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Assessing the Importance of Car Meanings and Attitudes in Consumer Evaluations of Electric Vehicles

AUTHORS

Craig Morton

Jillian Anable

John D Nelson

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ABSTRACT

This paper reports findings from a research study which assesses the importance of attitudinal constructs related to general car attitudes and the meanings attached to car ownership over evaluations of Electric Vehicles (EVs). The data are assessed using Principal Component Analysis to evaluate the structure of the underlying attitudinal constructs. The identified constructs are then entered into a hierarchical regression analysis which uses either positive or negative evaluations of the instrumental capabilities of EVs as the dependent variable. Results show that attitudinal constructs offer additional predictive power over socio-economic characteristics and that the symbolic and emotive meanings of car ownership are as, if not more, effective in explaining the assessment of EV instrumental capability as compared to issues of cost and environmental concern. Additionally, the more important an individual considers their car to be in their everyday life, the more negative their evaluations are of EVs whilst individuals who claim to be knowledgeable about cars in general and EVs in particular have a lower propensity for negative EV attitudes. However, positive and negative EV attitudes are related to different attitudinal constructs suggesting it is possible for someone to hold both negative and positive assessments at the same time.

KEY WORDS

Electric Vehicles, Attitude Measurement, Psychometric Modelling

INTRODUCTION

The Government of the United Kingdom (UK) has set in place legally binding targets for reductions in carbon dioxide (CO_2) emissions amounting to an 80% decrease by 2050 based on 1990 emissions level to be achieved by five-yearly carbon budgets (Great Britain 2008). In addition, improving energy security by diversifying sources of supply to the oil dependent transport system is considered a strategically important objective (OLEV 2013). Electric Vehicles (EVs), comprising both pure battery electric vehicles and plug-in hybrid vehicles, are viewed as a technology which holds the potential to decarbonise the passenger vehicle transport sector (Contestabile et al. 2012), which contributed 21% to the UK's greenhouse gas inventory in 2011 (Ricardo-AEA 2013), alongside introducing new fuel sources to the transport system (van Vliet et al. 2010). The Committee on Climate Change has published trajectories for the transport sector, detailing milestones necessary to reach the legislated reductions in CO_2. In reference to EV uptake, 12,000 were required to be sold in 2012 whilst the actual sales quantity stood at 2,250 by the end of that year (CCC 2013). This underachievement may have significant consequences for the UK's transition to a low carbon economy. This paper aims to offer new insights regarding why consumer demand for EVs is not reaching expectations in an effort to add towards the growing evidence base on this issue (Egbue and Long 2012; Shepherd et al. 2012).

With respect to private household (i.e. not fleet) car purchase behaviour which is the focus of this paper, the existing literature in this field is extensive with econometric (Train 1980; Mannering and Train 1985; Dagsvik et al. 2002), psychometric (Choo and Mokhtarian 2004; Ozaki and Sevastyanova 2011; Peters et al. 2011) and qualitative studies (Turrentine and Kurani 2007; Caperello and Kurani 2012; Graham-Rowe et al. 2012) having been applied to understand consumer uptake of alternatively fuelled vehicles. The novel instrumental characteristics of EVs, such as reduced range and limited fuel availability, have been repeatedly found to be significant issues in consumer aversion to this technology (Beggs et al. 1981; Calfee 1985; Potoglou and Kanaroglou 2007). However, little research has been conducted into the underlying motivations for these negative evaluations of the instrumental characteristics of EVs. This paper aims to address this gap in current understanding by determining if the attitudes of private car owners towards the instrumental capabilities of EVs are connected to and stem from related attitudinal constructs. Specifically, this paper will approach the following research questions:

- Can the meanings an individual attaches to the ownership of their car be used to explain their evaluations of EVs?

- Are the attitudes an individual holds towards cars in general useful in explaining their evaluations of EVs in particular?

To begin the paper, an overview of the relevant literature is offered. Following this, a description of the methodology selected to answer the research questions is provided, detailing the conceptual framework and the practicalities related to data collection. The paper proceeds by presenting the results of the analysis and uses the knowledge gained to address the specific research questions initially posed. To conclude, the key findings of the study are summarized and the implications for policy highlighted.

PREVIOUS STUDIES

Early research examining consumer demand for EVs approached the subject quantitatively through the application of econometric models to determine the magnitude of likely demand and assess consumer preferences for novel EV characteristics (Train 1980; Mannering and Train 1985). As no actual sales data was available for EVs, researchers tended to employ discrete choice models (DCM) (Train 2009) based on the random utility maximisation model (McFadden 1980) which used stated preference data attained from surveys that asked potential consumers to participate in hypothetical vehicle purchasing exercises. The DCM approach has a number of distinct benefits, allowing researchers to examine how the novel attributes of new products effect the subjective utility of consumers and to predict likely market shares leading to DCM remaining a popular approach in research studies in the present day. Studies of this nature confirmed that consumers tend to associate the limited ranges of EVs with a significant degree of disutility (Beggs et al. 1981). Moreover, consumers generally have high discount rates concerning vehicle operating costs (Musti and Kockelman 2011), meaning the fuel efficiency savings of EVs are unlikely to compensate for their substantial price premiums. The market potential of EVs has generally received muted predictions (Train 1980; Calfee 1985; Lieven et al. 2011) though studies have found that, if EVs can achieve similar technical performance levels to conventional vehicles and price parities, significant levels of consumer demand may emerge (Golob et al. 1993; Eggers and Eggers 2011). An excellent review of recent developments in DCM of the EV market alongside insights into the applications of agent based modelling and diffusion analysis is offered by Al-Alawi and Bradley (2013) who produced a synthesis of forecasting studies and provide a number of suggestions concerning how the validity of such studies can be improved.

More recently, researchers have applied psychometric models to assess the demand for EVs and other forms of low emission vehicle (Lane and Potter 2007). Offering initial guidance on how psychometric constructs, such as attitudes and values, can affect vehicle ownership decisions, Choo and Mokhtarian (2004) found that different vehicle types are more likely to be driven by individuals with certain personality characteristic, with individuals who desire social status more likely to drive a luxury or sports car whilst those with a calm disposition have a tendency to select minivans. Extending this research approach into the market for low emission vehicles, Sangkapichai and Saphores (2008) explored consumer interest in hybrid vehicles (HEVs) in California and found that individuals that hold concerns about the environment, energy efficiency, global warming and fuel prices tend to be more attracted to this vehicle type. Extending the examination of consumer preferences in this area, Ozaki and Sevatsyanova (2011) examined adopter motivation for HEVs in the UK and found that environmental considerations, such as having a reduced climate change and environmental impact, were prominent issues in uptake. Exploring the rationale for the purchase of an alternatively fuelled vehicle in Sweden, Jansson et al. (2011) measured a range of values and beliefs and found, surprisingly, that the desire for egoistic life pursuits positively influenced the likelihood of adoption, suggesting that early adopters may associate new vehicle technology with personal gain in wealth or status. Investigating the adoption of EVs in particular, Peters et al. (2011) explored the influence of constructs embedded in the Diffusion of Innovation Theory (Rogers 2003) and Theory of Planned Behaviour (Ajzen 1991). The constructs of compatibility, which measures the ability of EVs to integrate with a user's lifestyle, and relative advantage, both in terms of driving and operation, were found to be significant motivators for EV adoption.

