or reducing financial risk corresponded to a higher probability of leasing. A lower satisfaction with information on maintenance and operation of the vehicle was also associated with a higher likelihood of leasing. The lower satisfaction with O&M information indicates a higher uncertainty regarding O&M.

The prevalence of active peer effects (i.e., interpersonal communication with both neighbors and non-neighbors) was positively associated with the likelihood of leasing, whereas the passive influence of the presence of neighbors and coworkers who owned EVs was not significantly associated with the choice of acquisition method.

Younger respondents were associated with a higher likelihood of leasing their vehicle. This is most likely a reflection of their lower accumulated disposable financial savings leading to a higher propensity to look for financial savings and returns.

5.1.5.2 Case 2: Solar PV

This section heavily draws on findings from the 'Overcoming barriers and uncertainties in the adoption of residential solar PV' study. The solar survey included a question that asked the respondents to rate on a scale of "strongly disagree" to "strongly agree" the importance of factors affecting the choice of acquisition mechanism. Major reported determinant factors were the availability of upfront funds, operation and maintenance (O&M) concerns and calculated financial returns. Those that agreed that availability of upfront funds determined their method of acquisition used TPO mechanisms more than expected. A further investigation of dependencies of these determinant factors revealed that respondents with a solar PV system in their neighborhood report agreement that their acquisition-method decision was determined more frequently by a conversation with their neighbors than expected under independence. A logit model was run to determine the drivers behind the method of acquisition, controlling for neighbor contact, decision period, decision-making factors, spark events, and relevant demographics. Financial returns and concerns about O&M

remained significant determinants of the mode of adoption. Respondents that regarded O&M concerns as very important or extremely important and have the option to lease or enter a PPA, had 40 – 50% higher odds of pursuing TPO. All else equal, respondents that valued financial returns as very important or extremely important and had the option to lease or enter a PPA were about 25% less likely to pursue TPO.

5.1.5.3 Theory of Planned Behavior Implications

For this section, the procurement mechanism choice will be considered behavior in the context of TPB. In both the EV and solar PV analyses, higher concerns regarding O&M increased the likelihood of choosing TPO/leasing. This implies that technological uncertainty had a direct impact on the attitude and consequently influenced intention and behavior towards leasing. The availability of upfront funds influenced behavior among the solar PV respondents, which indicates that perceived behavioral control impacted the decision-making process. It is plausible that the effect of age on procurement mechanism choice in the EV analysis reflects the influence of behavioral control, as younger adopters may lack requisite upfront funds. If their control beliefs are a reflection of actual behavioral control, the effect of age on procurement choice in the EV analysis reflects the influence of perceived behavioral control. In both EV and solar PV surveys, respondents indicated that interpersonal communication with peers influenced their procurement mechanism decision. The role of interpersonal communication is more explainable as the role of trusted information in choosing a procurement mechanism, rather than the role of communicated subjective norms on the decision because there are no clearly established expectations in the buy or lease decision. Interpersonal communication may involve the relaying of descriptive norms to the adopter regarding the choice of procurement mechanism.

Chapter 6: Conclusions

6.1 Conclusions

This study finds several conclusions in alignment with Rogers' generalizations regarding communication channels and characteristics of earlier adopters. Both EV and solar PV respondents were wealthy and highly educated. A high level of trust is placed in technology providers and lower degree of trust in the adopters' interpersonal network, indicating a higher value for information received directly from those with direct technological and pricing knowhow, than information gained from the subjective evaluation of relatable peers.

The relatively low degree of interest in technological aspects of the innovation places adopters in both groups out of the innovators category. A common finding from both EV and solar PV analyses was the increased influence of peers in the innovation-decision process with time. This is expected under Rogers' diffusion of innovations theory when adopters move from earlier adopter stages to later stages. No significant transitions in underlying motivations were observed with time, signifying no observable shift in adopter stage. Overall, the demographic and attitudinal characteristics of both EV and PV adopters in this study are indicative of early adopters and the increasing role of interpersonal communication with time, signals a shift to early majority or later early adopters.

