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Exploring Consumer Preferences towards Electric Vehicles: The Influence of Consumer Innovativeness

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ABSTRACT

The diffusion of Electric Vehicles (EVs) is regarded as an important aspect of government policy which aims to generate a transition to a low-carbon mobility system in the United Kingdom and the wider European context. This paper investigates consumer demand for EVs by examining the influence of consumer innovativeness alongside attitudes concerning the functional capabilities of EVs over EV preferences. A conceptual framework is developed and applied which includes measurements of innovativeness at both an adoptive level, through an assessment of technology ownership, and at an innate level, by measuring a cohort of psychological and sociological factors. Additionally, the framework incorporates measurements of attitudes towards the functional performance of EVs to determine their effect on preferences. Data has been collected through the application of a self-completion household survey distributed over the cities of Dundee and Newcastle upon Tyne in the United Kingdom. Results of the analysis indicate that adoptive innovativeness and attitudes concerning the functional performance of EVs significantly affect preferences for Plug-In Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs).

Key Words

Electric Vehicles; Consumer Innovativeness; Vehicle Preferences; Psychometric Analysis

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1 INTRODUCTION

The challenge of transitioning the transport sector onto a low carbon trajectory is one that will likely define research in this field over the next decade (Schwanen, 2011). The magnitude of this challenge is significant, with the transport sector accounting for 40% of final energy consumption in the United Kingdom (UK) in 2011, with consumption having increased by 52% since 1980 (DECC, 2012). This energy is sourced almost entirely from fuels derived from crude oil (DECC, 2013a) resulting in a situation where the transport sector represents the second largest emitter of greenhouse gases (GHG), accounting for 21% of UK territorial emissions in 2011 (DECC, 2013b).

The UK Government has expressed a commitment to encouraging the uptake of Electric Vehicles (EVs; comprising both pure battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVS)) (OLEV, 2013), which are viewed as representing a means by which significant reductions in GHG emissions from the transport sector can be realized (CCC, 2013). Moreover, the UK Government considers EVs to represent a way in which the UK's strength in propulsion system technology can be maintained (BIS, 2013) and a mechanism to generate consumer demand for low carbon products (BIS, 2010). This strategic vision is replicated at the EU level, with the European Commission establishing a Green Cars Initiative to ensure the EU is a world leader in EV technology (EC, 2013).

The technical specification of EVs represents a substantial divergence from vehicles operating internal combustion engine (ICE) propulsion systems (van Vliet et al., 2010; Dijk et al., 2013). Specifically, functional issues concerning vehicle range, price premiums, operating costs, refuelling behaviours and stated environmental benefits combine to distinguish EVs from conventionally powered vehicles. This has led commentators to define EVs as representing a form of disruptive innovation (Christensen, 1997). As a result of the unique features of EVs and the current low sales volumes of these vehicles (DfT, 2013), it proves challenging to determine likely consumer response based on the existing market. Nonetheless, a detailed understanding of consumer response to EVs is likely to be necessary if the diffusion of these vehicles is to be widespread.

This paper contributes to improving the understanding of consumer response to EVs by evaluating if consumer innovativeness is related to the expressed preference towards EVs using a UK case study. The concept of consumer innovativeness can be considered to represent the inherent and revealed propensity of a consumer to adopt new products with different or advanced features and functions.

This concept has been widely researched in the marketing sciences (Midgley and Dowling, 1978; Goldsmith, 1991; Roehrich, 2004; Bartels and Reinders, 2011) though has received only modest attention in transport studies (Lin and Filieri, 2015). With the transport sector likely to witness a range of new innovations being introduced over the next decade, this paper provides a first step in evaluating if the concept of consumer innovativeness can be useful in distinguishing the early adopters of innovations in private vehicle transport.

2 CONSUMER DEMAND FOR ELECTRIC VEHICLES

Whilst EVs remain a niche market application, research examining consumer demand for EVs has been an active area of enquiry for the past thirty years. Research was initiated in the early 1980s due to the occurrence of the 1970s oil shocks and the growing awareness of air quality issues in some of the major conurbations of California which combined to generate interest in the possibility of shifting away from ICE vehicles (Sperling and Eggert, 2014). Initial research tended to approach the assessment of consumer demand using econometric methods, such as discrete choice modelling based on random utility theory (Train, 2009), which allowed researchers to quantify the effect of the novel functional features of EVs over consumer preferences (Mannering and Train, 1985). Research conducted using these methods assisted in identifying prominent adoption barriers such as aversion to the limited range of EV, the price premiums associated with EVs and high discount rates for operating costs (Beggs et al., 1981; Calfee, 1985). These issues corresponded with generally low expectations of the potential market for EVs (Train, 1980) which have been validated by low sales figures. As anxieties relating to the stability of oil supplies began to subside and the technical deficiencies associated with the functional performance of EVs became clearer, interest in understanding the market potential of EVs declined.

Over the past decade, interest in EVs has resurfaced (Rezvani et al. 2015), mostly due to the importance placed on this technology in transitioning the transport sector onto a low carbon trajectory (van Bree et al. 2010; Dijk et al. 2013; Geels, 2012; Stienhilber et al. 2013; Greene et al. 2014). A significant quantity of forecasting studies have been conducted to assess potential adoption pathways for EV demand (Karplus et al. 2010; Eggers and Eggers, 2011; Musti and Kockleman, 2011; Anable et al. 2012; Shepherd et al. 2012). These forecasting studies have tended to investigate the potential effect of different market developments, such as improvements to battery technology and reductions in price premiums, alongside the influence of government incentives. Whilst market forecasting at the system level allows for the effect of different technical development scenarios and policy mixes to be considered, it provides little insight regarding how EVs are being evaluated by

individual consumers. In an effort to shed light on this issue, research activity in consumer demand for EVs has progressed through the application of psychometric models which draw on concepts originating in psychology and sociology (Lane and Potter, 2007). This is an extension of the increasing application of socio-psychological methods in order to evaluate the challenge of transitioning towards a sustainable transport system (Gehlert et al., 2013), with the importance of attitudes (Gärling et al., 1998) alongside affective and symbolic motives (Steg et al., 2001; Steg, 2005) in explaining travel behaviour now being well established (van Acker et al., 2010).