Research that makes use of DCM, which is based on economic theory, and psychometric modelling, which is more closely linked to psychology, have tended to be considered as mutually exclusive alternatives. However, efforts have been made in order to bridge the divide which exists between these different approaches in an effort to produce integrated models that can simultaneously account for the influence of the instrumental attributes of EVs and the psychological profiles of the consumers. Offering a potential means through which this can be achieved, Ben-Akiva et al. (2002) outlined the hybrid choice model (HCM) which relaxes a number of the modelling assumptions of DCM in order to allow for the inclusion of latent psychological constructs. Applying a HCM in order to examine consumer reaction to new car technologies in Canada, Bolduc et al. (2008) incorporated latent psychological constructs which measure environmental concern and appreciation for new car features and found that this leads to both

the specification of a more realistic model and an improvement to model fit compared to only including the instrumental features of the vehicles. These findings are supported in a HCM developed by Daziano and Bolduc (2013) which found that consumers with a high degree of environmental concern have a higher willingness to pay for low emission vehicles compared to unconcerned consumers. Further demonstrating the potential for HCMs, Glerum et al. (2013) produced a latent variable model in order to measure attitudes towards car leasing contracts and then integrated this with a DCM procedure. Findings from this research illustrate that consumers who have positive pro-leasing attitudes tend to be less sensitive to changes in the cost of monthly EV battery rental contracts. In an effort to fully integrate psychometric and DCM, Daziano and Chiew (2012) have proposed an extensive choice model of EV purchase which incorporates the findings of previous studies, though modelling complexity and data requirements are likely to represent significant challenges for this project.

Taking into consideration the literature reviewed so far, it is evident that researchers examining the demand for EVs have primarily made use of quantitative methods in order to explain and predict demand. To counter balance the dominance of quantitative methods in this field, researchers have proposed novel methodologies (Turrentine and Sperling 1992) and have applied reflexive techniques to provide a deeper understanding of how consumers are evaluating EVs (Kurani et al. 1996). Qualitative methods have been successful in identifying new issues regarding EV adoption. Heffner et al. (2007) examined the symbolic frameworks which have formed surrounding HEV ownership in California with their analysis demonstrating that common depictions of HEV owners as environmentalists or technological enthusiasts are overly simplistic. Exploring the motivations of EV adoption in France, Pierre et al. (2011) found that adopters can be partitioned based on either their pioneering spirit to protect the environment and make use of advanced technology or their desire to seize opportunities by taking advantage of favourable conditions for EV adoption. Individuals who have the opportunity to trial EVs express opinions that they are still a work in progress (Graham-Rowe et al. 2012) with similar results observed by Caperello and Kurani (2012) who found that plug-in hybrid EVs are often viewed as representing a technological future as opposed to a present day reality.

CONCEPTUAL FRAMEWORK

The literature on the private consumption of new vehicle technologies in general, and EVs in particular, is vast and growing as this technology takes on a dominant role in transport, energy and climate change policy around the globe. New methods and theoretical paradigms are increasingly being applied to

investigations of personal car ownership as outlined in the previous section. Nevertheless, the majority of this research concentrates on measuring attitudes in relation to very specific EV attributes, mostly with the goal of explaining *intentions* to adopt these vehicles. Whilst this has provided some detailed accounts of the role of range anxiety or purchase price premiums on potential adoption, the review conducted for this study found very little emphasis on understanding what factors underpin the evaluations of specific EV attributes, including, for instance, the role of prior knowledge and understanding, how EVs fit into private car owners' beliefs and the meanings attached to car ownership.

The emphasis in the literature on the process of diffusion of innovations and therefore the implicit recognition of the dynamic processes of changes in attitudes and preferences that will inevitably take place makes this failure to understand the development of attitudes all the more surprising. Some literature does track the spread of attitudes throughout the population as technology becomes more prevalent in the market (Mau et al. 2008; Axsen et al. 2009; Heutel and Muehlegger 2009), focusing on important processes of social learning and contagion of norms and behaviour. This captures the changes in social concerns, increased credibility and learning from others with more experience as well as marketing, education and shifts in social norms that will take place as the adoption rate increases (Axsen et al. 2009; Heutel and Muehlegger 2009). This, in turn, feeds into the technological learning that is realised with increased diffusion (Heutink et al. 2009).

In this paper, we do not examine the *process* of attitude change and diffusion directly, but we do focus on the factors which potentially underpin attitudes to EVs that would need to change in order for the transformation of norms and diffusion of behaviour to take place. As such, the study reported in this paper adds towards the recent research which has applied psychometric models to consumer demand for EVs, by developing and applying a conceptual framework which aims to explain attitudes towards the instrumental characteristics of EVs through related attitudinal constructs pertaining to car ownership. The framework is illustrated in Figure 1 and contains three primary components which are each associated with a unique attitudinal measurement scale.

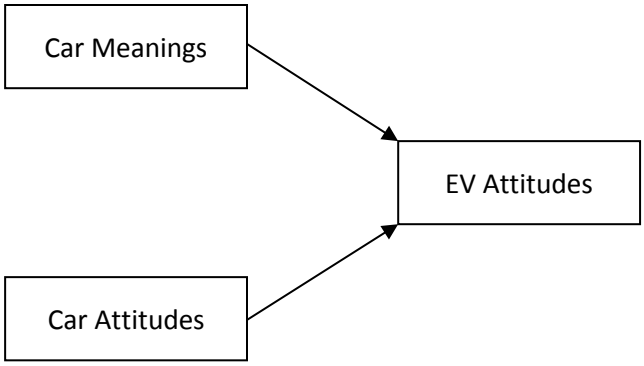

Figure 1: An illustration of the conceptual framework developed in this study with the main components of [1] *Car Meanings*, [2] *Car Attitudes* and [3] *EV Attitudes* detailed.

The first of these components (*Car Meanings*) measures the symbolic, emotive and instrumental meanings individuals place on car ownership[1]. As initially proposed by Dittmar (1992), variants of this scale have been applied in transport studies (Anable and Gatersleben 2005; Steg et al. 2001; Steg 2005) and have been found to significantly distinguish between car drivers based on their attitudes towards cars and car use behaviour. Moreover, the scale has been adapted to examine consumer intention to adopt an EV based on the importance of instrumental, hedonic and symbolic EV attributes (Schuitema et al. 2012). The results of Schuitema et al.'s study indicate that instrumental EV features are underpinning the hedonic and symbolic interpretations of the vehicles. Moreover, symbolic and emotive considerations of EVs significantly influence the intention to adopt these vehicles. In the study reported in this paper, the inclusion of this component in the conceptual framework assists in determining how the assignment of symbolic, emotive and instrumental meanings to cars in general influences appraisals of the instrumental performance of EVs in particular. An attitudinal scale comprising 12 statements has been developed in order to measure the meanings an individual places on car ownership.

The second component (*Car Attitudes*) measures a number of general attitudes towards cars to determine if they are useful in explaining evaluations of the instrumental characteristics of EVs. Included in this component are attitudes which have already received significant attention in this field, such as the concerns an individual holds regarding the environmental consequences of car use (Sangkapichai and Saphores 2009) alongside issues relating to vehicle purchase and running costs (Eggers and Eggers 2011), whilst also including aspects which as yet remain unexplored. Specifically, the research presented in this paper draws on the work of Chandler and Schwatz (2010), who found that perceived car

[1] The manner in which ownership is considered in this paper is primarily related to the outright purchase of a car and not car leasing or rental.

importance holds a significant influence over vehicle replacement times, and applies this to determine if the importance an individual places on car ownership is useful in explaining their evaluations of EV instrumental attributes. Additionally, Lai (1991) found that pre-existing knowledge of a product significantly effects the adoption of a new innovation. The study reported in this paper examines this issue by observing if self-reported knowledge concerning cars in general and EVs in particular holds explanatory power over attitudes towards the instrumental attributes of EVs. An attitudinal scale comprising 15 statements has been developed in order to measure these general car attitudes.