This study also finds strong support for the theory of planned behavior, through the identification of the role of personal norms, subjective norms, attitude, and perceived behavioral control on intention and, ultimately, behavior. The mix of environmental, societal, and self-oriented values was clearly observed in the decision-making process. A combination of environmental and societal values, and the observed influence of peers in the respondents' decisions suggests an influential role for personal and subjective norms. The role of perceived behavioral control was pronounced in the procurement mechanism decision, plausibly due to the capital-intensive nature of these innovations placing large demands on the available resources of adopters. In the EV cohort, the most frequently reported marketing medium revealed a possible role of habit in the information search process, which in turn has been observed in previous studies to be followed by habitual decision-making process. TPB does not have scope for the role of habit in behavioral decision-making. While this study cannot conclude the role of habit decisively, it does suggest a possible influence.

6.2 Implications for Future Research

Diffusion and adoption theories from economics can benefit greatly from a union with individual decision-making concepts that have historically burgeoned in fields of psychology. Rogers' and other relevant innovation diffusion theories characterize adopters and explain the flow of information, using observations of diffusion and theorizing the individual decision-making model. On the other hand, theories on individual decision-making from fields such as psychology explore individual decision-making and behavior without much regard for the network effects of communication between individuals. Innovation diffusion theory may benefit greatly from integrating the concepts of psychology into diffusion models to enhance understanding of the adoption process at an individual level.

Appendix

A.1. Description of variables

Table 4. Description of variables

Variable	Description
Lease.Indicator	Buy or Lease. 1 indicates lease, 0 indicates buy.
Pp	Purchase price of vehicle in thousands ($)
Payment	Monthly payment ($)
Envbin	Dichotomized numeric variable for 5-point Likert item for importance of *Reducing environmental impacts* in decision to acquire a PEV. 1 when rated as *Very important* or *Extremely important*; 0 otherwise.
Savebin	Dichotomized numeric variable for 5-point Likert item for importance of *Saving money on fuel costs* in decision to acquire a PEV. 1 when rated as *Very important* or *Extremely important*; 0 otherwise.
Postombin	Dichotomized numeric variable for 5-point Likert item for agreement after completion of information gathering with statement *I understood what was required to maintain and operate a PEV*. 1 when rated as *Agree* or *Strongly agree*; 0 otherwise.
Postperfbin	Dichotomized numeric variable for 5-point Likert item for agreement after completion of information gathering with statement *I understood what to expect regarding the performance of PEVs*. 1 when rated as *Agree* or *Strongly agree*; 0 otherwise.

Table 4. Description of variables (continued)

Postwarbin	Dichotomized numeric variable for 5-point Likert item for agreement after completion of information gathering with statement *I thought the warranty on the vehicle and components was adequate*. 1 when rated as *Agree* or *Strongly agree*; 0 otherwise.
Postfinbin	Dichotomized numeric variable for 5-point Likert item for agreement after completion of information gathering with statement *I understood what to expect regarding the financial costs and benefits of my PEV acquisition*. 1 when rated as *Agree* or *Strongly agree*; 0 otherwise.
Evinnei_bin	1 if respondent had EVs in neighborhood; 0 otherwise.
Evincowork_bin	1 if respondent had coworkers who owned EVs; 0 otherwise.
Num_nei_cont_bin	1 if respondent communicated with neighbors who owned EVs; 0 otherwise.
Num_cont_notnei_bin	1 if respondent communicated with non-neighbors who owned EVs; 0 otherwise.
Age	Age of respondent
Year	Year of acquiring an EV
Trustfamfrbin	Dichotomized numeric variable for 5-point Likert item for importance of information from *A family member, friend or colleague* in decision to acquire a PEV. 1 when rated as *Very important* or *Extremely important*; 0 otherwise.
Trustneibin	Dichotomized numeric variable for 5-point Likert item for importance of information from *Neighbor who drives a PEV* in decision to acquire a PEV. 1 when rated as *Very important* or *Extremely important*; 0 otherwise.

