DEMAND DRIVERS IN THE EMERGING MARKET FOR LOW EMISSION VEHICLES IN SCOTLAND

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1. ABSTRACT

Moving towards a more sustainable transport system within Scotland has been a primary objective of the Scottish Government for a considerable length of time. Specifically looking at the high dependence on private vehicle use, the associated problems of road accidents, urban pollution, congestion and energy security are clearly evident. Whilst attempting to reduce this private vehicle dependency is a worthy endeavour, it is likely that the majority of passenger trips will be conducted in private vehicles for the foreseeable future. Rather than focusing on changing the quantity of transport demand satisfied by passenger vehicle use, it may prove fruitful to consider changing the type of private vehicle consumers operate. Low Emission Vehicles (LEVs) have been developed to address some of these outlined problems and are ready to be introduced into the mainstream automotive market. How successful they are at reducing these problems will be dependent on consumer reaction to and adoption of these LEVs.

Traditionally, demand for a vehicle has been estimated using formally rational decision making models where consumers are represented as self interested utility maximizers basing their decision primarily on the price and specification of the vehicles. Whilst this approach has considerable merit, it is clear that consumers take into consideration other factors when deciding what car to purchase. To account for this, we aim to augment the traditional perspective by employing a dual framework approach. Firstly, we apply a model developed on the principles put forward in the Diffusion of Innovation Theory to address the predictive nature of this research. Secondly, we have developed a 3 construct framework which includes functional, symbolic and emotive vehicle characteristics to observe what influence these have over LEV preference formation. Results will be presented at this conference from an initial distribution of 1996 household self completion questionnaires that were distributed in Dundee city.

2. INTRODUCTION

Scotland, like any other mature economy, faces a conundrum in relation to the car dependency of the majority of its populace on the one hand, and its ambition to reduce greenhouse gas emissions on the other. Yet, in 2010, 2.26 million cars were registered in Scotland, travelling some 33.6 billion kilometres (Scottish Government 2011a & b). Despite some stabilisation in recent years, the number of licensed cars and their use grew by 20% and 7% respectively between 2000 and 2010 (ibid.). Although the average efficiency of the car vehicle fleet is improving incrementally year on year and these improvements meaning that CO2 from cars is finally reducing in absolute terms, they still account for 15% of total CO2 emissions in Scotland (AEA, 2011). Both the UK (OPSI, 2008) and Scottish Government (2009a) have committed to substantial reductions in greenhouse gas emissions. Recognising the imperative for more radical and rapid reductions in this sector in order to be able to achieve these targets, the EU (European Commission, 2011), UK (Dft, 2009) and Scottish Governments (2009b) have expressed support for the introduction of Low Emission Vehicles (henceforth, LEVs) into the automotive market.

Vehicles employing fuel efficient internal combustion engine technology alongside those which include electric elements within their powertrain architectures are at or near to market (SMMT, 2011). The potential of these vehicles to reduce emissions levels is well documented (Fontaras and Samaras, 2010; Lytton, 2010; van Vliet et al., 2010; IEA, 2011) but this is contingent upon these vehicles being adopted by consumers. Whilst research focusing on the technical aspects of these vehicles is valuable there has been a lack of consumer centric investigation. Previously attempted transitions to these LEVs have met with muted success (Hoyer, 2008) partly due to their lack of technical capability but also, it can be argued, due to a lack of attention given to consumers.

This research project aims to address this gap in the current knowledge base by investigating the likely consumer response to the introduction of LEVs into the Scottish automotive market. Through the application of a household survey, we attempt to measure key attitudes and determine how they may influence a respondent's preferences towards LEVs. Specifically, we augment previous research which has focused on the instrumental or functional

aspects of these vehicles by including symbolic and emotional considerations. Additionally, we investigate how a respondent's tendency to demonstrate characteristics of "innovativeness" may influence LEV preference. In this paper we focus on the results from the Dundee component of our sample and have selected a number of theoretical constructs in order to explore their specific relationship with LEV preference. It is hoped that the results generated by this research will be able to inform policy relating to consumer demand and specifically understanding of key attitudes which appear to be promoting, or conversely, hindering LEV preferences and direct future research.