In relation to EVs, studies which apply psychological theory comprise a rapidly growing and already substantial body of literature examining a variety of emotional or non-conscious regulatory processes, but with only loose consensus as to the factors emerging as most directly or even indirectly influential on an individual's adoption intention or behaviour (Anable et al. 2014). The examined factors include relatively rational and linear relationships between consumer attitudes and their EV adoption intentions (Moons and De Pelsmacker, 2012), more normative models of behaviour investigating personal norms such as strong moral obligation towards environmental issues or values (Moons and De Pelsmacker, 2015), as well as those focusing on indirect and social processes (Axsen et al. 2013) that impinge on behaviour including symbolic meanings attached to cars (Heffner et al. 2007; Morton et al. 2015; Noppers et al. 2015), self-identity (Peters et al., 2011a; Barbarossa et al., 2015) and personality (Skippon and Garwood, 2011). Whilst methodologically and theoretically diverse, these studies consistently demonstrate the importance of the degree to which EVs are perceived to be compatible with lifestyle and personal image alongside the relative advantage of operation. For example, several studies have found that hedonic and symbolic motives are valid predictors of preferences towards EV variants (Ozaki and Sevastyanova, 2011; Schuitema et al., 2013) and others have concentrated specifically on how pro-environmental values, beliefs and social norms assist in explaining the adoption of an alternatively fuelled vehicle (Peters et al., 2011b; Jannson et al., 2011; Ozaki and Sevastyanova, 2011). Whilst the majority of studies attempting to include psychological factors in their models of EV adoption behaviour have found these elements to explain more or at least as much of the variance as functional factors, this is not always the case. For instance, when comparing adopters of EVs to owners of conventional cars in Norway, Nayum et al. (2016) found that attitudes towards functional issues such as car performance and convenience are most useful in distinguishing EV owners vis a vis norms and values.

Whilst existing research has explored some of the psychological antecedents to preferences towards EVs and has attempted to identify the prominent characteristics of consumers more inclined to

consider the purchase of an EV, little attention has been paid to the fundamental predisposition of consumers to be attracted to the innovative and unique features of EVs. To this end, this paper specifically concentrates on the concept of consumer innovativeness in order to consider if this characteristic is useful in distinguishing consumers who are more likely to adopt an EV. In this sense, the research presented here responds to a call for a broadening of the factors included in demand models for EVs in order to more fully account for the diverse range of aspects which potentially hold influence in this emerging market (Daziano and Chiew, 2012).

3 CONSUMER INNOVATIVENESS

When new innovations are introduced into a market, they undergo a diffusion process. The process is illustrated in the Diffusion of Innovation (DOI) theory which postulates that the adoption of innovations tends to follow a normal temporal distribution, with a small quantity of innovators and early adopters acquiring the innovation relatively early, followed by the majority of mainstream consumers with the diffusion process concluded when the laggard consumers decide to adopt (Rogers and Shoemaker, 1971; Rogers, 2003). Central to this theory is the concept of consumer innovativeness, which can be considered at a general level to represent a characteristic which relates to an individual's basic tendency to adopt new innovations.

Midgley and Dowling (1978) note that the initial research investigating the concept of consumer innovativeness tended to be vague in the description of the concept and usually assigned degrees of innovativeness to individuals based on a simple measurement of the relative time taken to adopt an innovation. They proceed to argue that such an approach is prone to error due to factors which may inhibit individuals from being innovative across all contexts. To account for the described limitations, Midgley and Dowling (ibid.) propose that consumer innovativeness should be considered as a multidimensional concept which has different levels of operation.

At the abstract level, individuals have an innate tendency to be attracted to the unique qualities of innovations. This is generally referred to as innate innovativeness and concerns an individual's inherent propensity to desire to adopt innovations. Innate innovativeness can be considered to represent a personality trait which is possessed to a greater or lesser extent by all members of society (Goldsmith and Hofacker, 1991) and includes psychological aspects such as curiosity, ambition and rationality alongside sociological elements such as exposure to media sources, heterophily and acting as a source of information concerning innovations (Midgley and Dowling, 1978). Considering innate innovativeness to be a dimension of personality was partly motivated by

the increasing attention placed on personality characteristics in distinguishing consumer groups (Kassarjian, 1971) and those individuals more prone to adopt innovations (Jacoby, 1971) through the use of psychographic analysis (Wells, 1975) to compliment traditional demographic profiling. The concept of innate innovativeness has been empirically tested to determine its influence over the adoption of innovations, with the evidence suggesting that innate innovativeness is a significant factor (Manning et al., 1995; Lu et al., 2005, van Rijnsoever and Donders, 2009). Of particular relevance to the topic of this paper, Feldman and Armstrong (1975) found that the constructs of opinion leadership, interest in the product and venturesomeness significantly distinguished early adopters of a rotary engine car from laggard adopters. In a recent synthesis of the consumer innovativeness literature, Bartels and Reinders (2011) note that innate innovativeness remains an important concept in understanding the adoption of new technologies.

At the visible level, individuals have a revealed degree of adoptive behaviour in regards to innovations, generally referred to as actualised innovativeness. Midgley and Dowling (1978) argue that the transference of an individual's innate innovativeness into the revealed adoption of a particular innovation is likely to be mediated by intervening variables which may impede adoption. These intervening variables include such issues as an individual's interest in the particular product category to which the innovation is being introduced, the communicated experiences an individual receives from trusted sources concerning the quality of the innovation and situational factors which may restrict their adoption such as financial constraints or inflexibilities in ancillary systems. In this sense, intervening variables act to restrain an individual's innate tendencies to adopt new technologies meaning that, in certain contexts, individuals who have a predisposition towards innovations may be late adopters of a particular innovation.

4 CONCEPTUAL FRAMEWORK

The specific focus of the research presented in this paper is to investigate whether the concept of consumer innovativeness is helpful in explaining the desirability and adoption of EVs. In order to consider this, a conceptual framework has been constructed which contains four components, two of which focus on the concept of consumer innovativeness. This framework is illustrated in Fig. 1 with the components outlined below and the hypothesised links between the components described.