Table 4. Description of variables (continued)

Trustutilbin	Dichotomized numeric variable for 5-point Likert item for importance of information from *Electric utility* in decision to acquire a PEV. 1 when rated as *Very important* or *Extremely important*; 0 otherwise.
Trustmanubin	Dichotomized numeric variable for 5-point Likert item for importance of information from *PEV Manufacturer website* in decision to acquire a PEV. 1 when rated as *Very important* or *Extremely important*; 0 otherwise.
Tesla_bin	Binary variable for ownership of a Tesla EV. 1 when EV owned is a Tesla; 0 otherwise.
tindexbin	Dichotomized numeric variable for average of three 5-point scale Likert items for importance of *Desire for newest technology*, *Vehicle performance*, and *Supporting diffusion of EV technology*. Average of the three items is converted to a binary value such that averages of 4 or greater are coded as 1, and the rest are coded as 0.
Income	Household income level
Make	Make and model of the vehicle

A.2. Logistic regression models

All tables below are results of binomial logit regression models. The dependent variable is displayed at the top of each table and the independent variable names are displayed in the first columns for rows containing their respective coefficients.

All binomial logit models can be expressed as

$$\ln\left(\frac{\hat{p}}{1-\hat{p}}\right) = \beta_0 + \sum \beta X$$

where $\hat{p}$ refers to the probability of the dependent variable being 1, β_0 refers to the intercept, X refers to the independent variables and β refers to the coefficients corresponding to the independent variables

The tables below show the β coefficients and place their corresponding standard errors in parentheses. In some cases where variables were included in the model as control variables, their corresponding coefficients are not shown and are instead shown to be included with the indicator *Yes* .

Table 5. Binomial logit regression results for model on technology-driven motivation level

	Dependent variable: Logit(tindexbin)
tesla_bin	1.448*** (0.081)
Age	-0.001 (0.002)
Year	Yes
Income	Yes
Constant	-0.425*** (0.163)
Observations	5,629
Log Likelihood	-3,683.219
Akaike Inf. Crit.	7,410.437
Note:	$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$ Standard errors are displayed in parentheses

Table 6. Binomial logit regression results for models on procurement mechanism

	Dependent variable: Logit (Lease.Indicator) (Lease =1, Buy = 0)				
	Model 1	Model 2	Model 3	Model 4	Model 5
Pp	0.128*** (0.015)	0.246*** (0.021)	0.247*** (0.021)	0.246*** (0.021)	0.257*** (0.022)
payment		-0.009*** (0.0004)	-0.010*** (0.0004)	-0.009*** (0.0004)	-0.009*** (0.0004)
Envbin			0.034 (0.129)	0.041 (0.130)	0.025 (0.131)
Savebin			0.328** (0.152)	0.308** (0.154)	0.341** (0.155)
postombin				-0.304** (0.153)	-0.321** (0.155)
evinnei_bin					0.202 (0.127)
evincowork_bin					-0.061 (0.117)
num_nei_cont_bin					0.482** (0.197)
num_cont_notnei_bin					0.493*** (0.130)
Age	-0.027*** (0.004)	-0.031*** (0.005)	-0.030*** (0.005)	-0.030*** (0.005)	-0.032*** (0.005)
Constant	-3.744*** (0.626)	-4.244*** (0.821)	-4.603*** (0.844)	-4.315*** (0.855)	-5.159*** (0.887)
Observations	4,051	3,168	3,149	3,102	3,102
Log Likelihood	-1,742.160	-1,110.027	-1,094.881	-1,078.721	-1,068.098
Akaike Inf. Crit.	3,566.321	2,300.054	2,273.762	2,243.442	2,230.197
Note:	*p<0.1; **p<0.05; ***p<0.01 Standard errors are displayed in parentheses				

Table 7. Binomial logit regression results for models on satisfaction with understanding of performance, operation and maintenance, warranty and financial aspects, after information gathering was complete

