

## Diffusion Analysis of the Emerging Market for Low Emission Vehicles

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### Abstract

A large degree of public and private funding is being allocated to accelerating the introduction of Low Emission powertrains for passenger cars, especially plug-in Hybrid and Pure Battery Electric Vehicles (EVs). If these new vehicles are to make a significant contribution towards moving the UK to a more sustainable personal transportation system, a detailed understanding of the likely consumer demand for them is a fundamental requirement. The success of these new vehicles will be as much dependent on their desirability to customers as to their technical ability.

This paper draws upon Roger's Diffusion of Innovation Theory to understand the potential importance of consumer 'innovativeness' as a pre-cursor to at least the early adoption of new vehicle technology. It presents preliminary results from an extended household pilot self completion survey conducted in Aberdeen City which respondents were asked questions relating to both conventional vehicles and Low Emission Vehicles (e.g. electric powertrains). These questions included aspects of Consumer Culture Theory in addition to an innovation scale that covers the three main variations of innovativeness that have been identified in the literature: (1) personality and communication traits (also referred to as innate innovativeness), (2) adoptive innovativeness that has further been segmented into (a) general adoption of consumer technology and (b) specific preferences towards Low Emission Vehicles. The results will be presented using Factor and Correlation analysis and will aim to understand the relative importance of the constructs with respect to consumer preference towards Low Emission Vehicles. Our findings suggest that innovativeness can be measured both through adoptive behaviour, psychological inclination and communication activity with these 3 constructs showing a degree of interaction. It proved more challenging to identify interactions between these 3 constructs and the local measure of innovativeness in the LEV market suggesting that innovative behaviour has yet to be "switched on" in this setting.

### Introduction

The extensive use of Internal Combustion Engine (ICE) passenger vehicles in the United Kingdom and the majority of the industrialised World brings a large degree of economic and social benefit to the individuals, households and societies in which they are used however, these benefits are not without their costs. The observable financial costs associated with the purchase and operation of ICEs are only part of the total economic cost which also incorporates the aspects of pollution, congestion, accidents and energy security. In order to account for these additional costs, that are often shared by society rather than directly paid

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by the user, Low Emission Vehicles (LEVs) are being introduced to address the issues of greenhouse gas emissions and energy security (see van Vliet et al., 2010, for a review on LEV technology). These vehicles are viewed as strategically important by the UK Government (DfT, 2009) and EU Governments (EC, 2011) and thus require academic investigation to determine how they are perceived in society.

Some of these LEVs (such as electric and plug-in electric vehicles) will be significantly different from their conventional ICE counterparts. These differences will alter the way consumers approach them from both a purchase and use dimension. Consumers often hesitate when it comes to adopting new product with this period of indecision often increasing dependent on the perceived importance of the purchase. Determining what motivates consumers in the attitudes and preference formation towards innovations in general and LEVs in particular will assist governments and manufacturers to proactively respond so that the diffusion of LEVs can be accelerated.

This research paper aims to enhance the understanding of consumer behaviour in the emerging market for LEVs in the UK. Specifically, this paper will put forward a methodology aimed at measuring an individual's level of innovativeness and investigate the effect this has onto their attitudes toward LEVs. It is expected that individuals that exhibit a higher degree of innovativeness will be more likely to have positive preferences towards LEVs. This knowledge should assist in identifying and targeting market interventions at the candidates most likely to be early adopters in this market to streamline the diffusion process. Where other papers in this field have concentrated on the instrumental aspects of the vehicles, we take a more consumer orientated perspective. In this sense, this paper is more concerned with what makes individuals more attracted to LEVs rather than what makes LEVs more attractive to individuals.