3. PREVIOUS RESEARCH

Academic activity in the field of LEV consumerism commenced in the US in the early 1980s in response to the worldwide oil crises of the 1970s (Salameh, 2004) generating a desire to increase energy security by diversify a transport system highly dependent on petroleum. Research often took the form of discrete choice modelling whereby respondents would be asked to state their preferences when presented with descriptions of cars employing a variety of powertrains (Lave and Train; 1979, Manski and Sherman; 1980, Train; 1980, Beggs and Cardell; 1981). Researchers utilising this approach often based their studies on the logit modelling methodology developed by McFadden (1973). Mannering and Train (1985) provide a detailed review of this research direction describing the incremental improvements in these models which have expanded their variable sets whilst reducing their exposure to measurement error and bias. These models often took an instrumental approach to describing respondent's choice patterns attempting to estimate demand alterations given marginal changes in vehicle characteristics such as purchase cost, size and acceleration. The great value of this research is in its ability to direct those researchers working in the technical LEV field towards improving the vehicle characteristics which are likely to generate the largest increases in demand and to predict future car purchase behaviour.

Turrentine (1992) provides a strong critique to this choice modelling approach arguing that as consumers have little experience or understanding of these vehicles their preferences towards them are likely to be unstable and thus the results generated in these hypothetical environments may

indeed be spurious. More recently, research has progressed by including additional dimensions which have influence over LEV preference. Kurani et al. (1994) acknowledge the limitations of choice experiments and instead employ an exploratory approach which includes a household's entire stock of vehicles finding that perceived vehicle range requirements are significantly lower than previous research suggested. In a related piece of work, Kurani et al. (1996) use a reflexive study to determine electric vehicle demand in multicar households and find that a large number of respondents choose to actively diversify the powertrain structure of their household fleets. Heffner et al. (2007) investigate the symbolic meanings used by Hybrid Electric Vehicle owners in California finding a wide variation of symbolic attachments which are often linked to an owner's self identity. Following a similar direction, Mau et al. (2008) investigates the neighbour effect finding that LEVs are likely to be more successful in locations which have greater LEV market penetrations. Taking a more social perspective, Axsen and Kurani (2011) explore interpersonal influences relating to consumer perceptions of Plug-in Hybrid Electric Vehicles and find that consumers that have a social network which supports the societal values embodied by PHEVs tend to have more positive preferences towards them.

Turning our attention to the Scottish literature, it has proved difficult to identify relevant research discussing consumer dimensions of LEVs within Scotland. The earliest work identified was conducted by MacPherson (1989) which investigated the applicability of introducing Electric Vehicles into Scottish island communities finding that these communities potentially represent an innovative EV market segment with an estimated EV demand of between 3-12% of the island car market. Continuing the rural theme, CNP (2010) present the early findings from the EV trial which took place within the Cairngorms National Park discussing the user feedback generated which included references to functional capability and environmental consciousness alongside emotive connection and symbolic dimensions. Specifically, users expressed anxiety relating to the noise free operation of the EVs whilst stating that the EV was highly distinctive in the rural setting. Relating to functional operation, users stated that the EV proved superior to a conventional car in snow conditions whilst conveying concerns relating to performance in cold temperatures and when traversing hills.

Looking at Scotland's vehicle market from a technocentric perspective, the CCC (2010) develops a scenario based approach which is further detailed by the Scottish Government (2009c). Under the extended ambition scenario, to achieve an emissions reduction target of 34% by 2020 only 3% of new cars sold at that time should be powered by conventional internal combustion engines with 38% being Mild Hybrids, 38% Full Hybrids, 8% Plug-in Hybrids and 12% Pure EVs. This approach is replicated by Element Energy (2009) who developed a 4 scenario approach to 2030 which are emission target driven where consumer demand is treated as an exogenous input rather than a described feature. Specifically, their stretch scenario states that a seismic shift in consumer attitudes and purchasing behaviour is required without investigating how this could be achieved. It is clear from reviewing the limited literature in relation to LEV adoption in Scotland that there is a requirement for a detailed investigation concerning consumer attitudes and preferences in this emerging market.

4. METHODOLOGY

This research project employed a 12 page self completion household survey that was hand delivered to 1996 households in the Dundee City metropolitan area. In order to ensure that this distribution was representative of the Dundee population, 3 areas were identified based on the Scottish Index of Multiple Deprivation (Scottish Executive, 2004) to represent areas with high, middle and low deprivation. The area with the lowest deprivation is in the west of the city surrounding Perth Road and Dundee Technology Park whilst the middle deprivation area of Baxter Park and the high deprivation area of Douglas and Angus are in the east of the city. These 3 sites have been highlighted in grey in Figure 1. Within each site, distribution streets were selected through the process of taking an arterial road and selecting every other feeder street to receive surveys. Within each street, every other household was selected to receive a survey thus adding a component of random selection to the distribution. From the initial distribution of 1996 surveys, we received a usable response of 239 which is an overall response rate of 12%. The quantity of surveys distributed to each site and the associated response rates is detailed in Figure 2.