	Dependent variable: Logit of			
	postperfbin	postombin	postwarbin	postfinbin
Year 2013 with respect to 2012	0.056 (0.132)	-0.328*** (0.121)	-0.042 (0.103)	0.007 (0.135)
evinnei_bin	0.352*** (0.136)	0.250** (0.11)	0.217** (-0.099)	0.286** (0.135)
evincowork_bin	0.141 (0.122)	0.226** (0.1)	0.089 (-0.09)	0.117 (0.119)
num_nei_cont_bin	-0.043 (0.204)	-0.195 (0.167)	-0.095 (-0.15)	-0.399** (0.2)
num_cont_notnei_bin	0.145 (0.129)	-0.088 (0.111)	-0.015 (-0.1)	-0.184 (0.135)
Age	-0.004 (0.005)	0.006 (0.004)	0.009** (-0.004)	0.0002 (0.005)
Constant	2.194*** (0.341)	2.008*** (0.302)	1.172*** (0.262)	2.472*** (0.353)
Observations	4,005	3,992	3,996	4,005
Log Likelihood	-1,188.11	-1,579.87	-1,838.78	-1,208.44
Akaike Inf. Crit.	2,424.21	3,207.74	3,725.57	2,464.87
Note:	*p<0.1; **p<0.05; ***p<0.01 Standard errors are displayed in parentheses			

Table 8. Binomial logit regression results for models on level of importance of *Reducing environmental impacts* and *Saving money on fuel costs* in PEV acquisition decision

	Dependent variable: Logit of	
	Envbin	Savebin
Year 2013 with respect to 2012	-0.016 (0.094)	0.248*** (0.093)
evinnei_bin	0.283*** (0.089)	0.02 (0.092)
evincowork_bin	0.023 (0.082)	0.058 (0.085)
num_nei_cont_bin	0.136 (0.143)	-0.09 (0.141)
num_cont_notnei_bin	-0.08 (0.091)	-0.225** (0.098)
Age	0.023*** (0.004)	-0.021*** (0.004)
Household Income	No sig. relationship	Negative
Constant	0.206 (0.241)	2.106*** (0.249)
Observations	4,032	4,039
Log Likelihood	-2,083.40	- 1,982.24
Akaike Inf. Crit.	4,214.79	4,012.49
Note:	*p<0.1; **p<0.05; ***p<0.01 Standard errors are displayed in parentheses	

Table 9. Binomial logit regression results for models on level of importance of information from family members and friends, neighbors, utility and manufacturer

Dependent variable:	trustfamfrbin	trustneibin	trustutilbin	trustmanubin
Year 2013 with respect to 2012	0.182** (0.091)	-0.028 (0.139)	0.086 (0.103)	0.083 (0.082)
evinnei_bin	-0.126 (0.082)	0.075 (0.127)	-0.097 (0.095)	-0.027 (0.078)
evincowork_bin	0.251*** (0.074)	0.189* (0.106)	0.042 (0.087)	-0.044 (0.072)
num_nei_cont_bin	1.198*** (0.128)	1.889*** (0.183)	0.174 (0.141)	-0.283** (0.117)
num_cont_notnei_bin	1.072*** (0.093)	0.767*** (0.157)	-0.139 (0.098)	-0.169** (0.081)
Age	-0.015*** (0.003)	-0.012** (0.005)	-0.018*** (0.004)	-0.004 (0.003)
Income	Yes	Yes	Yes	Yes
Constant	-0.580** (0.227)	-1.876*** (0.338)	-0.509** (0.259)	0.458** (0.207)
Observations	3,451	2,672	3,260	3,824
Log Likelihood	-2,268.48	-1,233.28	-1,808.31	-2,532.97
Akaike Inf. Crit.	4,584.96	2,514.55	3,664.63	5,113.94
Note:	*p<0.1; **p<0.05; ***p<0.01 Standard errors are displayed in parentheses			

References

2013 Motor Trend Car of the Year: Tesla Model S. (2012, November 12). Retrieved from Motor Trend: http://www.motortrend.com/news/2013-motor-trend-car-of-the-year-tesla-model-s/

Accenture. (2010). *The New Energy World: The Consumer Perspective.* Accenture.

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, 179-211.

Ajzen, I., & Fishbein, M. (2000). Attitudes and the attitude-behavior relation: Reasoned and automatic processes. *European review of social psychology*, 1-33.