The final component (*EV Attitudes*) measures the attitudes individuals hold towards the instrumental characteristics of EVs. With previous research highlighting the importance of range anxiety (Beggs et al. 1981; Egbue and Long 2012), fuel cost (Potoglou and Kanaroglou 2007) and purchase price premiums (Ewing and Sarigöllü 1998) to consumer evaluations of EVs, these have been incorporated into this component. Moreover, EV attributes which have received relatively less attention, such as concerns relating to the reliability of EVs, the associated complexity of EVs and the safety implications of EV operation have also been included in the analysis to determine their importance. An attitudinal scale comprising 8 statements has been developed in order to measure attitudes regarding the functional capabilities of EVs. This component represents the focal point of the conceptual framework and acts as the dependent variable in the hierarchical regression analysis.

METHODOLOGY

The framework has been applied through a self-completion household questionnaire distributed in the cities of Newcastle upon Tyne and Dundee during the winter of 2011. A two site approach was selected to assess the role of recent government policy deployed in the region of Newcastle upon Tyne. The results of this aspect of the project can be viewed in related work (Morton 2013) with the dataset being unified for the analysis presented in this paper. The decision was made to concentrate specifically on the attitudes of private households with the implications for fleet purchases not specifically covered.

The household questionnaire incorporated 18 different sections including details of current household cars, travel patterns, attitudes towards cars, attitudes towards EVs, preferences for EVs, personal value structures and socio-economic details. Four of the sections included in the household questionnaire are utilised in this paper, including the attitudinal scales measuring car meanings, car attitudes, EV attitudes and socio-economic characteristics.

In order to improve the probability of attaining a representative dataset, a stratified random sampling procedure was utilised. The Index of Multiple Deprivation[2] (DCLG 2010; ONS 2009) was used as a partition metric with three areas representing low, medium and high deprivation levels identified in both of the sites. Questionnaires were distributed to households in these three areas in each of the two sites following a semi-randomised approach whereby every other road connected to a trunk-route was selected for distribution with every other household on the selected roads receiving a questionnaire.

Table 1: Comparison between population and sample characteristics

Variable	Category	Population	Sample
Car Ownership [a]	No car	25%	11%
	One car	42%	54%
	Two or more cars	33%	35%
Annual Car Mileage [a]	Mean	8430	8260
Age (years) [b]	18-30	22%	6%
	31-50	35%	27%
	51-65	23%	37%
	65+	20%	30%
Gender [b]	Male	49.2%	59.1%
	Female	50.8%	40.9%
Employment Status [c]	Full time employment	42%	46%
	Part time employment	16%	9%
	Unemployed	5%	1%
	Economically inactive	18%	4%
	Retired	19%	40%
Gross Household Income (GBP) [c]	< 10, 000	9%	7%
	10 - 30, 000	44%	40%
	30 - 50,000	24%	28%
	50 - 70.000	12%	14%
	70 - 90,000	5%	7%
	> 90, 000	6%	6%

[a] – DfT (2011) [b] – ONS (2011) [c] – ONS (2012)

A total of 506 responses were received with the sample providing a satisfactory fit to the general population. Table 1 presents an overview of how the sample compares against the general populace of the UK. Briefly, the sample attained provides a close match to the population with respect to gross household income and annual car mileage. Some moderate divergences are observed for the gender split and levels of car ownership with some larger discrepancies being present for the age profile and

[2]The Index of Multiple Deprivation measures spatial variance in employment, income, health, education, access and crime.

employment status. To evaluate the effects of these highlighted differences, socio-economic characteristics have been included as independent variables in the regression analysis to determine their influence.

RESULTS

The results of the statistical analysis applied to the sample are presented in three phases. To begin, the attitudinal scales measuring the components of the conceptual framework are assessed using principal components analysis (PCA), illustrating how the scales have been partitioned and which statements have been grouped together. Following this, a correlation analysis between the constructs identified in the PCA and socio-economic characteristic is conducted. To conclude the section, the conceptual framework and the strength of the antecedents of attitudes towards the instrumental attributes of EVs is evaluated through the application of hierarchical regression analysis which appraises the explanatory power of the framework.

The three attitudinal scales which comprise the components of the conceptual framework have been analysed in separate PCAs (Pearson 1901; Hotelling 1933) alongside Varimax rotation (Kaiser 1958) with the factor scores calculated using the regression method (Harris 1967). The selection of this statistical approach was due to the ability of PCA combined with Varimax rotation to produce clear separation in the constructs identified and the ease in which these constructs can be transferred into appropriate factor scores (Joliffe and Morgan 1992). For each attitude statement, a 7 point Likert scale (Likert 1932) response format was utilised running from the response category of "highly disagree" to "highly agree". The dataset was subjected to a list-wise exclusion to remove the impact of missing values leading to a reduced sample of 400 being employed in the analysis. Attitude statements have been assigned to constructs where the coefficient loading of a statement on a particular construct is in excess of 0.3. To evaluate the quality of the constructs identified, Cronbach's alpha (α) (Cronbach 1951) has been calculated to determine the internal consistency of the construct and this proves satisfactory in most instances[3]. The total variance explained (TVE) by each identified construct is also stated to illustrate its prominence in the related scale. Moreover, the Kaiser-Meyer-Olkin (Cerny and Kaiser 1977) test of sampling adequacy and Bartlett's test of sphericity (Bartlett 1950) have been calculated for each scale and provide satisfactory results[4], meaning the scales are suitable for structure detection. The results of

[3]Schmitt (1996) notes that an alpha in excess of 0.5 is adequate for the estimation of valid coefficients.

[4] KMO values of .866 for *Car Meanings*, .742 for *Car Attitudes* and .709 for *EV Attitudes* whilst Bartlett's test was significant in all instances at the 0.01 p-value level.

the analysis are summarized in Table 2 (*Car Meanings* and *Car Attitudes* scales) and Table 3 (*EV Attitudes* scale) which notes the constitute attitude statement structures for each construct, the Cronbach's alpha, the TVE, their associated labels and their coefficients.