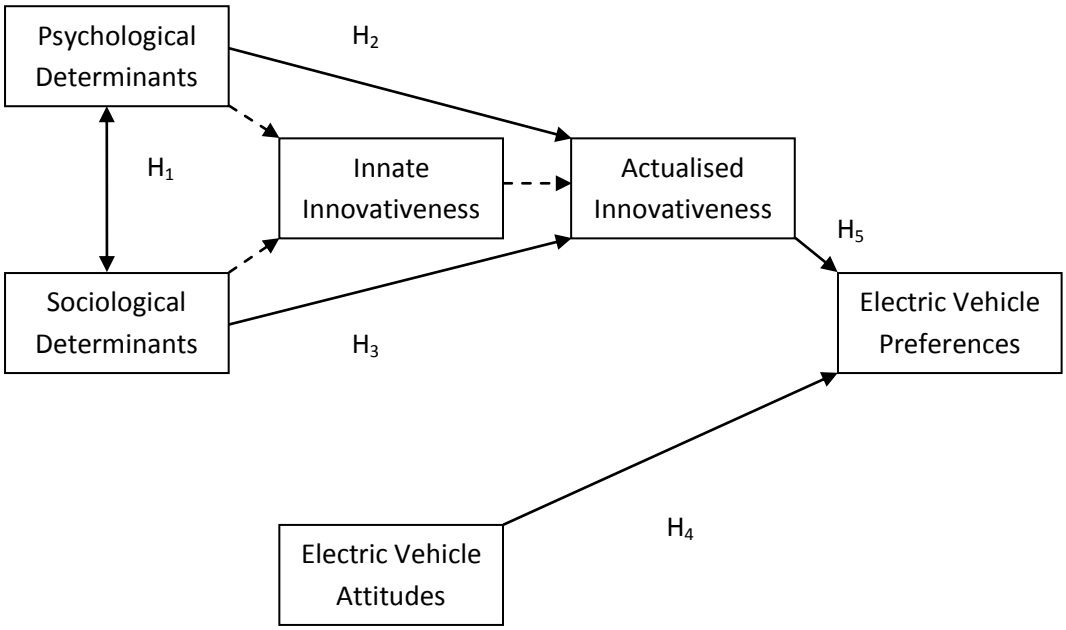

Fig. 1: Illustration of the conceptual framework containing [1] Consumer Innovativeness, [2] Electric Vehicle Attitudes and [3] Electric Vehicle Preferences.

4.1 Innate Innovativeness

The inherent propensity for an individual to be attracted to innovations has been included in the framework. Following the approach of past research in this area (Midgley and Dowling, 1978; Rogers, 2003), the conceptual framework distinguishes between the psychological and sociological determinants of innate innovativeness which are positioned in the framework at the deepest level of abstraction.

A hypothesised link is established between the psychological and sociological determinants of innate innovativeness (H_1) with the expectation being that, as these determinants correspond to the same concept, a significant relationship between the two should be present. Furthermore, hypothesised links are established between the psychological (H_2) and sociological (H_3) determinants of innate innovativeness and the observed level of actualised innovativeness with the expectation being that, as loadings on these factors increase, so too will the levels of revealed adoption of innovations.

4.2 Actualised Innovativeness

The displayed behaviour of an individual concerning the adoption of innovations has been included as a component of the conceptual framework. This component takes note of the revealed tendency

of an individual to adopt new technologies, with the implicit assumption being that an individual's past adoptive behaviour is likely to be of importance when considering their future adoptive behaviour (Arrts et al. 1998).

A hypothesised link is established between actualised innovativeness and EV preferences (H_5), with the expectation being that, as observed levels of actualised innovativeness increase, so too will preferences towards EVs.

4.3 Electric Vehicle Attitudes

The existing literature covering EV demand has recognized a wide range of issues which have the potential to affect how consumers form opinions of and preferences towards EVs. Specific attention has been paid to identifying barriers which are inhibiting EV demand (Egbue and Long, 2012), with the functional characteristics of EVs, such as restricted range and price premiums, representing prominent issues (Bunch et al., 1993; Eggers and Eggers, 2011, Krupa et al. 2014). Indeed, in a comprehensive assessment of the psychometric characteristics which can distinguish EV adopters from mainstream car buyers, Nayum et al. (2016) found that attitudes towards the functional characteristics of cars proved to be the most effective, indicating that functional barriers are central concerns. These barriers can be thought of as representing some of the intervening variables which influence an individual's receptivity to a particular innovation. In the conceptual framework, attitudes towards EV functional performance have been included as a component to consider their connection with EV preferences.

A hypothesised link is established between EV attitudes and EV preferences (H_4), with the expectation being that as attitudes towards the functional characteristics of EVs improve, so too will expressed preferences for these vehicles.

4.4 Electric Vehicle Preferences

Expressed preferences towards EVs represent the focal point of the conceptual framework. The framework postulates that these preferences are affected by actualised innovativeness, which notes the displayed adoption of innovations by an individual, and EV attitudes, which relates to evaluations of the functional performance of EVs.

5 METHODS

This section of the paper details the instruments developed in order to measure the components of the conceptual framework, the manner in which the data required to evaluate the conceptual framework has been sourced and the statistical approach which was employed in this evaluation.

5.1 Measurement Instruments

5.1.1 Innate Innovativeness

For innate innovativeness, Midgley and Dowling (1978) recommend that a series of questionnaire items be formatted, which are associated with essential elements of the concept, in order to produce a measurement method. In a review of the measurement methods so far produced for innate innovativeness, Roehrich (2004) note that existing approaches tend to employ the use of attitudinal scales comprised of opinion statements to elicit the concept. These existing scales tend to display low levels of correlation with and predictive validity over innovative behaviour, with Roehrich (ibid.) suggesting that improvements to the theoretical foundations of the measurement scales could enhance their effectiveness. With this in mind, two attitudinal scales are developed in this paper, with the first focusing on the psychological determinants of innate innovativeness whilst the second considers the sociological determinants of innate innovativeness as specified in Rogers' (2003) DOI theory. These attitudinal scales are detailed in Table 1 and note the opinion statements which they contain and the determinant which they focus on. For each scale, a seven point Likert-scale response format is utilised running from Highly Disagree to Highly Agree.

Table 1: Attitudinal scales developed to measure the psychological and sociological determinants of innate innovativeness.