Bass, F. M. (1980). The relationship between diffusion rates, experience curves, and demand elasticities for consumer durable technological innovations. *Journal of Business*, S51-S67.

Bolinger, M. (2014). *An Analysis of the Costs, Benefits, and Implications of Different Approaches to Capturing the Value of Renewable Energy Tax Incentives.* Lawrence Berkeley National Laboratory.

Bollinger, B. &. (2012). Peer effects in the diffusion of solar photovoltaic panels. *Marketing Science*, 900-912.

Branker, K. P. (2011). A review of solar photovoltaic levelized cost of electricity. *Renewable and Sustainable Energy Reviews*, 4470-4482.

Bunch, D. S., Bradley, M., Golob, T. F., Kitamura, R., & Occhiuzzo, G. P. (1993). Demand for clean-fuel vehicles in California: a discrete-choice stated preference pilot project. *Transportation Research Part A: Policy and Practice*, 237-253.

Burris, M. S. (2007). Reaction to the managed lane concept by various groups of travelers. *Transportation Research Record: Journal of the Transportation Research Board*.

Caird, S. R. (2008). Improving the energy performance of UK households: Results from surveys of consumer adoption and use of low-and zero-carbon technologies. *Energy Efficiency*, 149-166.

Carley, S. (2009). Distributed generation: An empirical analysis of primary motivators. *Energy Policy*, 1648-1659.

Coughlin, J. &. (2009). *Solar photovoltaic financing: residential sector deployment.* National Renewable Energy Laboratory.

Davidson, C. S. (2015). Exploring the market for third-party-owned residential photovoltaic systems: insights from lease and power-purchase agreement contract structures and costs in California. *Environmental Research Letters*.

Davis, M. A. (2013). *Total Cost of Ownership Model for Current Plug-in Electric Vehicles.* Palo Alto, California: Electric Power Research Institute.

De Groot, J. I. (2008). Value orientations to explain beliefs related to environmental significant behavior how to measure egoistic, altruistic, and biospheric value orientations. *Environment and Behavior*, 330-354.

Department of Energy. (2016, April 22). *Alternative Fuels Data enter*. Retrieved from Maps and Data: http://www.afdc.energy.gov/data/

Diamond, D. (2009). The impact of government incentives for hybrid-electric vehicles: Evidence from US states. *Energy Policy*, 972-983.

DrivingSales News. (2016, February 18). *Tesla's New Referral Program Offers Chance For Any Participant To Win*. Retrieved from DrivingSales: http://drivingsalesnews.com/teslas-new-referral-program-offers-chance-for-any-participant-to-win/

Drury, E. M. (2012). The transformation of southern California's residential photovoltaics market through third-party ownership. *Energy Policy*, 681-690.

Edmunds. (2013, July 16). *Edmunds*. Retrieved from Leasing Is Shifting the New Car Market But It Isn't the Best Choice for Everyone: http://www.edmunds.com/about/press/leasing-is-shifting-the-new-car-market-but-it-isnt-the-best-choice-for-everyone-says-edmundscom.html

Environmental Protection Agency. (2016, April). *Overview of Greenhouse Gases*. Retrieved from EPA: Climate Change.

Ewing, G., & Sarigöllü, E. (2000). Assessing consumer preferences for clean-fuel vehicles: A discrete choice experiment. *Journal of public policy & marketing*, 106-118.

Fuchs, D. A. (2002). Green electricity in the market place: the policy challenge. *Energy policy*, 525-538.

Gallagher, K. S., & Muehlegger, E. (2011). Giving green to get green? Incentives and consumer adoption of hybrid vehicle technology. *Journal of Environmental Economics and Management*, 1-15.

Gardner, G. T. (2008). The short list: The most effective actions US households can take to curb climate change. *Environment: science and policy for sustainable development*, 12-25.

Gärling, T. F. (2003). Moderating effects of social value orientation on determinants of proenvironmental behavior . *Journal of environmental psychology*, 1-9.

Gärling, T., Fujii, S., Gärling, A., & Jakobsson, C. (2003). Moderating effects of social value orientation on determinants of proenvironmental behavior intention. *Journal of environmental psychology*, 1-9.