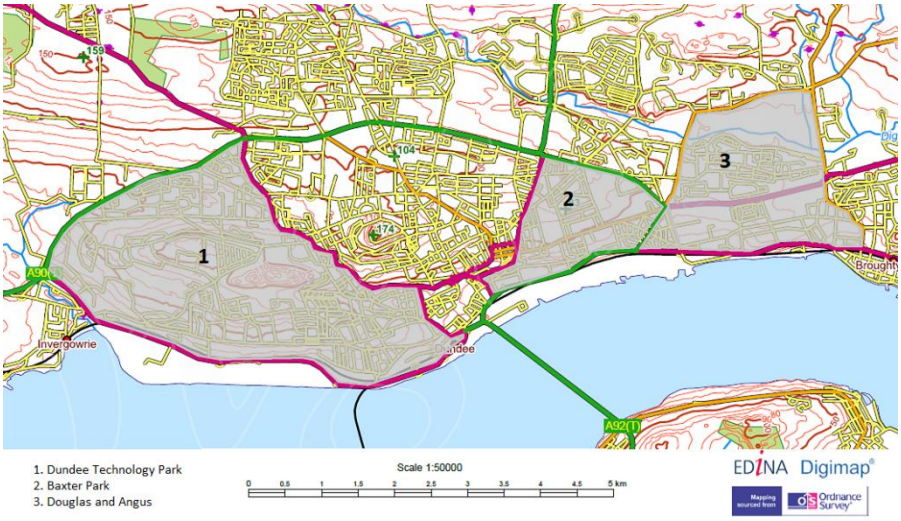

Figure 1 - Selected Distribution Areas

Looking at the socioeconomic makeup of respondents, we have attained a sample which has a larger share of retired subjects of 49.8% compared to the population statistics of Dundee City of 27.8% (Scottish Neighbourhood Statistics, 2010). It should be noted that these statistics may over represent the difference as subjects under the age of 18 would not have been able to complete the survey with this group representing 16.6% of the Dundee City population. Respondent age does appear to be normally distributed with the mean year of birth being 1951 with a standard deviation of 15.7 years. There is a rather even split over levels of academic achievement with 12.3% having no formal education whilst 35.6% hold a university degree. 66.5% of respondents come from households with a gross annual income of between £10,000 and £50,000 with 9.6% falling below this band and 23.9% above it. The majority of respondents (61.8%) are married and homeowners (88.6%).

Site	Sent	Received	% Return	% Of Distribution	% Of Returns
Technology Park	864	115	13%	43%	48%
Baxter Park	543	67	12%	27%	28%
Douglas and Angus	589	57	10%	30%	24%

Figure 2 - Survey Distribution and Response Rates

5. THEORY AND CONCEPTS

With LEVs still not being widely available in the automotive market, it proves challenging to measure consumer preferences towards these goods using revealed data. With this in mind, this research project has employed a choice experiment in order to measure respondent's LEV preference. Drawing from much of the previous empirical research in this field, a choice experiment was developed where respondents were presented with 6 different powertrain options including Petrol, Diesel, Mild Hybrids, Full Hybrids, Plug-in Hybrids and Pure EVs and asked to state on a 7 point Likert Scale their preference for each option. This part of the study draws directly on the principles of Rational Choice Theory (Crouch, 1979) in so much that we require respondents to make a decision after reflecting on their preferences based on the information they are provided with. The variables derived from this stage of the survey will be used as the dependent variable in the regression modelling.

In order to assist in explaining the preferences towards LEVs, we utilise two distinct conceptual and theoretical fields. Firstly, we draw inspiration from the work conducted by Steg et al. (2001) and Steg (2005), and develop a 3 construct framework which attempts to measure the functional, symbolic and emotive meanings respondents attach to car use. This conceptual approach is illustrated in Figure 3. To achieve this, we adapt an attitudinal scale initially developed by Dittmar (1992) and further refined by Richins (1994) in an attempt to measure these latent constructs. This is referred to as the Car Meanings scale.