## Literature Review

The subject of innovativeness has attracted considerable academic attention, most notably in the fields of marketing. An extensive overview of the initial research conducted in this field is provided by Midgley and Dowling (1978) who discuss the emergence of the concept and the efforts that have been made to measure it. The distinction is made between the psychological trait of innovativeness and that of the observable adoption of an innovation. The psychological trait of innovativeness is defined as an individual's innate willingness to adopt an innovation early in its diffusion. This links closely with the temporal aspect of innovativeness with individuals that adopt an innovation early in its diffusion viewed as exhibiting a higher level of observable innovativeness. The interaction between innate and observable innovativeness has been further investigated by Im et al., (2007) who show that the relationship between these different levels of innovativeness is indirect and situation dependent.

Roehrich (2004) provides an updated overview and discusses the application of attitude scales used in an attempt to measure innate innovativeness. He concludes that the scales that have so far been applied can be viewed as imperfect and do not appear to fully attach to the current conceptualisation of innovativeness. In order to improve the theoretical foundation of this field, Burns (2007) proposes a model that rejects the concept of innate innovativeness, which is viewed as being limited in its explanatory power, and replaces it with the concept of variety seeking. This form of individual behaviour is not unique to innovativeness and instead attempts to explain innovativeness through an individual's innate desire for variety and uniqueness. Sassatelli (2007) argues that novelty is a key concept in Consumer Culture and underpins the desire for distinction which is propagated through a social system via individual's inherent inclination to imitate those who they consider to be their social superiors. An obvious example of this form of consumer behaviour in western society is the prevalence of celebrity endorsement which is discussed in detail by McCracken (1989).

Looking specifically at the transport field, it proves difficult to pick out examples of where the concept of innovativeness has been applied. Perhaps unsurprisingly, the examples that do exist are in the automotive sector with Feldman and Armstrong (1975) offering an initial investigation attempting to identify buyers of automotive innovations. In this research they

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show that automotive innovators exhibit significantly different characteristics across a variety of demographic, psychological and transport attitude variables. A large proportion of the initial research conducted in this field involved statistical choice modelling (for a detailed review see Mannering and Train, 1985) which assigned utility values to car characteristics in an attempt to predict demand for vehicles. Bunch et al., (1993) follows this methodology but also includes socioeconomic characteristics to add an additional dimension to their model. These characteristics were included to observe their interaction with vehicle choice showing that older respondents were less likely to consider an electric car whilst individuals with a college level education were more likely. Using a similar methodology, Ewing and Sarigollu (1998) analyzed the effect of economic incentives and travel demand management on vehicle choice whilst also including in their analysis socioeconomic and segmentation variables. Their findings were that age negatively affected preferences towards LEVs whilst a positive environmental attitude improved preferences. Additionally, it was seen that females were much less sensitive to a reduction in a vehicles range than were male respondents.

More closely linked to the direction of this research project, Choo and Mokhtarian (2004), whilst not being specifically focused on LEVs, look at an individual's car type choice based on their attitudes and lifestyles. Results were presented using a descriptive analysis of owner categories based on the 9 standard vehicle types, for illustrative purposes only two of the types will be discussed here. Owners of small vehicles tend to have more positive environmental attitudes, are less likely to be work or status orientated and are less socially connected. On the other end of the scale, luxury car owners tend to be status orientated, frequent long distance travellers and are more likely to be male and older. A more recent and UK specific example is provided by Ozaki and Sevastyanova (2011) who investigate Hybrid Vehicle owners and their purchase motivations. They found that hybrid vehicle owners place emphasis on financial motivations and have favourable attitudes towards science, technology and also the environment.

Whilst previous studies have clearly been concerned with market segmentation and preferences towards LEVs, so far none (that we have discovered) have focused specifically on an individual's level of innovativeness and attempted to observe the influence this has onto attitudes towards and reaction to LEVs. We take this to signify that there is an academic requirement to investigate this area and have thus produced this research project to shed light on this area of interest.