Table 2: Overview of principal component analysis of the *Car Meanings* scale and *Car Attitudes* scale (n=400)

Statement	Coefficient
Car Meanings: Symbolism and Emotion (α: .907) (TVE: 41.8%)*	
Improve my appearance or the way I look	.878
Make others think well of me	.877
Provide me with social status	.860
Improve my mood	.767
Provide emotional security	.749
Be beautiful or attractive in appearance	.723
Allow me to express myself	.682
Car Meanings: Instrumental (α: .696) (TVE: 15.5%)*	
Allow me to be efficient in my daily life and work	.716
Be a sensible financial decision	.672
Have a lot of practical usefulness	.650
Provide enjoyment	.631
Be a hassle	-.560
Allow me to express myself	.327
Car Attitudes: Importance (α: .805) (TVE: 21.7%)	
I consider my car to be part of the family	.837
If my car was stolen, I'd feel as if I had lost a part of myself	.811
The car I drive is irreplaceable	.806
I often treat my car as if it were a person	.683
My car is the most important thing I own	.629
Without my car, my life would become very difficult	.471
Car Attitudes: Environment (α: .785) (TVE: 16.8%)	
I am concerned about the environmental impact of driving my car	.871
I am willing to spend more on a car that has lower pollution levels	.832
I think it is my responsibility to reduce the environmental impact of driving my car	.806
I am willing to spend more on a car that has better fuel economy	.529
Car Attitudes: Knowledge (α: .772) (TVE: 13.6%)	
I know how my car works on a mechanical level	.901
I'm capable of fixing any rudimentary problems with my car	.830
I know a lot about the new types of cars (such as hybrid and electric cars) being released into the car market	.732
Car Attitudes: Cost (α: .350) (TVE: 8.5%)	
I worry about how much of my money I spend on filling up my car	.719
When buying a car the purchase cost is my number one concern	.678

*Scale anchor phrase: "Most of the time, I think a car can…"
** Statement which loads on multiple constructs
α - Cronbach's alpha
TVE - Total variance explained

In total, eight attitudinal constructs have been extracted from the three attitudinal scales associated with the components of the conceptual framework as illustrated in Figure 2. Two constructs emerge from the *Car Meanings* scale, with the first construct (*Car Meanings: Symbolism and Emotion*) combining attitudinal statements which cover symbolic (status and means of expression) and emotive (improving mood) considerations, whilst the second construct (*Car Meanings: Instrumental*) is focused on instrumental issues (practicality and efficiency). A greater degree of separation is observed in the *Car Attitudes* scale, with four constructs identified by the analysis. The first of these constructs (*Car Attitudes: Importance*) incorporates statements which focus on car importance as an integral part of everyday life and personal attachment whilst the second construct (*Car Attitudes: Environment*) groups statements which are related to environmental concern and willingness to pay more for a less polluting and more fuel efficient vehicle. Thirdly, the *Car Attitudes* scale groups statements capturing self reported knowledge of mechanical aspects of cars in general and EVs in particular (*Car Attitudes: Knowledge*). In the final construct extracted from this scale (*Car Attitudes: Cost*), statements relating to the cost of car ownership in terms of purchasing and operating are grouped. However, a low Cronbach's alpha (α: .350) suggests this construct exhibits internal inconsistency, perhaps indicating that attitudes towards costs of purchasing a car and operating a car tend to be divergent. Concerning the *EV Attitudes* scale, two constructs are detected with the first of these (*EV Attitudes: Negative*) orientated around negative opinions regarding the instrumental capabilities of EVs (reliability, safety and performance) whilst the second construct (*EV Attitudes: Positive*) is positively focused (running costs and refuelling from home).

Table 3: Overview of principal component analysis of the *EV Attitudes* scale (n=400)

Statement	Coefficient
EV Attitudes: Negative (α: .701) (TVE: 28.5%)	
Electric cars are less reliable than conventional cars	.792
I would feel relatively less safe in an electric car	.785
I think electric cars would be complicated to use	.769
Electric cars don't offer enough performance*	.521
EV Attitudes: Positive (α: .508) (TVE: 19.5%)	
I think I can fulfil all my transport needs with an electric car that has a range of 100 miles before recharging	.709
Electric cars are relatively more expensive to purchase but can pay for themselves in lower fuel costs	.656
I would value the ability to refuel my car from home	.582
I think it would be easy for me to find places to plug in an electric car	.511
Electric cars don't offer enough performance*	-.315

* Statement which loads on multiple constructs
α - Cronbach's alpha
TVE - Total variance explained

Table 4 presents a series of correlation analyses which explore how the attitudinal constructs measured in this paper interact with socio-economic characteristics. The correlation coefficients (r) which prove to be statistically significant are highlighted in bold. In terms of gender, it is apparent that females tend to consider their cars to be an important possession and have the propensity to form a personal attachment to their cars (*Car Attitudes: Importance* – r: .158) though this importance placed on car ownership does not extended to a heightened knowledge of car operation where it is observed that males tend to express a closer affiliation with vehicle mechanics and awareness of new vehicle technologies (*Car Attitudes: Knowledge* – r: -.484). Additionally, gender displays significant positive correlations with both *EV Attitudes: Positive* (r: .215) and *EV Attitudes: Negative* (r: .267) which can be interpreted as females holding both an appreciation for the instrumental benefits of EVs such as home recharging whilst acknowledging the limitations of EVs in terms of performance and reliability. A number of interactions are also observed between the attitudinal constructs and age, with a significant negative relationship with *Car Meanings: Symbolism and Emotion* (r: -.092), suggesting that younger individuals have a higher propensity to consider their cars to be symbols of status and sources of positive emotion, a significant positive relationship with *Car Attitudes: Knowledge* (r: .174), indicating that older individuals are more likely to have an appreciation for the mechanical operation of cars and a knowledge of new car technologies whilst a significant negative relationship is identified with *Car Attitudes: Cost* (r: -.191) which suggests that older individuals are less concerned about the cost of a vehicle when considering a new purchase.

Table 4: Correlation analysis between socio-economic characteristics and attitudinal constructs of the conceptual framework (n=400 *: p < 0.05 **: p < 0.01)

	Gender[A]	Age	Education[B]	Household Income
Car Meanings: Symbolism and Emotion	-.021	**-.092***	-.028	-.008
Car Meanings: Instrumental	.015	.028	**-.103***	.037
Car Attitudes: Importance	**.158****	.026	**-.147****	**-.155****
Car Attitudes: Environment	.092	-.036	**.128***	.063
Car Attitudes: Knowledge	**-.484****	**.174****	-.028	-.085
Car Attitudes: Cost	.071	**-.191****	-.080	-.119*
EV Attitudes: Negative	**.215****	-.007	**-.130****	.016
EV Attitudes: Positive	**.267****	.045	-.038	**-.193****

[A] – Gender coded as a dummy variable with 1 = female
[B] – Education coded as a dummy variable with 1 = attainment of university level qualification

The level of education an individual possesses, measured in this study by whether or not a university level qualification has been attained, exhibits a number of significant correlations with the attitudinal constructs. Individuals who have attained a university level qualification appear to be less likely to consider their cars to possess instrumental meanings (*Car Meanings: Instrumental* – r: -.103) whilst also having a lower propensity to consider cars to be important possessions (*Car Meanings: Importance* – r: -.147). Moreover, individuals with a university level qualification have a tendency to be more concerned about the environmental consequences of car use (*Car Attitudes: Environment* – r: .128), which supports the findings of Jannson et al. (2011) who found that individuals with more years spent in formal education have an increased awareness of car related environmental impacts. Moreover, individuals with a university level qualification are less likely to hold negative attitudes towards the instrumental capabilities of EVs (*EV Attitudes: Negative* – r: -.130) which corresponds to the findings of Sangkapichai and Saphores (2009) who demonstrated that individuals with a university degree are more likely to be adopters of a HEV. In terms of household income, two significant correlations are observed with higher levels of household income tending to be related to lower levels of car importance (*Car Attitudes: Importance* – r: -.155), suggesting that wealthy individuals are less personally connected with their cars. Moreover, a significant negative relationship exists between household income and *EV Attitudes: Positive* (r: -.193). This finding lends partial support to the previous evidence offered by Potoglou and Kanarolou (2007) who found that consumers from middle income households were the most likely to adopt a clean fuelled vehicle compared to low or high income households.