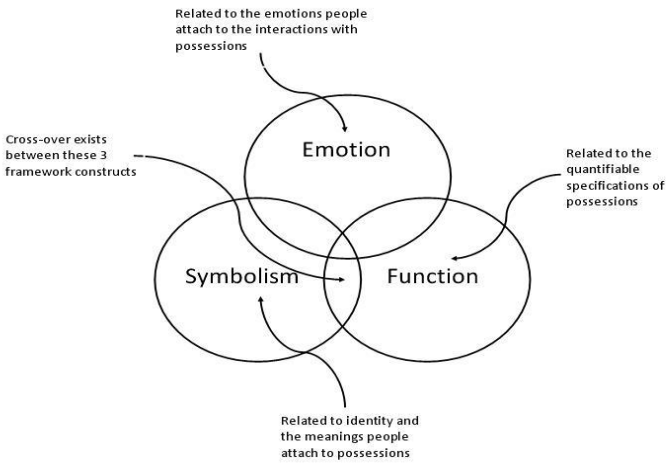

Figure 3 – Car Meaning Framework

Secondly, we utilised the Diffusion of Innovations Theory (Rogers, 1995) which attempts to describe how an innovation diffuses through a social system over time. Within this theory, the construct of innovativeness is defined as the tendency of an individual to adopt an innovation early in its diffusion process. This is split into two different forms of innovativeness, firstly a respondent's psychological and communicative tendency to behave in an innovative manner which is referred to as innate innovativeness and secondly a respondent's tendency to take up innovations which is referred to as adoptive innovativeness. In this research project, we take forward the concept of innate innovativeness by developing and applying 2 attitudinal scales based on the determinants of innate innovativeness as proposed in the Diffusion of Innovation Theory. The first scale focuses on a respondent's communication behaviour (referred to as Communication Determinants of Innovativeness scale) whilst the second concerns key psychological characteristics (referred to as Psychological Determinants of Innovativeness scale).

6. RESULTS AND DISCUSSION

6.1 Powertrain Choice Experiment

Presented in Figure 4 are the results from the choice experiment for all 6 powertrain options ranging from Petrol to Pure EVs. This is the order the respondents were presented with in the survey and ranges from the most conventional powertrain to those embodying higher proportions of powertrain electrification. The 7 point likert scale is arrange negatively to positively (an order which was kept constant throughout the survey) from highly unlikely to highly likely. The anchor phrase used in this choice experiment was "state how likely you would be to consider each engine option in your next car purchase". The reason for this approach was that it was felt that respondents were more likely to have a stable preference set for their next vehicle purchase as opposed to some pre defined time in the future.