Gillingham, K., Deng, H., Wiser, R., Dargouth, N., Nemet, G., Barbose, G., . . . Dong, C. (2014). *Deconstructing Solar Photovoltaic Pricing: The Role of Market Structure, Technology, and Policy.* Lawrence Berkeley National Lab.

Green Tech Media. (2016, April 22). *Here Are the Top Five Residential Solar Installers of 2014*. Retrieved from Green Tech Media: http://www.greentechmedia.com/articles/read/Here-Are-the-Top-Five-Residential-Solar-Installers-of-2014

Green, E. H. (2014). Increasing electric vehicle policy efficiency and effectiveness by reducing mainstream market bias. *Energy Policy*, 562-566.

Hagerman, S. J. (2016). Is rooftop solar PV at socket parity without subsidies? *Energy Policy*, 84-94.

Hardman, S. S.-W. (2015). Changing the fate of Fuel Cell Vehicles: Can lessons be learnt from Tesla Motors? *International Journal of Hydrogen Energy*, 1625-1638.

Hassett, K. A. (1993). Energy conservation investment: Do consumers discount the future correctly? *Energy Policy*, 710-716.

Hidrue, M. K., Parsons, G. R., Kempton, W., & Gardner, M. P. (2011). Willingness to pay for electric vehicles and their attributes. *Resource and Energy Economics*, 686-705.

Howarth, R. B. (1995). Discount rates and energy efficiency. *Contemporary Economic Policy*, 101-109.

Hunecke, M. B. (2001). Responsibility and environment ecological norm orientation and external factors in the domain of travel mode choice behavior. *Environment and Behavior*, 830-852.

IPCC. (2014). *Climate Change 2014 Synthesis Report: Summary for Policymakers.* IPCC.

Johnson, J. P. (2014). The Role and Growth of New-Car Leasing: Theory and Evidence. *Journal of Law and Economics*, 665-698.

Kavalec, C. (1999). Vehicle choice in an aging population: some insights from a stated preference survey for California. *The Energy Journal*, 123-138.

Klein, J. (2010). *Comparative Costs of California Central Station Electricity Generation.* California Energy Commission.

Kley, F. L. (2011). New business models for electric cars—A holistic approach. *Energy Policy*, 3392-3403.

Lane, B. (2012). *Plug-in Electric Vehicles-A Practical Plan for Progress: The Report of an Expert Panel.* SelectedWorks.

Li, J. E. (2007). Who chooses to carpool and why?: examination of Texas carpoolers. *Transportation Research Record: Journal of the Transportation Research Board*, 110-117.

Loukopoulos, P. J. (2004). Car-user responses to travel demand management measures: goal setting and choice of adaptation alternatives. *Transportation Research Part D: Transport and Environment*, 263-280.

Mannering, F. &. (1985). A dynamic empirical analysis of household vehicle ownership and utilization. *The RAND Journal of Economics*, 215-236.

Margolis, R. M. (2009). *Break-even cost for residential photovoltaics in the United States: key drivers and sensitivities.* National Renewable Energy Laboratory.

Mints, P. (2011). *The 12-step solar program: towards an incentive-less future.* . Navigant Consulting on ElectoIQ.

National Conference of State Legislatures. (2016, April 22). *State Renewable Portfolio Standards and Goals*. Retrieved from National Conference of State Legilsatures: http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx

Natural Resources Defense Council. (2007). *The Next Generation of Hybrid Cars: Plug-In Hybrids Can Help Reduce Global Warming and Slash Oil Dependency.* Natural Resources Defense Council.

Nayum, A. &. (2014). A comprehensive socio-psychological approach to car type choice. *Journal of Environmental Psychology*, 401-411.

New York Times. (2011, January 30). *New Electricity Meters Stir Fears*. Retrieved from New York Times: http://www.nytimes.com/2011/01/31/science/earth/31meters.html?_r=0

NREL. (2015). *Sustainable Transportation.* National Renewable Energy Laboratory.

Platzer, M. D. (2012). *U.S. Solar Photovoltaic Manufacturing: Industry Trends, Global Competition, Federal Support.* Congressional Research Service.