The final stage of the analysis tests the explanatory power of the conceptual framework. This is achieved through the application of hierarchical ordinary least squares regression analysis with the results presented in Table 5. Two different models have been specified with the first examining the determinants of negative EV attitudes, whilst the second concentrates on explaining positive EV attitudes. Each of the dependent variables is normally distributed and their values are continuous. The variance inflation factor was calculated for all of the independent variables with no score found to exceed 1.5, indicating that the analysis does not suffer from multicollinearity. The adjusted R^2 values show that the models account for 22% and 16% of the variance in negative and positive EV attitudes respectively. The beta coefficients (β) which prove to be statistically significant are highlighted in bold. To understand the respective explanatory power of socio-economic characteristics and attitudinal constructs, a two stage entry procedure was used for the independent variables (Field 2009), with socio-economic characteristics entered first and attitudinal constructs entered second. The adjusted R^2 change between the two stages is significant in both models, indicating that the inclusion of the attitudinal constructs explains additional variance above what has already been explained by the socio-economic characteristics. Indeed, the adjusted R^2 change between the first and second stage of the *EV Attitudes: Negative* model suggests that the attitudinal variables hold a higher explanatory power compared to socio-economic characteristics, although this is not the case for the *EV Attitudes: Positive* model.

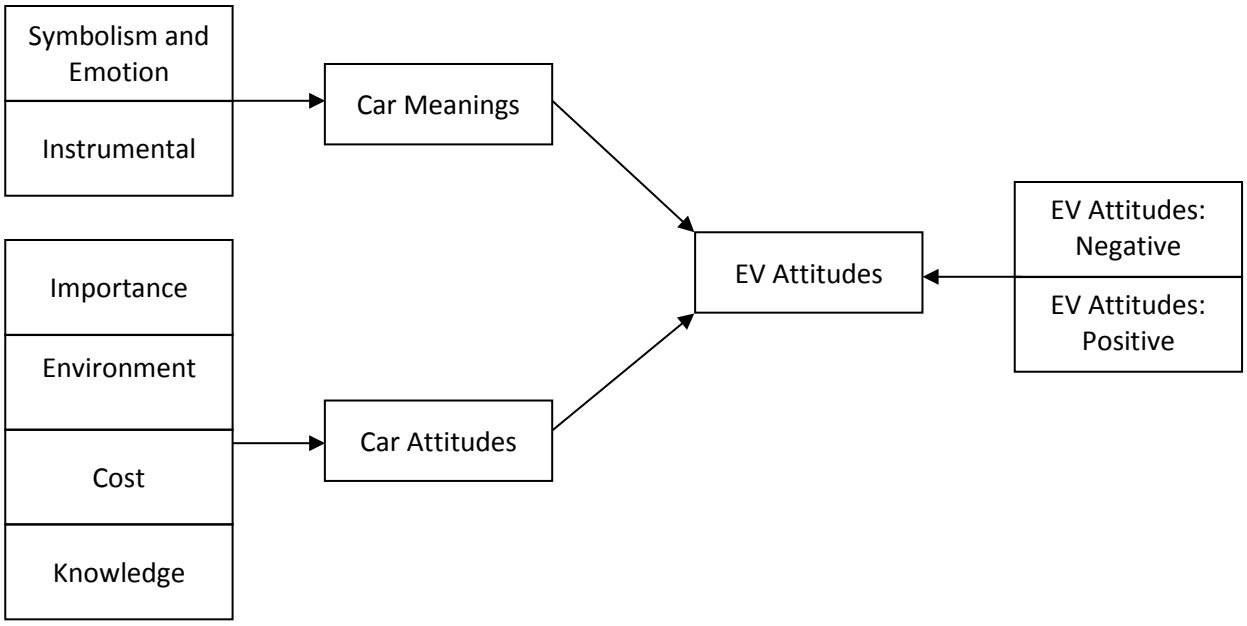

Figure 2: An illustration of the extended conceptual framework developed in this study which details the attitudinal constructs identified in the PCA.

Examining the importance of the socio-economic characteristics, a similar result is observed in reference to the influence of gender as was identified in the correlation analysis. Specifically, gender holds a significant positive influence in both models (β: .536 and β: .524), suggesting that females have a greater propensity to hold both positive and negative evaluations of EVs. Whilst this finding appears counterintuitive on the surface, it may be explained through the differences in the internal statement structures of the two EV attitudes constructs. For example, it is conceivable that females in general could hold both positive opinions towards the lower operating costs and ability to refuel EVs at home whilst, at the same time, holding negative evaluations of the reliability and safety of EVs. In terms of the other socio-economic characteristics, the results are more expected with the attainment of a university level qualification appearing to reduce *EV Attitudes: Negative* (β: -.328) whilst increases in household income leads to a reduction of *EV Attitude: Positive* (β: -.146), perhaps suggesting that EVs are felt to be inferior goods at higher levels of income.

Table 5: Hierarchical ordinary least squares regression analysis evaluating the structure of the conceptual framework (n=400 *: p < 0.05 **: p < 0.01)

Model	EV Attitudes: Negative		EV Attitudes: Positive	
	β	Sig.	β	Sig.
Stage One				
(Constant)	-.793	.023	-.436	.197
Gender[A]	**.536****	**.000**	**.524****	**.000**
Age	.001	.751	.003	.425
Education[B]	**-.328****	**.004**	.039	.728
Household Income	.056	.207	**-.146****	**.001**
Adjusted R^2	.072		.091	
Stage Two				
(Constant)	-.954	.005	-.262	.448
Gender	**.265***	**.028**	**.457****	**.000**
Age	.007	.054	.002	.634
Education	-.127	.245	-.041	.711
Household Income	**.086***	**.040**	**-.134****	**.002**
Car Meanings: Symbolism and Emotion	**.170****	**.002**	**-.115***	**.040**
Car Meanings: Instrumental	.086	.170	**-.126***	**.049**
Car Attitudes: Importance	**.195****	**.001**	.071	.226
Car Attitudes: Environment	**-.174****	**.001**	**.231****	**.000**
Car Attitudes: Knowledge	**-.194****	**.001**	-.021	.715
Car Attitudes: Cost	**.111***	**.026**	**.109***	**.032**
Adjusted R^2	.217		.157	

[A] – Gender coded as a dummy variable with 1 = female
[B] – Education coded as a dummy variable with 1 = attainment of university level qualification

The size and significance of the beta coefficients assigned to the explanatory attitudinal constructs differ according to whether positive or negative evaluations of EVs are being modelled. For the *EV Attitudes: Negative* model, all of the attitudinal constructs apart from *Car Meanings: Instrumental* are significant explanators. No single attitudinal construct stands out as being a dominant factor, although interestingly *Car Attitudes: Cost* (β: .111) is the least predictive suggesting that other factors are more important. The more cars are generally considered to embody symbolic and emotive meanings, the more negative the attitudes towards the instrumental capabilities of EVs tend to be (β: .170). Similarly, the degree to which cars are generally regarded as important and irreplaceable components of everyday life tends to positively explain negative EV attitudes (β: .195). Conversely, the concerns held about the environmental consequences of car use appear to be useful in explaining negative EV attitudes (β: -

.174). A similar result is observed for the construct *EV Attitudes Knowledge* (β: -.194), suggesting that an increasing appreciation for the mechanical operation of cars in general and an awareness of new car technologies reduces negative evaluations of the instrumental performance of EVs.