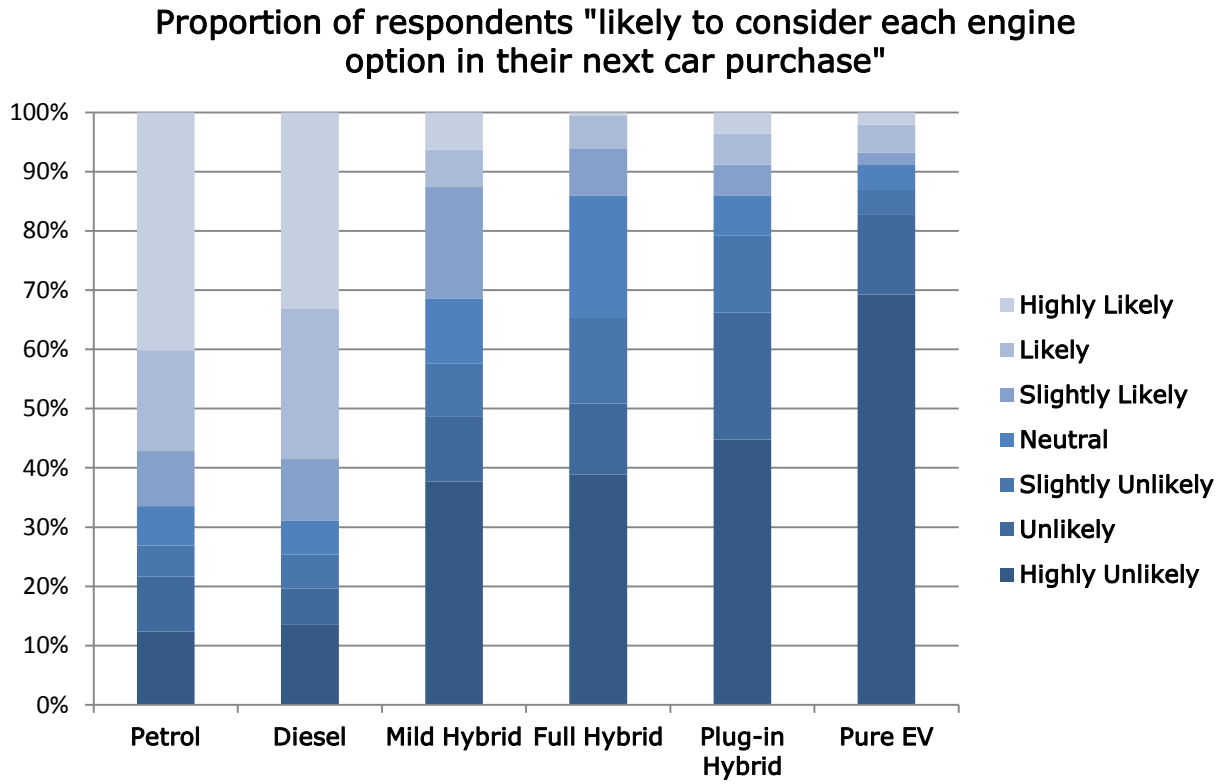

Figure 4 - Powertrain Preference Results

Examining these results in detail, it appears as though as the proportion of electrification in the powertrain increases, likelihood to adopt the powertrain in the next car purchase decreases. From these results we can propose that during the next vehicle purchasing cycle the market penetration of LEV powertrains is likely to be small with Petrol and Diesel powertrains attaining a relatively even split of the majority market. Mild Hybrids are likely to attain the highest degrees of market penetration for LEV powertrain options with the role played by Pure EVs likely to remain as a niche application. It appears as though the market is likely to undergo a period of incremental change as opposed to sudden transition from conventional internal combustion engines to electric power delivery. Hybrid powertrains are likely to serve as a bridge between these two forms of propulsion. The will allow consumers to experience an alternative power delivery system which includes advanced technology without having to significantly adapt their refuelling or travel behaviour or require a willingness to accept significant price premiums. By the time the vehicles purchased in the current vehicle cycle come to the end of their usable lives, battery technology is likely to have advanced leading to lower prices and longer all electric ranges

(Element Energy, 2012). With this in mind, it is likely that Pure EVs will play a more prominent role in the market in future vehicle cycles as opposed to the forthcoming one.

Critically examining these results, it is clear there is a stark contrast between the scenarios developed for powertrain diversification in Scotland as described in the literature section and current consumer preferences. Whilst the scenarios developed are concerned more with what is technically feasible as opposed to practically achievable, bridging the gap between the scenarios and current consumer preferences is likely to be a substantial challenge. These results indicate there is a requirement to construct a scenario based study investigating powertrain diversification from a consumer perspective.

6.2 Principle Components Analysis on Attitudinal Scales

The attitudinal scales included in the survey have been examined using Principal Components Analysis (Hotelling, 1933) with Varimax Rotation (Kaiser, 1958) in SPSS[ii] to reduce the number of variables into the underlying latent variables present in the data. Components have been extracted which display an eigenvalue of 1 or greater with missing values been treated as mean scores. To assist interpretation, coefficients of under 0.3 have been hidden and the statements have been arranged by coefficient size.

The reliability of each construct was tested using Cronbach's alpha. Hair et al. (1998) indicate a score on 0.7 to be an acceptable reliability but lower thresholds are sometimes used in exploratory research. Respondents have been assigned a factor score for each component calculated using the regression method (Harris, 1967).

Statements	Component		
	1	2	3
Improve my appearance or the way I look	.872		
Make others think well of me	.865		
Provide me with social status	.854		
Provide emotional security	.752		
Improve my mood	.745		
Be beautiful or attractive in appearance	.722		
Allow me to express myself	.682	.450	
Be a hassle		-.760	
Provide enjoyment		.674	
Be a sensible financial decision		.635	
Allow me to be efficient in my daily life and work		.536	.495
Have a lot of practical usefulness			.916

Figure 5 - PCA of Car Meanings Scale

Figure 5 presents the results from the PCA conducted on the Car Meanings attitudinal scale which included 4 statements associated with symbolic, emotive and functional car constructs. 3 components have been extracted accounting for 64.2% of the variation. The Kaiser-Meyer-Olkin measure for this scale is .852 with component Cronbach's alphas of .910 for Component 1, .630 for Component 2 and .445 for Component 3.

Where we would have anticipated that the 4 attitudinal statements associated with each of the 3 constructs (symbolic, emotive and functional car meanings) would form 3 associated components, we instead are presented with a one component which includes symbolic and emotive statements and two components which are orientated around functional car aspects. Component 1 includes elements such as symbolism, identity and improvements to emotional state and appearance. Component 2 includes functional considerations such as enabling daily life, cost effectiveness and the provision of enjoyment. Component 3 is somewhat unusual having only 1 component unique statement though is clearly focused around functional considerations. On reflection, these results are not counter intuitive as, whilst the attachment of symbolic, emotive and functional meanings to cars may indeed by conceptually separate, these constructs clearly are related. For example, if a person has a strong symbolic attachment to their cars, seeing it as an extension of their identity, they are likely to associate this relationship with strong positive emotional attachment.