Potoglou, D., & Kanaroglou, P. S. (2007). Household demand and willingness to pay for clean vehicles. *Transportation Research Part D: Transport and Environment*, 264-274.

Quintal, V. A. (2010). Risk, uncertainty and the theory of planned behavior: A tourism example. *Tourism Management*, 797-805.

Rai, V., & Sigrin, B. (2013). Diffusion of environmentally-friendly energy technologies: buy versus lease differences in residential PV markets. *Environmental Research Letters*.

Rai, V., Reeves, D. C., & Margolis, R. (2016). Barriers to Solar PV Adoption in Maturing Markets (Working Paper).

Rai, V., Reeves, D. C., & Margolis, R. (2016). Overcoming barriers and uncertainties in the adoption of residential solar PV. *Renewable Energy*, 498-505.

Rogers, E. (2003). *Diffusion of Innovations.* Free Press.

Schaefers, T., Lawson, S. J., & Kukar-Kinney, M. (2015). How the burdens of ownership promote consumer usage of access-based services. *Marketing Letters*, 1-9.

Schneider, H. (2010). Moral hazard in leasing contracts: Evidence from the New York City taxi industry. *Journal of Law and Economics*, 783-805.

Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychological science*, 429-434.

Schwartz, S. H. (1973). Normative explanations of helping behavior: A critique, proposal, and empirical test. *Journal of Experimental Social Psychology*, 349-364.

Schwartz, S. H., & Howard, J. A. (1984). Internalized values as motivators of altruism. In *Development and maintenance of prosocial behavior* (pp. 229-255). Spring US.

Secretariat, C. C. (1992). *United Nations Framework Convention on Climate Change.* Geneva: UNEP/IUC.

Skerlos, S. J. (2010). Targeting plug-in hybrid electric vehicle policies to increase social benefits. *Energy Policy*, 705-708.

Steel, B. S. (2015). Environmental Value Considerations in Public Attitudes About Alternative Energy Development in Oregon and Washington. *Environmental management*, 634-645.

Taylor, M. (2008). Beyond technology-push and demand-pull: Lessons from California's solar policy. *Energy Economics*, 2829-2854.

Tuttle, D. P. (2012). Electrified vehicle technology trends, infrastructure implications, and cost comparisons. *Journal of the Transportation Research Forum*.

Tylock, S. M. (2012). Energy management under policy and technology uncertainty. *Energy Policy*, 156-163.

U.S. Department of Energy. (2014). *Revolution Now.* U.S. Department of Energy.

U.S. Environmental Protection Agency. (2014). *GHG Abatement Measures*. U.S. Environmental Protection Agency.

United Nations. (2015). Conference of the Parties. *Conference of the Parties.* Paris: United Nations.

United Nations. (2016, April 22). *List of Parties that signed the Paris Agreement on 22 April*. Retrieved from United Nations Sustainable Development: http://www.un.org/sustainabledevelopment/blog/2016/04/parisagreementsingatures/

Verplanken, B. A. (1997). Habit, information acquisition, and the process of making travel mode choices. *European journal of social psychology*, 539-560.

Wang, T. &. (2012). Attitudes, mode switching behavior, and the built environment: A longitudinal study in the Puget Sound Region. *Transportation research part A: policy and practice*, 1594-1607.

Washington State Department of Transportation. (2007). *HOV User Survey*. Washington State Department of Transportation.

Wiidegren, Ö. (1998). The new environmental paradigm and personal norms. *Environment and behavior*, 75-100.

Yang, C. (2010). Reconsidering solar grid parity. *Energy policy*, 3270-3273.

Zhang, T., Gensler, S., & Garcia, R. (2011). A Study of the Diffusion of Alternative Fuel Vehicles: An Agent-Based Modeling Approach*. *Journal of Product Innovation Management*, 152-168.

Ziegler, A. (2012). Individual characteristics and stated preferences for alternative energy sources and propulsion technologies in vehicles: A discrete choice analysis for Germany. *Transportation Research Part A: Policy and Practice*, 1372-1385.