For the *EV Attitudes: Positive* model, fewer of the explanatory attitudinal constructs explain variance. Environmental attitudes stand out as having the strongest explanatory power and predictive value (β: .231). This suggests that individuals who attach importance to the mitigation of the environmental impact of cars tend to rate EVs positively. It is interesting that *Car Attitudes: Importance* and *Car Attitudes: Knowledge* are not significant in this model. However, unlike for negative EV attitudes, instrumental car meanings do explain some of the variance in positive EV attitudes (β: -.126). This result suggest that the more an individual perceives cars generally to represent an efficient and practical choice, the less likely they are to positively rate the performance, reliability and safety of EVs. Providing further support to the importance the meanings an individual places on car ownership have over evaluations of EVs, the construct *Car Meanings: Symbolism and Emotion* displays a significant negative beta coefficient in this model (β: -.115).

DISCUSSION

Evaluations of EVs have been measured through an attitudinal scale which includes both relatively well examined aspects, such as range anxiety and decentralized fuelling, as well as underexplored issues such as EV safety, reliability and complexity. The output from the PCA of this scale (Table 3) presents a clear divide between positively and negatively orientated statements. The construct *EV Attitudes: Negative* includes statements which capture the perceived inferiority of EVs in terms of reliability and safety whilst incorporating concerns relating to the perceived complexity of these vehicles and their lack of performance. Conversely, the construct *EV Attitudes: Positive* contains statements which express optimistic assessments of EV running costs and the attractiveness of decentralised fuelling at home. This outcome suggests that individuals are assessing the instrumental characteristics of EVs in a polarized manner and indications that individuals can hold positive and negative opinions simultaneously. Moreover, this dual factor structure assists in explaining barriers to EV adoption as the regression analysis demonstrated that the constructs which significantly explain *EV Attitudes: Negative* are somewhat distinct from those which explain *EV Attitudes: Positive*.

To structure the discussion, the initial research questions posed in the introduction are assessed in the light of the evidence presented in the results section before more general reflections on the findings are made and implications for public policy considered.

- Can the meanings an individual attaches to the ownership of their car be used to explain their evaluations of EVs?

In the conceptual framework, car meanings are evaluated with reference to symbolic attachment, emotive connection and instrumental importance. Two distinct constructs have been identified by the PCA (Table 2) with the statements connected with symbolism and emotion combining in the first factor whilst instrumental car meanings are seemingly considered as a separate issue. This combination of symbolic and emotive statements makes intuitive sense as it is difficult to envisage an individual who considers their car to be a representation of their values and an expression of their identity without also the formation of an emotional connection. Moreover, these findings are supported by previous variations of the scale which found symbolic and emotive car meanings to be connected (Steg et al. 2001).

The results of the regression analysis (Table 5) indicate that individuals who tend to think of their cars as representations of their identity and a source of positive emotion are more likely to hold negative opinions of the instrumental performance of EVs and are less likely to hold positive evaluations of EVs. For negative evaluations of EVs, symbolic and emotional car meanings are more important than instrumental car meanings and are equally important to other car attitudes such as environmental impact, cost and self-reported knowledge. The implications of this are that firms and agencies promoting the adoption of EVs may want to consider how they can assign and promote desirable symbolic, emotional and instrumental attachments to this technology. This would assist in allowing consumers who purchase an EV to exhibit their personal identities which Ozaki and Sevastyanova (2011) found to be an important issue with consumers whom have adopted a HEV. This strategy is likely to prove as rewarding as the dominant environmental agenda which is being communicated through such means as eco-labels (Teisl, Rubin and Noblet 2008) and the social networks of early adopters (Axsen and Kurani 2012).

- Are the attitudes an individual holds towards cars in general useful in explaining their evaluations of EVs in particular?

The PCA of the attitudinal scale associated with the car attitudes component of the conceptual framework identified four distinct attitudinal constructs (Table 3). A number of these, such as attitudes regarding the environmental consequences of car use (Sangkapichai and Saphores 2009; Daziano and Bolduc 2013) and concerns associated with car cost (Ozaki and Sevastyanova 2011) have been acknowledged in previous research. In addition, this study has discerned two new constructs of car attitude linked firstly to the importance placed on car ownership both in terms of practical value and personal connection (*Car Attitudes: Importance*) and secondly, the self-reported knowledge individuals hold concerning cars in general and EVs in particular (*Car Attitudes: Knowledge*). It is interesting to note that, in the construct *Car Attitudes: Importance*, statements have combined together which express both the essential nature of owning a car and the strong attachment and dependency drivers can form with their cars. This result implies that the formation of a personal bond with a car and considering cars to be important in reference to the services they offer are highly related concepts.

The regression modelling (Table 5) suggests that the predictive value of different components of general car attitude is different depending on whether negative or positive EV attitudes are being assessed. Negative EV attitudes are explained by a more complex combination of general car attitudes as this study would suggest that; unlike positive attitudes which are most strongly related to environmental concern, there is no one dominant attitude to explain poor perceptions of the reliability, safety, performance and complexity of EVs. The regression modelling implies that those individuals who form personal bonds with their cars and consider them to be essential possessions have a tendency to hold negative attitudes concerning the instrumental performance of EVs. This indicates that EVs may not fit with the desires of individuals who are enthusiastic about car performance and who see their cars as part of their lifestyles (colloquially known as gearheads). The model also suggests that a mechanical understanding of car operation and awareness of alternative car propulsion systems leads to a reduction in negative opinion regarding EV instrumental capability. There are two possible implications for those working to accelerate EV adoption which stem from this finding. Firstly, individuals who are knowledgeable about products often act as a source of information and opinion to their social networks (Iyengar et al. 2011). Thus, ensuring that these opinion leaders are advocates of EVs will likely improve the social acceptability and consumer desirability of EVs. Secondly, improving the knowledge of cars in

general and EVs in particular in society may lead to a reduction in negative evaluations of EV instrumental capabilities.

CONCLUSIONS

This paper has developed and applied a conceptual framework (Figure 2) which examined the influence of the meanings placed on car ownership and the general attitudes associated with cars over the opinions individuals hold concerning the instrumental performance of Electric Vehicles. Data were collected by a self-completion household questionnaire distributed over two sites in the UK. Attitudinal scales were assessed using principal component analysis to identify attitudinal constructs related to these issues. In total, 8 constructs were identified from the 3 attitudinal scales covering symbolic, emotive and instrumental car meanings; importance, environment, knowledge and car cost attitudes alongside positive and negative evaluations of EV instrumental capabilities. Hierarchical regression analysis was utilised to determine the explanatory power of car meanings and car attitudes in general over specific evaluations of EVs.

The results of the hierarchical regression analysis demonstrate that the explanatory attitudinal constructs included in the conceptual framework are valid indicators of the attitudes individuals hold towards the instrumental attributes of EVs. The meanings individuals attach to car ownership and the general attitudes individuals hold towards cars appear to be useful in explaining how individuals consider EV instrumental performance. More specifically, increasing the level of symbolic, emotive and instrumental meanings attached to car ownership in general tends to reduce positive evaluations of EV instrumental performance. The significance of environmental attitudes is supported in this study, with concerns relating to the environmental consequences of car use, self-reported responsibility and willingness to pay to reduce emissions supporting positive attitudes towards EVs whilst reducing negative EV attitudes. Moreover, new influences have been identified with the level of personal importance placed on car ownership increasing negative attitudes for EVs whilst self-reported mechanical knowledge of cars in general and knowledge of EVs in particular seems to reduce negative EV attitudes. The results in general may demonstrate that individuals have a tendency to consider EVs as a new addition to the dominant internal combustion engine car paradigm. If this is the case, decision makers in this area may want to consider how EVs can be positioned as a new form of personal mobility rather than being portrayed as a conventional car with a different powertrain system.