No.	Opinion Statement	Determinant
	Psychological Determinants	
1	Making sure I always make the correct decision is something that is important to me	Rationality
2	I prefer to let other people make decisions when I am not completely sure about the situation	Rationality
3	Science has no impact on how I live my life	Curiosity
4	I'm always looking for ways to alter my life to make it better	Ambition
5	I have confidence in myself in making the right decision in complicated situations	Rationality
6	I rarely use the things I learned in formal education in my daily life	Curiosity
7	I enjoy learning about new things	Curiosity
8	I'm a very ambitious person setting high standards and expectations for myself	Ambition
9	I'm never satisfied with my current position in life	Ambition
10	Compulsive behaviour usually governs my purchasing decisions	Compulsiveness
11	I quickly incorporate new ideas into how I live my life	Receptivity
12	My friends and family would consider me to be a highly innovative person	Receptivity
13	I'm usually one of the first people to acquire the latest consumer technology	Receptivity
14	I really enjoyed my science classes at school	Curiosity
	Sociological Determinants	
1	I regularly participate in activities such as sports, clubs and/or associations that have a formal structure	Social engagement
2	I have a small group of friends who all know each other well and share similar interests	Heterophily
3	My friends and family would say I was a cosmopolitan person	Social engagement
4	I have frequent contact with people working with new consumer technology	
5	I keep up-to-date with consumer technology by reading newspapers/magazines, websites or relevant TV shows	Information seeking
6	Friends and colleagues regularly come to me about advice concerning new consumer technology	Opinion leadership
7	I often know about the next 'must have' piece of consumer technology before it is released onto the market	Information seeking
8	I regularly seek information about the latest consumer technology	Information seeking
9	I often socialise with people from a large variety of different backgrounds	Heterophily

5.1.2 Actualised Innovativeness

To measure actualised innovativeness, a cross-sectional approach is utilised to gauge the revealed adoption of innovations. A cumulative measure is developed whereby a list of seventeen consumer and household technologies is presented to respondents who are then asked to state if they currently own the innovation or intend to own the innovation in the near future. In this sense, two distinct measurements of actualised innovativeness are taken, the first relating to the total quantity of technology owned (Total Owned) and the total quantity of technology desired to be owned in the near future (Total Desired). The list of household and consumer technology employed in the measurement is stated in Table 2.

Table 2: Consumer and household technologies included in the actualised innovativeness measurement.

Smart Phone	Household Combination Boiler
High Definition Flat Screen Television	Tablet Personal Computer
3D Television	GPS Navigation System
Laptop Personal Computer	Blueray Media Player
Household Photovoltaic Tiles	Touchscreen Personal Computer
Media Centre Personal Computer	Digital Camcorder
Household Heat Pump	eReader
Household Wireless Internet	Household Underfloor Home Heating
High Definition Satellite Television	

5.1.3 Electric Vehicle Attitudes

To measure attitudes towards the functional characteristics of EVs, an attitudinal scale is developed which contains a series of opinion statements that focus on interpretations of the novel features of EVs. This attitudinal scale is reported in Table 3 which notes the particular issues which the opinion statements are associated with. Respondents are asked to express the degree to which each of the opinion statements included in the scale reflects their position on a seven point Likert-scale which ranges from Highly Disagree to Highly Agree.

Table 3: Attitudinal scale developed to measure attitudes relating to the functional characteristics of Electric Vehicles.

No.	Statement	Issue
1	Electric cars are relatively more expensive to purchase but can pay for themselves in lower fuel costs	Vehicle: operation costs
2	I think I can fulfil all my transport needs with an electric car that has a range of 100 miles before recharging	Vehicle: range anxiety
3	I would value the ability to refuel my car from home	Infrastructure: decentralisation
4	Electric cars don't offer enough performance	Vehicle: performance
5	I would feel relatively less safe in an electric car	Vehicle: safety
6	I think it would be easy for me to find places to plug in an electric car	Infrastructure: availability
7	Electric cars are less reliable than conventional cars	Vehicle: reliability
8	I think electric cars would be complicated to use	Vehicle: complexity

5.1.4 Electric Vehicle Preferences

To measure preferences towards EVs, respondents were asked to complete a vehicle propulsion system choice experiment. This choice experiment contained four options, covering the conventional propulsion systems of Petrol ICE and Diesel ICE whilst including the EV options of Plug-in Hybrid Electric Vehicle (PHEV) and pure Battery Electric Vehicle (BEV). An attribute matrix was provided to respondents which listed the primary technical features of the four propulsion systems. The attribute matrix is reproduced in Table 4 and was based on the technical specifications of the propulsion systems available for purchase in the 2012 vehicle model year (the most up to date at the time of the choice experiment). Each of the attributes included in the choice experiment was associated with a definition to assist respondent comprehension. Preferences towards the propulsion systems options were elicited on a seven point Likert-scale reflecting the likelihood of a respondent to consider the propulsion system in their next car purchase from Highly Unlikely to Highly Likely.

Table 4: Reduced version of the attribute matrix measuring propulsion system preferences.

Attribute	Petrol Vehicle	Diesel Vehicle	Plug-in Hybrid Electric Vehicle	Pure Battery Electric Vehicle
Total Range	300 miles	300 miles	300 miles	100 miles
Electric Range	0 miles	0 miles	20 miles	100 miles
Purchase Price	£12,000	£15,000	£23,000	£25,000
Operating Cost	£1000 per annum	£850 per annum	£300 per annum	£150 per annum
CO_2 Emission	130 g/km	110 g/km	85 g/km	75 g/km
Brake Horse Power	110	100	90	80
Miles per Gallon	30	40	100	150

5.2 Data Collection

To apply the conceptual framework, a self-completion paper-based household survey was distributed by post in the cities of Dundee and Newcastle upon Tyne in the UK between November 2011 and February 2012. Respondents were entered into a random draw to receive two £50 vouchers to incentivize completion and were able to return completed surveys by post (95.5%) or by online submission (4.5%) up to May 2012. The household survey included eighteen different sections with an expected completion time of 25 minutes. A stratified random sampling procedure was followed in an effort to attain a representative sample. The Index of Multiple Deprivation (DCLG, 2010; ONS, 2009), which is a composite index that includes measurements of education, employment, health, crime and environmental quality at lower super output area resolution, was used to develop a spatially representative distribution schedule. A total of 4000 surveys were distributed with 506 completed surveys returned with a fairly even split between the two distribution sites. At the time of survey completion, no respondent had an EV in their household fleet. Of these 506 completed surveys, 106 are omitted from the analysis presented in this paper due to missing data on some of the components included in the conceptual framework.