Statements	Component	
	1	2
I often know about the next 'must have' piece of consumer technology before it is released onto the market	.872	
Friends and colleagues regularly come to me about advice concerning new consumer technology	.870	
I regularly seek information about the latest consumer technology	.867	
I keep up-to-date with consumer technology by reading newspapers/magazines, websites or relevant TV shows	.740	
I have frequent contact with people working with new consumer technology	.536	.391
My friends and family would say I was a cosmopolitan person		.734
I often socialise with people from a large variety of different backgrounds		.684
I regularly participate in activities such as sports, clubs and/or associations that have a formal structure		.589
I have a small group of friends who all know each other well and share similar interests		.567

Figure 6 - PCA of Communication Determinants of Innovativeness Scale

Figure 6 presents the results from the PCA conducted on the Communication Determinants of Innovativeness scale which included 9 statements associated with the generalisations of innate innovativeness as presented in the Diffusion of Innovations Theory. 2 components have been extracted accounting for 56.2% of the variation. The Kaiser-Meyer-Olkin measure for this scale is .825 with component Cronbach's alphas of .849 for Component 1 and .570 for Component 2.

Reviewing this scale, we observe the communication determinants of innovativeness separates out into 2 components each with 4 component unique statements. The first component is closely linked to a respondent's information seeking and information provision behaviour associated with innovations. This includes elements such as if the respondent actively searches for relevant information concerning new innovations through the mass media and if they act as information providers associated with innovations in their social networks. Component 2 is linked with social activity associated with innovativeness such as change agent contact, cosmopolitanism, and interacting with heterogeneous social groups. Oddly, the last statement on Component 2 seems counter intuitive positively linking

with a respondent's tendency to have a small friendship group which we would have expected to be negatively associated with this component. This may imply that the social dimension of innovation can be associated with those who have both a large and diverse or smaller, close-knitted networks of friendships.

Statements	Component			
	1	2	3	4
I'm never satisfied with my current position in life	.714			
I'm always looking for ways to alter my life to make it better	.698			
I'm usually one of the first people to acquire the latest consumer technology	.596			
I quickly incorporate new ideas into how I live my life	.564	.467		
I'm a very ambitious person setting high standards and expectations for myself	.531	.470		
I prefer to let other people make decisions when I am not completely sure about the situation		-.823		
I have confidence in myself in making the right decision in complicated situations		.764		
My friends and family would consider me to be an innovative person	.472	.518		
Science has no impact on how I live my life			-.727	
I really enjoyed my science classes at school			.676	
I enjoy learning about new things	.374		.603	
I rarely use the things I learned in formal education in my daily life			-.561	
Making sure I always make the correct decision is something that is important to me				.780
Compulsive behaviour usually governs my purchasing decisions	.517			-.558

Figure 7 - PCA of Psychological Determinants of Innovativeness Scale

Figure 7 presents the results from the PCA conduced on the Psychological Determinants of Innovativeness scale which includes 14 statements associated with the generalisations of innate innovativeness as presented in the Diffusion of Innovations Theory. 4 components have been extracted accounting for 56.5% of the variation. The Kaiser-Meyer-Olkin measure for this scale is .806 with Cronbach's alphas of .773 for Component 1, .757 for Component 2, .575 for Component 3 and .102 for Component 4.

Examining this scale, we see there has been a greater degree of data separation compared to the communication scale. Component 1 links well with the psychological determinant of ambition containing aspects associated with personal progression whilst including a self report relating to how early new technology is acquired. Component 2 contains statements connected with autonomous decision making and includes a self report relating to innovativeness. Component 3 is clearly orientated around the determinants of positive attitudes towards science and education. The final component is similar to Component 2 in that it is associated with how decisions are made, but is distinctive in that it captures the extent to which a person values deliberative and rational decision making processes.

In addition to these conceptual and theoretical frameworks, we include 5 further attitudinal scales which contain variables that have been shown in previous empirical research to be connected with LEV preferences. These additional attitudinal scales include "Car Importance and Knowledge", "Car Emotions", "General Car Attitudes", "EV Emotions" and "EV Functional Attitudes". We have detailed these additional attitudinal scales in Figure 8 stating the number of associated statements, component output from a PCA and a brief description concerning the meaning of each component. Also included in Figure 8 is a summary of the 3 primary attitudinal scales which have so far been discussed.