### **Theoretical and Conceptual Framework**

Understanding how new products diffuse through a social system has been an active field of research since the mid twentieth century. Investigations have approached the subject from different angles with some authors taking a mathematical modelling approach (for a detailed review of the literature see Mahajan et al., 1990) whilst others concern themselves with attempting to understand the sociotechnical transitions (see Geels, 2002, and Grin et al., 2010). The Diffusion of Innovations as proposed by Rogers (1976, 1995) provides a useful framework in considering how LEVs may be incorporated into the automotive market. One of the fundamental concepts within this theoretical framework is that of innovativeness. For the purposes of the research conducted in this paper, we define innovativeness as the tendency of an individual to acquire an innovation measured both by adoptive behaviour and psychological inclination. In this research, it is hypothesized that individuals that exhibit a high degree of innovativeness will be more likely to consider a LEV, thus it will be an important aspect of early entrants into the LEV market. Whilst being used here to investigate the automotive market, the concept is equally applicable to firm strategy, enterprise, entrepreneurialism and the diffusion of political ideologies.

Innovativeness itself can be measured on a number of different levels. Traditionally, it has been investigated in market analysis after the innovation has been completely diffused. This ex post or retrospective form of analysis determines when an individual adopted an innovation and uses this time metric to assign an appropriate level of innovativeness. This observed measure of innovation can be conducted for a single product or in an aggregate format whereby an individual is measured using the same method across a variety of different innovations. We refer to the first observed measure as a local measure of

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innovativeness whilst the second we label a global level. Innovativeness can also be measured at a higher level of abstraction where the measure is less concerned with adoptive behaviour and more with internal psychology. This is referred to in the literature as innate innovativeness and should be distinct from environmental or situational influence.

The measurement of innate innovativeness has predominantly been conducted using purposely constructed attitude scales. These scales are designed to fix on to what it is that makes an individual inherently innovative (or not) and allows for individuals to be distinguished according to this characteristic. In its simplest form, an innovativeness scale may ask a respondent simply to state how innovative they believe themselves to be. This form of self reporting has its limitations, most notably, being innovative is clearly viewed as a desirable trait. Individuals tend to consider themselves in a positive light when conducting exercises in introspection (Pronin, 2007). Thus, if you were to measure innovativeness using this basic measure, you would likely receive a significantly skewed distribution towards the highly innovative end of the scale. In order to overcome this limitation, researchers have employed scales where it less obvious what the "right answer" is. However, this challenge is one that has continually effected the accuracy of attitude scales with respondents either depicting themselves in a positive or desirable light by intention or unknowingly. Furthermore, it can be somewhat meaningless to ask someone to state their level of innovativeness completely out of context. Without the existence of a point of reference or common anchor it would be challenging for respondents to provide a universally correct response.

In the Diffusion of Innovations, Roger's proposes a number of characteristics that tend to influence how innovative an individual may be. These characteristics are split into 3 categories (1) socioeconomic characteristics (2) personality characteristics and (3) communication characteristics. Within these categories, the singular characteristics appear intuitively sensible such as individuals that have a greater level of formal education, have positive attitudes towards change and have more exposure to the mass media are more likely to exhibit innovative behaviour. We take this framework forward in this research project and use it to develop a measure of innate innovativeness. We enhance this by the addition of two additional measures of adoptive innovativeness whereby individuals are rated according to their observable innovative behaviour.

## **Methodology**

In order to construct a holistic measure of innovativeness within this research, it was decided to attempt to measure this concept at the 3 different levels. Within a household self completion survey, respondents were asked firstly to state how likely they would be to consider a variety of different powertrains for their next vehicle purchase, this provided a measure for local innovativeness. After this, respondents were presented with two attitude scales developed from the personality and communication characteristics identified in Roger's framework providing a measure of innate innovativeness. Lastly, respondents were presented with a list of current consumer technology and asked to state if they owned, intended to own in the near future or did not intend to own the technology providing a measure of global innovativeness.