Table 5: 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 Per Annum (GBP) [c]	Less than 10,000	9%	7%
	10 – 30,000	44%	40%
	30 – 50,000	24%	28%
	50 – 70,000	12%	14%
	70 – 90,000	5%	7%
	More than 90,000	6%	6%

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

Table 5 compares the sample attained from the survey to the characteristics of the general UK population. Assessing the comparability of the sample with the general populace it is clear that, for certain characteristics, the sample achieves a close fit whilst, for other characteristics, there is an obvious separation. To consider the possible influence of this moderate disparity between sample and populace, socio-economic characteristics are included as independent variables in the regression analyses.

5.3 Statistical Analysis

The statistical analysis employed in this paper is conducted over three stages. In the first stage, the measurements of the conceptual framework components are prepared and evaluated. For the attitudinal scales, an exploratory factor analysis (EFA) is conducted in order to identify the latent variables which exist in the scales. This EFA follows a Principal Component Analysis (PCA) specification (Pearson, 1901; Hotelling, 1933) with Direct Oblimin rotation, with the constructs being identified based on those which exceed an eigen-value of one. For each construct identified, a factor score is generated using the regression method (Harris, 1967) to allow for each respondent to be assigned a factor loading. For each scale, the KMO measure of sampling adequacy (Cerny and Kaiser, 1977) alongside Bartlett's test of sphericity (Bartlett, 1950) are calculated to consider if the scales are suitable for structure detection. To evaluate the reliability of the factors identified in the EFA, Cronbach's alpha (Cronbach, 1951) is calculated to consider the internal consistency of the grouped opinion statements.

The most effective measurements identified in the EFA are then further evaluated in a Confirmatory Factor Analysis (CFA) using maximum likelihood estimation (Bryne, 2009) to consider the degree to which the opinion statements are associated with the latent constructs. Modification indices and standardised estimates of the CFA are inspected to consider if any alterations to the specification of the opinion statements is required. The goodness of fit indices (Hooper et al., 2008) are evaluated to consider the degree to which the specified opinion statements fits the intended latent construct structure.

Following the CFA, a Spearman's correlation analysis between the components of the conceptual framework is conducted in order to identify where significant relationships exist and if these relationships agree with to the expectations of the framework. In the final stage of the analysis, two

sets of regression analyses are conducted. The first set examines the explanatory power of the measurements of innate innovativeness over actualised innovativeness. This analysis is conducted using Poisson regression due to the dependent variable being count data. The second set of regression models examines how consumer innovativeness and attitudes concerning the functional characteristics of EVs can be used to explain preferences for these vehicles. As EV preferences have been measured on a 7 point Likert-scale, an ordinal logistic regression analysis is conducted.

6 RESULTS

6.1 Electric Vehicle Preferences

Descriptive statistics of the propulsion system choice experiment are presented in the upper section of Table 6 and suggest that respondents to the survey tend to hold negative preferences for EVs. In terms of the response frequencies, 75.6% of respondents stated they were, to some degree, unlikely to consider a PHEV in their next car purchase with the figure increasing to 86.2% in the case of BEVs.

Table 6: Descriptive statistics of the measures of propulsion system preference and the measures of actualised innovativeness.

Variable	Mean	SD	Skewness
Propulsion System Preferences			
Petrol	5.03	2.10	-.777
Diesel	5.06	2.05	-.913
Plug-in Hybrid EV	2.47	1.73	1.06
Pure Battery EV	1.83	1.58	2.00
Actualised Innovativeness			
Total Owned	4.26	2.60	.671
Total Desired	2.16	2.16	1.55

SD: Standard deviation.

6.2 Actualised Innovativeness

The lower section of Table 6 reports the measurements of actualised innovativeness. The total quantity of technology owned (Total Owned) appears to be normally distributed, with respondents on average owning between 4 and 5 items of technology from the specified list. Relating to the total quantity of technology desired to be owned in the near future (Total Desired), the distribution is

negatively skewed, with respondents on average stating a desire to purchase approximately 2 innovations from the specified list.

6.3 Exploratory Factor Analysis

The PCAs of the attitudinal scales measuring the conceptual framework components related to the psychological and sociological determinants of innate are presented in Table 7 whilst the PCA of the EV attitudes scale is displayed in Table 8. At this stage of the analysis, statement number 1 from the psychological determinants scale and statement number 2 from the sociological determinants scale are removed due to low levels of extraction. In each PCA, all of the opinion statements which have a coefficient in excess of 0.4 for a particular factor are reported alongside the total variance explained (TVE) by the factor. The KMO measure of sampling adequacy and Bartlett's test of sphericity return acceptable results for each of the scales. Each of the factors identified in the PCAs have been provided with a label which attempts to capture the factor's orientation based on the grouped opinion statements.

Table 7: Output from the Principal Component Analysis of the attitudinal scales measuring the psychological and sociological determinants of innate innovativeness

No.	Statement	C	M	SD
	Psychological: Ambition – TVE: 29.03% α: .736			
9	I'm never satisfied with my current position in life	.623	3.20	1.60
13	I'm usually one of the first people to acquire the latest consumer technology	.613	2.53	1.46
11	I quickly incorporate new ideas into how I live my life	.597	4.19	1.35
10	Compulsive behavior usually governs my purchasing decisions	.590	2.60	1.50
12	My friends and family would consider me to be an innovative person	.575	3.92	1.42
4	I'm always looking for ways to alter my life to make it better	.564	4.74	1.35
8	I'm a very ambitions person setting high standards and expectations for myself	.451	4.59	1.60
	Psychological: Decision Making – TVE: 12.18% α: .743			
5	I have confidence in myself in making the right decision in complicated situations	.804	5.35	1.98
2	I prefer to let other people make decisions when I am not completely sure about the situation	-.744	3.60	1.68
8	I'm a very ambitions person setting high standards and expectations for myself	.507	4.59	1.60
11	I quickly incorporate new ideas into how I live my life	.456	4.19	1.35
12	My friends and family would consider me to be an innovative person	.454	3.94	1.45
	Psychological: Science and Education – TVE: 9.53% α: .573			
3	Science has no impact on how I live my life	-.757	2.60	1.53
14	I really enjoyed my science classes at school	.677	4.65	1.88
6	I rarely use the things I learned in formal education in my daily life	-.626	2.78	1.48
7	I enjoy learning about new things	.541	5.85	1.01
	Sociological: Knowledge – TVE:45.16% α: .865			
6	Friends and colleagues regularly come to me about advice concerning new consumer technology	.890	2.74	1.60
7	I often know about the next 'must have' piece of consumer technology before it is released into the market	.888	2.51	1.57
8	I regularly seek information about the latest consumer technology	.887	2.72	1.66
5	I keep up-to-date with consumer technology by reading newspapers/magazines, websites or watching relevant TV shows	.752	4.17	180
4	I have frequent contact with people working with new consumer technology	.521	3.59	1.70
	Sociological: Network – TVE: 18.54% α: .629			
9	I often socialise with people from a large variety of different backgrounds	.767	4.66	1.74
3	My friends and family would say I was a cosmopolitan person	.721	4.26	1.47
1	I regularly participate in activities such as sports, clubs and/or associations that have a formal structure	.693	4.45	1.96
4	I have frequent contact with people working with new consumer technology	.436	3.59	1.70