Overall, the analysis suggests that attitudinal constructs offer important additional explanatory power regarding how individuals are evaluating EVs over and above a simple consideration of the socio-economic characteristics. In this way, these results further support the important role that attitudes hold in this emerging market. Most importantly, the results presented in this paper have the potential to contribute to research and practice with respect to the uptake of alternatively fuelled vehicles in three further ways. Firstly, this study has shown that there are a larger number of attributes, both positive and negative, which are likely to represent important considerations for consumer evaluations of EVs over and above the more narrow range of attributes in relation to range, performance, cost and their environmental impact most often measured in the literature. In particular, the evidence demonstrates that the symbolic, emotive and instrumental meanings of car ownership are as, if not more, important in the assessment of EV instrumental performance as issues of cost and environmental concern. These findings could prove of use to researchers developing Hybrid Choice Models in this area who may want to consider the inclusion of symbolic, emotive and instrumental car meanings into model specifications.

Secondly, the difference in the explanatory power of the car meanings and car attitudes constructs in explaining negative or positive attitudes towards EVs is an important finding. This suggests that negative and positive evaluations of EVs are not simply different sides of the same coin. In other words, it is possible for someone to hold both negative and positive EV assessments at the same time and that each of these can be related to different attitudes and meanings about cars in general. For instance, positive evaluations of EVs are much more strongly related to environmental concern than negative evaluations are. Thirdly, rather than focusing on attitudes towards EVs as the antecedent of intention to adopt an EV, which is the most common approach in the literature, this study has focused on understanding the factors related to the EV attitudes themselves. The analysis has demonstrated an intricate web of meanings associated with car ownership and evaluations of car use in general which are related to the ways in which EVs are perceived. This suggests that further research and practice aiming to influence EV adoption will be less effective if it concentrates simply on what consumers think about this new technology without understanding the meanings that car ownership plays in more general terms.

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REFERENCES

Ajzen, I., (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes* 50, 179–211.

Al-Alawi, B.M., & Bradley, T.H., (2013). Review of hybrid, plug-in hybrid, and electric vehicle market modeling Studies. *Renewable and Sustainable Energy Reviews* 21, 190–203.

Anable, J., & Gatersleben, B., (2005). All work and no play? The role of instrumental and affective factors in work and leisure journeys by different travel modes. *Transportation Research Part A: Policy and Practice* 39, 163–181.

Axsen, J., Mountain, D. C., & Jaccard, M., (2009). Combining stated and revealed choice research to simulate the neighbor effect: The case of hybrid-electric vehicles. *Resource and Energy Economics*, 31, 21-238.

Axsen, J., & Kurani, K.S., (2012). Interpersonal influence within car buyers' social networks: applying five perspectives to plug-in hybrid vehicle drivers. *Environment and Planning A* 44, 1047 – 1065.

Bartlett, M.S., (1950). Tests of Significance in Factor Analysis. *British Journal of Statistical Psychology* 3, 77–85.

Beggs, S., Cardell, S., & Hausman, J., (1981). Assessing the potential demand for electric cars. *Journal of Econometrics* 17, 1–19.

Ben-Akiva, M., Mcfadden, D., Train, K., Walker, J., Bhat, C., Bierlaire, M., Bolduc, D., Boersch-Supan, A., Brownstone, D., Bunch, D.S., Daly, A., Palma, A.D., Gopinath, D., Karlstrom, A., & Munizaga, M.A., (2002). Hybrid Choice Models: Progress and Challenges. *Marketing Letters* 13, 163–175.

Bolduc, D., Boucher, N., & Alvarez-Daziano, R., (2008). Hybrid Choice Modeling of New Technologies for Car Choice in Canada. *Transportation Research Record: Journal of the Transportation Research Board* 2082, 63–71.

Calfee, J.E., (1985). Estimating the demand for electric automobiles using fully disaggregated probabilistic choice analysis. *Transportation Research Part B: Methodological* 19, 287–301.

Caperello, N.D., & Kurani, K.S., (2012). Households' Stories of Their Encounters With a Plug-In Hybrid Electric Vehicle. *Environment and Behavior* 44, 493–508.

CCC, (2013). Meeting Carbon Budgets: 2013 Progress Report to Parliament. http://www.theccc.org.uk/wp-content/uploads/2013/06/CCC-Prog-Rep-Book_singles_web_1.pdf. Accessed 20th February 2014.

Cerny, B.A., & Kaiser, H.F., (1977). A Study Of A Measure Of Sampling Adequacy For Factor-Analytic Correlation Matrices. *Multivariate Behavioral Research* 12, 43–47.

Chandler, J., & Schwarz, N., (2010). Use does not wear ragged the fabric of friendship: Thinking of objects as alive makes people less willing to replace them. *Journal of Consumer Psychology* 20, 138–145.

Choo, S., & Mokhtarian, P.L., (2004). What type of vehicle do people drive? The role of attitude and lifestyle in influencing vehicle type choice. *Transportation Research Part A: Policy and Practice* 38, 201–222.

Contestabile, M., Offer, G., & North, R. (2012) Electric Vehicles: A Synthesis of the Current Literature with a Focus on Economic and Environmental Viability.http://www.lcaworks.com/EV%20Lit%20Rev%20FINAL.pdf. Accessed 20th February 2014.

Cronbach, L., (1951). Coefficient alpha and the internal structure of tests. *Psychometrika* 16, 297–334.

Dagsvik, J.K., Wennemo, T., Wetterwald, D.G., & Aaberge, R., (2002). Potential demand for alternative fuel vehicles. *Transportation Research Part B: Methodological* 36, 361–384.

Daziano, R.A., & Bolduc, D., (2011). Incorporating pro-environmental preferences towards green automobile technologies through a Bayesian hybrid choice model. *Transportmetrica A: Transport Science* 9, 74–106.

Daziano, R.A., & Chiew, E., (2012). Electric vehicles rising from the dead: Data needs for forecasting consumer response toward sustainable energy sources in personal transportation. *Energy Policy* 51, 876–894.

DCLG, (2010). English Indices of Deprivation 2010.https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/6222/1871538.pdf. Accessed 20th February 2014.

DfT, (2011). National Travel Survey 2010.http://www.dft.gov.uk/statistics/releases/national-travel-survey-2010/. Accessed 20th February 2014.

Dittmar, H., (1992). *The Social Psychology of Material Possessions: To have is to be*. Prentice-Hall.

Egbue, O., & Long, S., (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy* 48, 717–729.

Eggers, Felix., & Eggers, Fabian., (2011). Where have all the flowers gone? Forecasting green trends in the automobile industry with a choice-based conjoint adoption model. *Technological Forecasting and Social Change* 78, 51–62.

Ewing, G.O., & Sarigöllü, E., (1998) Car fuel-type choice under travel demand management and economic incentives. *Transportation Research Part D: Transport and Environment* 3, 429–444.

Field, A., (2009). *Discovering Statistics Using SPSS*, Third Edition. SAGE Publications Ltd.

Glerum, A., Stankovikj, L., Thémans, M., & Bierlaire, M., (2013). Forecasting the Demand for Electric Vehicles: Accounting for Attitudes and Perceptions. Transportation Science.

Golob, T.F., Kitamura, R., Bradley, M., & Bunch, D.S., (1993). Predicting the market penetration of electric and clean-fuel vehicles. *The Science of The Total Environment* 134, 371–381.