Looking in greater detail at the attitude and communication scales, as shown in Tables 1 and 2, both scales utilised a 7 point Likert response format with anchor points from strongly disagree to strongly agree. These scales are presented in the tables below and then further defined in the following discussion. In the scale looking into attitude characteristics, as shown in Table 1, each characteristic shown to influence an individual's level of innovativeness was assigned two attitude statements. Initially, an extended list of statements was formulated and put through a test procedure to identify the two statements that best reflected the characteristic. Care was taken to ensure the statements were easily interpretable, avoided use of advanced terminology and attention was paid to ensure there was no obvious "right answer". In the table, each statement has been matched up to the attitude characteristic it is attempting to measure derived from Roger's generalisations.

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**Table 1: Innate Innovativeness Scale Relating to Attitude Characteristics**

Statement	Attitude Characteristic
<b>A.</b> Making sure I always make the correct decision is something that is important to me	Rationality
<b>B.</b> I prefer to let other people make decisions when I am not completely sure about the situation	Ability to cope with uncertainty
<b>C.</b> Science has no impact on how I live my life	Attitude towards science
<b>D.</b> I'm always looking for ways to alter my life to make it better	Attitude towards change
<b>E.</b> I have confidence in myself in making the right decision in complicated situations	Ability to cope with uncertainty
<b>F.</b> I rarely use the things I learned in formal education in my daily life	Attitude towards education
<b>G.</b> I enjoy learning about new things	Attitude towards education
<b>H.</b> I'm a very ambitious person setting high standards and expectations for myself	Aspiration
<b>I.</b> I'm never satisfied with my current position in life	Aspiration
<b>J.</b> Compulsive behaviour usually governs my purchasing decisions	Rationality
<b>K.</b> I quickly incorporate new ideas into how I live my life	Attitude towards change
<b>L.</b> My friends and family would consider me to be a highly innovative person	Self report of innovativeness
<b>M.</b> I'm usually one of the first people to acquire the latest consumer technology	Self report of innovativeness
<b>N.</b> I really enjoyed my science classes at school	Attitude towards science

Similar to the attitude characteristic scale, the scale developed to measure an individual's degree of innovativeness in relation to their social and communication activities, as shown in Table 2, was constructed using the characteristics identified from empirical research. As there was more social characteristics it was decided to attach only one attitude statement per characteristic to limit the perceived burden of completing the scale. The same test procedure was followed to reduce an extended list of possible statements down to those that best reflected the characteristic under measurement.

The two scales discussed above have been designed in an attempt to measure the innate level of innovativeness across psychological and communicative characteristics, we now move our attention to the measurement of more observable levels of innovativeness. To achieve this, we employ two measures with the first attempting to measure a local level of innovativeness focusing specifically on the LEV market whilst the second measures a more global level. Innovativeness in the vehicle market was measured by a respondent's willingness to consider a variety of advanced powertrain cars for their next vehicle purchase to provide a measure of local innovativeness. Similarly, respondents were presented with a list of consumer technology and asked to state if they currently owned the item, intended to own it in the near future or did not intend to own it to provide a measure for global

innovativeness. Both of these scales are illustrated in the Appendix under the headings of Figure 3 and 4 with the aggregated results presented in the next section.

**Table 2: Innate Innovativeness Scale Relating to Attitude Characteristics**

Statement	Communication Characteristic
<b>A.</b> I regularly participate in activities such as sports, clubs and/or associations that have a formal structure	Social participation
<b>B.</b> I have a small group of friends who all know each other well and share similar interests	Exposure to interpersonal networks
<b>C.</b> My friends and family would say I was a cosmopolitan person	Cosmopolitanisms
<b>D.</b> I have frequent contact with people working with new consumer technology	Change agent contact
<b>E.</b> I keep up-to-date with consumer technology by reading newspapers/magazines, websites or relevant TV shows	Mass media exposure
<b>F.</b> Friends and colleagues regularly come to me about advice concerning new consumer technology	Opinion leadership
<b>G.</b> I often know about the next 'must have' piece of consumer technology before it is released into the market	Knowledge of innovations
<b>H.</b> I regularly seek information about the latest consumer technology	Active information seeking
<b>I.</b> I often socialise with people from a large variety of different backgrounds	Interconnectedness with social system