TVE: Total variance explained; α: Cronbach's alpha; C: Coefficient; M: Mean; SD: Standard deviation.

Exploring the output of the PCAs, three factors have been identified in the psychological determinants scale principally focused on personal ambition (*Psychological: Ambition*), decision making ability (*Psychological: Decision Making*) and attitudes towards science and education (*Psychological: Science and Education*). In terms of the sociological determinants, two factors are found to be present covering the topics of knowledge concerning innovations (*Sociological: Knowledge*) and level of integration with social networks (*Sociological: Network*). The PCA on the scale measuring EV attitudes detected two factors with the first focusing on negative evaluations of the functional capabilities of EVs (*EV Attitudes: Negative*) whilst the second factor is positively orientated (*EV Attitudes: Positive*).

Table 8: Output from the Principal Component Analysis of the attitudinal scale measuring attitudes relating to the functional capabilities of electric vehicles.

No.	Statement	C	M	SD
	EV Attitudes: Negative – TVE: 28.54% α: .701			
7	Electric cars are less reliable than conventional cars	.792	3.88	1.20
5	I would feel relatively less safe in an electric car	.785	3.7	1.47
8	I think electric cars would be complicated to use	.769	3.45	1.42
4	Electric cars don't offer enough performance	.521	4.64	1.36
	EV Attitudes: Positive – TVE: 19.45% α: .508			
2	I think I can fulfil all my transport needs with an electric car that has a range of 100 miles before recharging	.709	3.08	1.81
1	Electric cars are relatively more expensive to purchase but can pay for themselves in lower fuel costs	.656	4.41	1.39
3	I would value the ability to refuel my car from home	.582	5.01	1.52
6	I think it would be easy for me to find places to plug in an electric car	.511	2.80	1.54
4	Electric cars don't offer enough performance	-.315	4.64	1.36

TVE: Total variance explained; α: Cronbach's alpha; C: Coefficient; M: Mean; SD: Standard deviation.

With a large quantity of factors having been identified in the PCAs, the next step is to select the optimal factors to represent the components of the conceptual framework. Evaluating the internal consistency of the factors identified across the scales, three of the factors (*Psychological: Science and Education*, *Sociological: Network* and *EV Attitudes: Positive*), display Cronbach's alphas (α) which fall below the acceptability threshold of 0.7, suggesting a reduced level of reliability. With this in mind, these factors have been excluded from the CFA and further analysis. In terms of the two remaining factors associated with the psychological determinants of innate innovativeness scale, it is apparent that a number of opinion statements cross-load on both factors, indicating overlap in their orientations. With the factor *Psychological: Ambition* displaying a larger TVE, it has been selected for

inclusion in the CFA. The factors *Sociological: Knowledge* and *EV Attitudes: Negative* are also taken forward in the CFA.

6.4 Confirmatory Factor Analysis

A benchmark CFA has been conducted on the factors *Psychological: Ambition*, *Sociological: Knowledge* and *EV Attitudes: Negative* which were identified in the PCA. In order to evaluate if revisions to the factor structures are required, the modification indices and standardised estimates of the benchmark CFA have been assessed. These investigations led to the exclusion of opinion statements 9 and 10 from the factor *Psychological: Ambition* and opinion statement 4 from the factor *EV Attitudes: Negative*. Additionally, the error terms between statements 13 and 4, 13 and 8 and 11 and 12 on the factor *Psychological: Ambition* have been allowed to covary. After these revisions to the factor structure had been conducted, a final CFA was calculated with the goodness of fit indicators suggesting an adequate specification (χ^2: 160.65, df = 61; GFI: .933; AGFI: .900; CFI: .941; RMSEA .069).

Table 9: Confirmatory factor analysis of components of the conceptual framework related to psychological determinants of innate innovativeness, sociological determinants of innate innovativeness and EV attitudes.

No.	Statement	SE
	Psychological Determinants	
13	I'm usually one of the first people to acquire the latest consumer technology	.88
11	I quickly incorporate new ideas into how I live my life	.56
12	My friends and family would consider me to be an innovative person	.54
4	I'm always looking for ways to alter my life to make it better	.54
8	I'm a very ambitious person setting high standards and expectations for myself	.54
	Sociological Determinants	
6	Friends and colleagues regularly come to me about advice concerning new consumer technology	.86
7	I often know about the next 'must have' piece of consumer technology before it is released onto the market	.86
8	I regularly seek information about the latest consumer technology	.85
5	I keep up-to-date with consumer technology by reading newspapers, magazines, websites or relevant TV shows	.69
4	I have frequent contact with people working with new consumer technology	.48
	Electric Vehicle Attitudes	
7	Electric cars are less reliable than conventional cars	.73
5	I would feel relatively less safe in an electric car	.65
8	I think electric cars would be complicated to use	.68

SE: Standardised estimate.

The finalised factor structure of the CFA is reported in Table 9. These factors represent the last stage of the measurement of the components of the conceptual framework associated with the psychological and sociological determinants of innate innovativeness and attitudes towards the functional characteristics of EVs.