Graham-Rowe, E., Gardner, B., Abraham, C., Skippon, S., Dittmar, H., Hutchins, R., & Stannard, J., (2012). Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: A qualitative analysis of responses and evaluations. *Transportation Research Part A: Policy and Practice* 46, 140–153.

Great Britain, (2008). Climate Change Act 2008: Elizabeth II. Chapter 27. London, The Stationery Office.

Harris, C., (1967). On factors and factor scores. *Psychometrika* 32, 363–379.

Heffner, R.R., Kurani, K.S., & Turrentine, T.S., (2007). Symbolism in California's early market for hybrid electric vehicles. *Transportation Research Part D: Transport and Environment* 12, 396–413.

Heutel, G. & Muehlegger, E. (2009). Learning, externalities and hybrid vehicle adoption. Paper presented at the Allied Social Science Associations, January 2-5, 2010.

Hotelling, H., (1933). Analysis of a complex of statistical variables into principal components. *Journal of Educational Psychology* 24, 417–441.

Iyengar, R., Bulte, C.V. den, & Valente, T.W., (2011). Opinion Leadership and Social Contagion in New Product Diffusion. *Marketing Science* 30, 195–212.

Jansson, J., Marell, A., & Nordlund, A., (2011). Exploring consumer adoption of a high involvement eco-innovation using value-belief-norm theory. *Journal of Consumer Behaviour* 10, 51–60.

Joliffe, I.T., & Morgan, B., (1992). Principal component analysis and exploratory factor analysis. *Stat Methods Med Res* 1, 69–95.

Kaiser, H., (1958). The varimax criterion for analytic rotation in factor analysis. *Psychometrika* 23, 187–200.

Kurani, K.S., Turrentine, T., & Sperling, D., (1996). Testing electric vehicle demand in 'hybrid households' using a reflexive survey. *Transportation Research Part D: Transport and Environment* 1, 131–150.

Lai, A.W., (1991). Consumption Situation and Product Knowledge in the Adoption of a New Product. *Asia Pacific Journal of Marketing and Logistics* 3, 55–67.

Lane, B., & Potter, S., (2007). The adoption of cleaner vehicles in the UK: exploring the consumer attitude-action gap. *Journal of Cleaner Production* 15, 1085–1092.

Lieven, T., Mühlmeier, S., Henkel, S., & Waller, J.F., (2011). Who will buy electric cars? An empirical study in Germany. *Transportation Research Part D: Transport and Environment* 16, 236–243.

Likert, R., (1932). A technique for the measurement of attitudes. *Archives of Psychology* 22 140, 55.

Mannering, F.L., & Train, K., (1985). Recent directions in automobile demand modeling. *Transportation Research Part B: Methodological* 19, 265–274.

Mau, P., Eyzaguirre, J., Jaccard, M., Collins-Dodd, C., & Tiedemann, K., (2008). The "neighbor effect": Simulating dynamics in consumer preferences for new vehicle technologies. *Ecological Economics* 68, 504–516.

McFadden, D., (1980). Econometric models for probabilistic choice among products. *The Journal of Business* 53, 13-29.

Morton, C., (2013). Accelerating the demand for low emission vehicles: A consumer led perspective. PhD thesis, University of Aberdeen, United Kingdom.

Musti, S., & Kockelman, K.M., (2011). Evolution of the household vehicle fleet: Anticipating fleet composition, PHEV adoption and GHG emissions in Austin, Texas. T*ransportation Research Part A: Policy and Practice* 45, 707–720.

OLEV, (2013). Driving the Future Today - A Strategy for ULEVs in the UK. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/239317/ultra-low-emission-vehicle-strategy.pdf. Accessed 20th February 2014.

ONS, (2009). Scottish Index of Multiple Deprivation: 2009 General Report. http://www.scotland.gov.uk/Resource/Doc/933/0115249.pdf. Accessed 20th February 2014.

ONS, (2011). Annual Mid-Year Population Estimates. http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-england-and-wales/mid-2011--2011-census-based-/stb---mid-2011-census-based-population-estimates-for-england-and-wales.html. Accessed 20th January 2014.

ONS, (2012). Labour Market Statistics. http://www.ons.gov.uk/ons/rel/lms/labour-market-statistics/october-2012/statistical-bulletin.html. Accessed 20th January 2014.

Ozaki, R., & Sevastyanova, K., (2011). Going hybrid: An analysis of consumer purchase motivations. *Energy Policy* 39, 2217–2227.

Pearson, K., (1901). LIII. On lines and planes of closest fit to systems of points in space. *Philosophical Magazine Series* 6 2, 559–572.

Peters, A., Popp, M., Mareike, A., & Raphael, R., B., (2011). Electric mobility - a survey of different consumer groups in Germany with regard to adoption. European Council for an Energy-Efficient Economy.

Pierre, M., Jemelin, C., & Louvet, N., (2011). Driving an electric vehicle. A sociological analysis on pioneer users. Energy Efficiency 4, 511–522.

Potoglou, D., & Kanaroglou, P.S., (2007). Household demand and willingness to pay for clean vehicles. *Transportation Research Part D: Transport and Environment* 12, 264–274.

Ricardo-AEA, (2013). Overview: GHG Inventory Summary Factsheet. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/210491/1_GHG_Inventory_Overview.pdf. Accessed 20th February 2014.

Rogers, E.M., (2003). *Diffusion of innovations*. Free Press, New York.

Sangkapichai, M., & Saphores, J.-D., (2009). Why are Californians interested in hybrid cars? *Journal of Environmental Planning and Management* 52, 79–96.

Schmitt, N., (1996). Uses and abuses of coefficient alpha. *Psychological Assessment* 8, 350–353.

Schuitema, G., Anable, J., Skippon, S., & Kinnear, N., (2013). The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles. *Transportation Research Part A: Policy and Practice* 48, 39–49.

Shepherd, S., Bonsall, P., & Harrison, G., (2012). Factors affecting future demand for electric vehicles: A model based study. *Transport Policy* 20, 62–74.

Steg, L., Vlek, C., & Slotegraaf, G., (2001). Instrumental-reasoned and symbolic-affective motives for using a motor car. *Transportation Research Part F: Traffic Psychology and Behaviour* 4, 151–169.

Steg, L., (2005). Car use: lust and must. Instrumental, symbolic and affective motives for car use. *Transportation Research Part A: Policy and Practice* 39, 147–162.

Teisl, M.F., Rubin, J., & Noblet, C.L., (2008). Non-dirty dancing? Interactions between eco-labels and consumers. *Journal of Economic Psychology* 29, 140–159.

Train, K., E., (1980).The potential market for non-gasoline-powered automobiles. *Transportation Research Part A: General* 14, 405–414.

Train, K. E., (2009). *Discrete Choice Methods with Simulation*, 2nd ed. Cambridge University Press, New York.

Turrentine, T.S., & Kurani, K.S., (2007). Car buyers and fuel economy? *Energy Policy* 35, 1213–1223.

Turrentine, T., & Sperling, D. (1992). Theories of New Technology Purchase Decisions: The Case of Alternative Fuel Vehicles. http://www.uctc.net/papers/129.pdf. Accessed 20th February 2014.

van Vliet, O.P.R., Kruithof, T., Turkenburg, W.C., & Faaij, A.P.C., (2010). Techno-economic comparison of series hybrid, plug-in hybrid, fuel cell and regular cars. *Journal of Power Sources* 195, 6570–6585.