Scale Focus	Number of Statements Included	Number of Components Extracted	Component Label
3 Primary Attitudinal Scales			
Car Meanings	12	3	Car Meanings – Symbolic and emotion Car Meanings – Functional – slotting in with daily life Car Meanings – Functional - practicality
Communication Determinants of Innovativeness	9	2	Communication – Information seeking and provision behaviour Communication – Social activity
Psychological Determinants of Innovativeness	14	4	Psychological – Ambition Psychological – Decision making Psychological – Science and education Psychological – Rationality
5 Additional Attitudinal Scales			
General Car Attitudes	13	4	Car Attitudes – Environmental concerns of car use Car Attitudes – Status and emotive car connection Car Attitudes – Operating and purchasing costs Car Attitudes – Value of fuel efficiency and independence
Car Emotions	10	2	Positive car emotions Negative car emotions
Car Knowledge and Importance	11	3	Car importance and personification Car knowledge EV experience
EV Emotions	10	2	Positive EV emotions Negative EV emotions
EV Attitudes	8	2	Negative attitudes concerning EV functional characteristics Positive attitudes concerning EV functional characteristics

Figure 8 – Summary of Attitudinal Scales

6.3 Regression Analysis

Taking the variables which have been calculated in the previous sections, we examine how successful these measurements are at explaining respondent's LEV preferences by specifying an explanatory model. Through the application of a multiple linear regression model using the backwards method (Brace et al. 2002) we incorporate a respondent's mean preference across all LEV options included in the powertrain choice experiment as the dependent variable ("Mean preference for LEVs as a main car"). The explanatory variables contained in this model include the components extracted from the car meanings scale, the two determinants of innate innovativeness scales, and the 6 additional attitudinal scales (as detailed in Figure 8) alongside respondent socioeconomic variables and respondent's current car details.

The model required 30 iterations before a stable solution was determined with the result presented in Figure 10. From a total quantity of 29 explanatory variables included in the model, 8 prove to be statistically significant and have been included in the final model solution. The model explains 35% of the variance in mean LEV preferences as detailed in Figure 9.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.592	.351	.302	1.094

Figure 9: Model 1 Summary

Model 1	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	S.E	Beta		
(Constant)	3.153	.421		7.480	.000
Communication– information seeking and provision	.262	.111	.186	2.359	.020
Psychological – autonomous decision making	.353	.112	.253	3.162	.002
Gross household income	-.207	.099	-.193	-2.095	.038
Years car license has been held	-.022	.007	-.236	-2.974	.004
Usual expenditure on car purchasing	6.822E-5	.000	.300	3.391	.001
Car importance and personification	-.344	.105	-.253	-3.268	.001
EV experience	-.392	.106	-.296	-3.690	.000
Car attitudes - environment	.432	.115	.283	3.757	.000
Car attitude – value of fuel efficiency and independence	.281	.103	.210	2.735	.007

Dependent Variable: Mean preference for LEVs as main car

Figure 10: LEV Preference Multiple Regression Model

Examining the model explanatory variables in order, we observe that 2 variables from the innate innovativeness attitudinal scales prove to be statistically significant. Firstly, Component 1 (information seeking and provision behaviour) from the Communication Determinants of Innovativeness scale, which is associated with a respondent's tendency to search for and provide information concerning innovations, positively influences mean LEV preferences. Secondly, Component 2 (autonomous decision making) from the Psychological Determinants of Innovativeness scale, which is associated with a respondent's confidence in making decisions and their own self reported tendency towards innovative behaviour, also positively influences mean LEV preferences. From these findings it is proposed that the construct of innate innovativeness from both a communication and psychological perspective does appear to influence a respondent's mean LEV preference. Thus, people that score highly on these measures should be targeted as potential early adopters in this emerging market with policy interventions and information campaigns.

From the socioeconomic variables, we observe that gross household income negative influences mean LEV preferences. This is initially surprising, we

would expect respondents with higher levels of household income to tend to have relatively positive mean LEV preferences. A possible explanation for this finding is that currently LEVs are not associated with affluence and thus households desiring to express their economic prosperity may be less inclined to consider an LEV as their next car. The other socioeconomic variables of respondent age and level of formal education also do not appear to hold significant explanatory power over mean LEV preference. With these findings in mind, and considering the higher purchase price of many LEVs, it may be necessary for LEVs to become associated with affluence and status in order that they become more attractive to those with higher household incomes. This could be achieved through marketing campaigns and the use of certain fiscal incentives such as company car tax. The results suggest, however, that such interventions do not need to be further targeted to any particular consumer group defined by age or formal education levels.