6.5 Correlation Analysis

The Spearman's correlation analysis between the components of the conceptual framework is reported in Table 10. A number of significant relationships are identified by the analysis, with these relationships generally agreeing with the hypothesised links of the conceptual framework. A strong positive correlation is present between the psychological and sociological determinants of innate innovativeness (r_s: .662) with these two factors also holding moderate positive correlations with the total quantity of technology owned (Total Owned r_s: .378, .423) and weak positive correlations with the total quantity of technology desired (Total Desired r_s: .203; .303). This suggests that both psychological and sociological determinants of innate innovativeness as measured in this paper are reasonably useful indicators of actualised innovativeness.

Table 10: Spearman's correlation analysis between the components of the conceptual framework.

Variable	A	B	C	D	E	F	G
Psychological Determinants (A)	-						
Sociological Determinants (B)	.662**	-					
Total Owned (C)	.378**	.423**	-				
Total Desired (D)	.203**	.303**	.121**	-			
EV Attitudes (E)	-.109*	-.162**	-.017	-.112*	-		
PHEV Preferences (F)	.127*	.109*	.060	.214**	-.173**	-	
BEV Preferences (G)	.077	.041	.081	.135**	-.155**	.651**	-

*: p-value < .05; **: p-value < .01.

However, no significant correlation is identified between the total quantity of technology owned and preferences for EVs (PHEV Preferences and BEV Preferences), with only weak significant positive correlations present between the total quantity of technology desired and preferences for EVs (r_s: .214; .135). This indicates that actualised innovativeness may not act as a strong indicator of preferences towards EVs. Significant correlations are identified between attitudes towards the functional characteristics of EVs (*EV Attitudes*) and PHEV and BEV Preferences (rs: -.1.73; -.155), though the size of the correlation coefficients imply that these attitudes are only weak indicators of preferences.

6.6 Regression Analysis

The first set of regression analyses examines the degree to which the measurements of innate innovativeness (measured by the psychological and sociological determinants of innate innovativeness reported in Table 9) can be of use in explaining variation in actualised innovativeness (measured by the total quantity of technology owned and the total quantity desired to be owned reported in Table 6). Two different regression models are specified with the first employing the total quantity of technology owned (Total Owned) as the dependent variable whilst the other uses the total quantity of technology desired (Total Desired). Results of the analyses are displayed in Table 11 with the variables which hold significant explanatory power being highlighted in bold. The two models are significant, indicating that the independent variables explain additional variation in the quantity of technology owned and desired to be owned compared to using an intercept only model.

Table 11: Poisson regression analysis examining the effect of socio-economic characteristics and the measurements of innate innovativeness over actualised innovativeness.

Variable	Total Owned		Total Desired	
	Beta	Std. Err.	Beta	Std. Err.
Age				
Years	**-.004***	**.002**	**-.009****	**.002**
Highest Level of Qualification (No Qualification as reference)				
High School	.103	.139	-.138	.210
Pre-University	.079	.136	**.411***	**.192**
Undergraduate Degree	-.058	.138	.346	.195
Postgraduate Degree	.026	.136	**.416***	**.192**
Professional Qualification	.083	.142	.135	.207
Gross Household Income (Under £10,000 as reference)				
£10 - £30,000	.256	.196	-.362	.216
£30 - £50,000	**.436***	**.199**	-.232	.219
£50 - £70,000	**.670****	**.203**	-.325	.229
£70 - £90,000	**.679****	**.213**	-.374	.249
Over £90,000	**.755****	**.211**	-.479	.249
Gender (Male as reference)				
Female	.003	.054	.067	.077
Determinants of Innate Innovativeness				
Psychological Determinants	.059	.039	.037	.055
Sociological Determinants	**.201****	**.033**	**.180****	**.048**

Model Fitting		
Log Likelihood	-797.498	-726.727
Akaike Information Criterion	1625.996	1483.435
Bayesian Information Criterion	1683.576	1542.035

* - p < 0.05 ; ** - p < 0.01.

Examining the variables which hold significant influence in the models, it is apparent that a number of the socio-economic characteristics are useful at explaining variance in actualised innovativeness. The variable measuring age is associated with significant negative coefficients in both models (Beta: -.004; -.009), suggesting that older individuals are less likely to be adoptively innovative. In the Total Owned model, the variable measuring gross household income is associated with a series of significant positive coefficients across the different measurement levels (Beta: .436; .670; .679; .755), indicating that increasing levels of affluence positively effects actualised innovativeness. In the Total Desired model, the variable distinguishing highest level of education is associated with two significant positive coefficients (Beta: .411; .416), indicating that individuals with a high school qualification or a postgraduate degree are more likely to desire to own innovations in the near future as compared to individuals without any formal qualification. Shifting the focus to the variables measuring innate innovativeness, only the variable measuring the sociological determinants of innate innovativeness (*Sociological Determinants*) holds a significant effect over actualised innovativeness (Beta: .201; .180).

The second set of regression models examines how the measurements of actualised innovativeness (Total Owned and Total Desired) and attitudes concerning the functional characteristics of EVs (*EV Attitudes*) can be used to explain preferences for these vehicles. Two models are specified with the first using preferences for PHEVs as the dependent variable whilst the second uses preferences for BEVs. The results of the analysis are presented in Table 12 with the variables which hold a significant influence being highlighted in bold.

Table 12: Ordinal logistic regression analysis examining the effect of socio-economic variables, actualised innovativeness and Electric Vehicle Attitudes over Electric Vehicle Preferences

Variable	PHEV Preferences		BEV Preferences	
	Beta	Std. Err.	Beta	Std. Err.
Age				
Years	.004	.008	.008	.009
Highest Level of Qualification (No Qualification as reference)				
High School	-.352	.555	-1.041	.640
Pre-University	.338	.531	-.655	.601
Undergraduate Degree	.213	.535	-.572	.596
Postgraduate Degree	.366	.530	-.153	.583
Professional Qualification	.671	.558	.245	.607
Gross Household Income (Under £10,000 as reference)				
£10 - £30,000	.337	.737	.721	.905
£30 - £50,000	.447	.750	.746	.919
£50 - £70,000	.265	.781	.534	.954
£70 - £90,000	.738	.824	1.251	.989
Over £90,000	.368	.829	.747	.998
Gender (Male as reference)				
Female	**-.843****	**.226**	**-.711****	**.260**
Actualised Innovativeness				
Total Owned	.049	.040	.086	.046
Total Desired	**.171****	**.049**	**.146****	**.055**
Electric Vehicles Attitudes				
EV Attitudes	**-.580****	**.127**	**-.531****	**.146**
Model Fitting				
Log Likelihood	1092.314		776.330	
Nagelkerke R^2	.147		.119	