Looking at the variables relating to respondent's current car and car use behaviour, we observe that the length of time a respondent has held a driving license negatively influences mean LEV preferences whilst the amount respondents usually spend when purchasing a car has a positive influences. A possible explanation for the first finding is that respondents which have been using conventional cars for a long time are more ingrained in their car use and purchasing habits and thus less likely to consider an LEV. With LEVs currently having a considerable cost premium over conventional cars, it is expected that individuals that tend to spend more when purchasing cars will be more likely to consider an LEV. Somewhat surprisingly, a respondent's total annual car mileage doesn't appear to have a significant influence.

Exploring the variables included which have been derived from the 5 additional attitudinal scales, we observe that 4 of these variables exhibit a statistically significant influence. Firstly, the "Car Importance" variable, which includes aspects associated with how important a car is to a person and if they personify their car, appears to negatively influence mean LEV preferences. Secondly, the level of experience a respondent has either driving or being the passenger in an EV ("EV Experience") also displays a negative influence. Two variables extracted from the General Car Attitudes scale display positive influences with the first variable associated with a respondent's concern relating to the environmental consequences of car use

("Car attitudes – environment") whilst the second reflects a respondent's willingness to spend more on a fuel efficient car and ability to affect how exposed they are to increases in fuel prices ("Car attitudes – value of fuel efficiency and independence").

The first two findings from these additional attitudinal scales are the most interesting. A possible explanation relating to the negative influence of car importance is that respondents lack confidence in the ability of LEVs to operate in a way they require to enable their lives and thus those respondent's who consider their cars to be important possessions are less likely to consider LEVs. To address this issue, policy makers and manufacturers should focus attention on LEV reliability, refuelling potential and effectively communicate these aspects. The finding that respondents that have experience of driving or being the passenger in LEVs are less likely to consider an LEV is more challenging to explain. We would expect practical experience of EVs would tend to positively influence respondent's LEV preferences but this would be entirely contingent on the type of experience a respondent has been exposed to. If this result is being generated by respondents that are linking this variable to their use of, for example, golf carts, then clearly this experience would likely reflect negatively once transposed to car use. This finding may be indicative of the importance of ensuring EV experiences are positive as opposed to negative.

Whilst the 8 explanatory variables which have been included in the final model iteration are informative, clearly a large number of variables have been excluded due to having no significant explanatory power over mean LEV preference. Surprisingly, the 3 components extracted from the Car Meanings scale (symbolic and emotional, functional – slotting in with daily life and functional – practicality) exhibit no influence. Additionally, neither of the 2 components associated with the "Car Emotions" scale, the 2 components of the "EV Emotions" scale or the 2 components from the "EV Functional Attitudes" scale display significant explanatory power over mean LEV preferences. What may initially be interpreted as a disappointing result, which may suggest that the survey did not accurately capture relevant attitudes related to LEVs, on further reflection may indicate that symbolic, emotive and functional attachments have yet to be formed by the general population with respect to LEVs. Whilst these variables have no positive explanatory power, they also have no negative explanatory power. This may

indicate that an opportunity still exists to direct the development of these attachments through effective policy incentives and information provision.

7. SUMMARY

Having set challenging greenhouse gas emissions reductions targets, the Scottish Government has committed to a decarbonisation pathway which will be difficult to achieve without addressing the significant emissions released by cars. This research project has attempted to identify the key attitudes that are likely to influence consumer preferences towards Low Emission Vehicles through the application of a household questionnaire in Dundee City.

Through the specification of an explanatory model, we have been successful in identifying a number of attitudes alongside other important variables which prove to be statistically significant in explaining respondent LEV preferences. The concept of innate innovativeness exhibits a significant influence with individuals who are active in seeking and providing information concerning technological innovations and tend to be autonomous decision makers who rely less on other people's opinions being more likely to consider an LEV. This finding demonstrates the importance of ensuring information concerning LEVs is effectively distributed and easily available so that innovators and early adopters in this market can easily evaluate and make informed purchasing decisions.

We have additionally attempted to measure how respondents place symbolic, emotive and functional meanings onto cars. Surprisingly, these variables have not proven to be not statistically significant in our model. This suggests that it is too early for strong positive or negative associations to have been formed with respect to the perceived enjoyment of driving or the relative status of owning a LEV. Thus, this nil result perhaps indicates that an opportunity exists for policy makers and industry operators to ensure positive meanings are attached.

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10. NOTES

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[ii] Statistical Package for Social Sciences (IBM SPSS Statistics 19)