* - p < 0.05 ; ** - p < 0.01

In both instances, the models specified provide a significant contribution to explaining variance in EV preferences. Of the socio-economic variables included in the models, only the variable distinguishing gender is associated with a significant negative coefficient (Beta: -.843; -.711), indicating that females have a decreased likelihood of holding positive preferences for PHEVs and BEVs compared to males. In terms of the variables measuring actualised innovativeness, the desire to own technology in the near future (Total Owned) can be of use in explaining the variance in preferences towards PHEVs and BEVs (Beta: .176 and .134). In terms of the measurement of attitudes towards

the functional capabilities of EVs (*EV Attitudes*), results follow expectations with increasing levels of negative attitudes towards EVs significantly reducing the likelihood for holding positive preferences for EVs (Beta: -.531 and -.489). However, the low explanatory power of the models indicates that socio-economic characteristics, actualised innovativeness and attitudes towards EVs functional performance are seemingly weak predictors of EV preferences.

7. DISCUSSION AND CONCLUSIONS

This paper applies a conceptual framework which examines the effect consumer innovativeness and attitudes towards the functional characteristics of EVs have over expressed preferences for these vehicles. This conceptual framework contains a series of hypothesised links which connect framework components. The results of the statistical analysis indicate that:

H_1 – the link between the sociological and psychological determinants of innate innovativeness is supported by a strong correlation coefficient.
H_2 – the link between the psychological determinants of innate innovativeness and actualised innovativeness is partially supported by moderate correlation coefficients though lacking significance in the regression analysis.
H_3 – the link between the sociological determinants of innate innovativeness and actualised innovativeness is supported by moderate correlation coefficients and significant regression coefficients.
H_4 – the link between EV attitudes and EV preferences is supported by a weak correlation coefficient and a significant regression coefficient.
H_5 – the link between actualised innovativeness and EV preferences is partially supported by weak correlation coefficients and significant regression coefficients.

Of particular importance for the expressed aim of this paper is the hypothesised link between actualised innovativeness and the preferences an individual holds towards EVs (H_5). Here, the results of the analysis seem to imply only a partial connection exists between these framework components, with the total quantity of technology desired to be owned in the near future (Total Desired) holding significant but weak correlation and regression coefficients with EV preferences whilst the total quantity of technology owned (Total Owned) is insignificant. A number of potential explanations exist concerning the basis for this weak connection between actualised innovativeness and EV preferences.

Firstly, taking a cross sectional approach to measuring actualised innovativeness has a number of prominent limitations, with the list of household and consumer technology (Table 2) unlikely to be exhaustive of all innovations which can be adopted and with this list containing technologies that are at different stages of their diffusion and with different degrees of market appeal. Similarly, the manner in which EV preferences are elicited in this research, through a simple approach of providing information concerning the new propulsion systems and asking for likelihood of purchase, could bias the measurement of this important issue. Kurani et al. (1994) note that individuals unfamiliar with new propulsion systems often require an extended time to reflect on these technologies before they can understand their implications. A similar position is taken by Skippon and Garwood (2011), who argue that direct experience of EVs is required in order to reduce the psychological distance individuals have to this technology. Consequently, the measurements of actualised innovativeness and EV preferences applied in this paper may not be effective at quantifying these issues.

Secondly, with this paper utilising measurements of consumer innovativeness at a general level, covering innate tendencies and actualised behaviour in the broad household and consumer technology market, there is the potential for consumers who have a highly specific expressions of innovativeness in the automotive market to be overlooked (Goldsmith et al. 1995). The emerging market for EVs may represent a unique environment for the expression of consumer innovativeness, allowing individuals to be innovators or laggards in terms of EVs whilst they display different levels of innovativeness in more general circumstances. In this sense, EVs may represent a specific domain of innovativeness, which is not linked to other domains. This paper lacks an appreciation of the possibility for domain specific innovativeness (Goldsmith, 2001) to be present in the EV market and how this concept can be useful in identifying early adopters (Hoffman and Soyez, 2010). Consequently, research which investigates the propensity of an individual to be innovative in the automotive market (domain specific innovativeness) may identify a stronger link than the more general measurements of innovativeness utilised in this research.

Thirdly, the intervening variables which exist in terms of EV adoption, often discussed in the literature as adoption barriers (Egbue and Long, 2012; Steinhilber et al. 2013), are potentially creating substantial disruptions to the transference of an individual's innovativeness into their stated preferences towards EVs. Whilst this paper has attempted to take account of attitudes towards the functional characteristics of EVs, the existing literature on consumer response to EVs suggests that a wide range of additional issues are affecting how these vehicles are perceived (Rezvani et al. 2015).

Consequently, research integrating social interactions concerning EVs (Axsen et al. 2013), interest in EV technology (Noppers et al. 2015), situational factors linked to EV practicality for a particular user (Peters et al. 2011b) alongside a measurement of consumer innovativeness might offer a more integrated perspective.

Fourthly, the results of the analysis may imply that, during the early introduction of EVs into the mainstream automotive market, these vehicles are not being considered as desirable innovations. However, this interpretation is likely to be an oversimplification of a complex issue, with Heffner et al. (2007) having already found that certain adopters of Hybrid Electric Vehicles in California did express a general desire to embrace new technology whilst others expressed dissonance with being labelled a technophile. Consequently, the research in this paper resonates with other recent research on EV uptake which suggests that there is more than one early adopter segment (Heffner et al., 2007; Anable et al., 2016). Each of these adopter groups is unique, and conspicuous differences exist between groups. The research in this paper would suggest that innovativeness may not be an individual characteristic that has a powerful enough effect on the acceptance decisions of EVs to classify potential user groups into distinct and meaningful groups on its own. However, it does suggest that the construct of innate innovativeness, and potentially actualised innovativeness, would be good candidates to place alongside other psychological constructs to map onto specific adopter categories to allow the identification of groups of adopters who have distinct predisposed tendencies towards EV adoption. This is important for manufacturers and policy makers to focus marketing and implementation efforts on those adopters who are more likely to embrace the new technology and facilitate its further diffusion by serving as conduits for information, change agents and opinion leaders.

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