## Results

The result presented here are from an extended pilot conducted in Aberdeen City, Scotland, over the summer of 2011. An initial distribution of 200 full paper surveys was delivered over 4 sites that were selected using the Scottish Index of Multiple Deprivation (Scottish Executive, 2006) to ensure the distribution was evenly spread in reference to socioeconomic divisions. From this initial distribution, 43 responses were attained from a drop a collect system. In an attempt to attain larger sample size, a further 100 one-page letters were distributed to the same areas inviting households to participate using the online survey version. From the 100 one-page letters a response of 11 surveys was generated making a total sample size of n=54.

An Exploratory Factor Analysis was conducted using a Principle Components extraction method on the data set for both the attitude and communication characteristic attitude scales. The following tables show the results using Varimax Rotation, loadings have been arranged by order of magnitude and values of less than 0.3 have been hidden.

Looking into the internal consistency and reliability of the communication scale and its components, the Cronbach alpha score for the entire scale is 0.799 with component 1 attaining an alpha score of 0.86, component 2 of 0.649 and component 3 of 0.489. The total variance explained by the 3 components is 71.716% with component 1 accounting for 41.919% of the variation, component 2 for 17.352% and component 3 for 12.445%.

Table 3: Exploratory Factor Analysis of the Communication Innate Innovativeness Scale

Rotated Component Matrix	Component		
	1	2	3
I regularly seek information about the latest consumer technology	.904		
Friends and colleagues regularly come to me about advice concerning new consumer technology	.874		
I often know about the next 'must have' piece of consumer technology before it is released onto the market	.863		
I keep up-to-date with consumer technology by reading newspapers/magazines, websites or relevant TV shows	.808		
I have frequent contact with people working with new consumer technology	.554		
I have a small group of friends who all know each other well and share similar interests		.841	
I often interact with people from a large variety of different backgrounds		.817	
I regularly participate in activities such as sports, clubs and/or associations that have a formal structure			.938
My friends and family would say I was a cosmopolitan person	.439		.494

Shifting out attention to the attitude characteristic scale, the data analysis followed the same pattern to the communication scale with a Cronbach alpha for the entire scale of 0.602 with component 1 attaining an alpha score of 0.660, component 2 of 0.741, component 3 of 0.622, component 4 of 0.659 and component 5 of 0.370. The total variance explained by the 5 components is 67.446% with component 1 accounting for 25.086% of the variation, component 2 for 15.746%, component 3 for 11.061%, component 4 for 8.838% and component 5 for 7.170%.

Table 4: Exploratory Factor Analysis of the Attitude Innate Innovativeness Scale

Rotated Component Matrix	Component				
	1	2	3	4	5
I'm a very ambitious person setting high standards and expectations for myself	.779				
I'm never satisfied with my current position in life	.660	.482			
Making sure I always make the correct decision is something that is important to me	.636				
I enjoy learning about new things	.564			.435	
I'm usually one of the first people to acquire the latest consumer technology		.818			
Compulsive behavior usually governs my purchasing decisions		.806			
I quickly incorporate new ideas into how I live my life		.517		.384	
I really enjoyed my science classes at school			-.807		
Science has no impact on how I live my life	.368		.755		
I rarely use the things I learned in formal education in my daily life			.669		
My friends and family would consider me to be an innovative person				.800	
I'm always looking for ways to alter my life to make it better				.735	
I prefer to let other people make decisions when I am not completely sure about the situation					-.903
I have confidence in myself in making the right decision in complicated situations	.352			.400	.610

The aggregated results for the scale determining the quantity of consumer technologies owned are displayed in Figure 1. Here we can see that the distribution is approximately normal in appearance with the majority of individuals owning between two and six forms of consumer technology. The mean of the distribution is 4.84 with a standard deviation of 2.63 and a skewness of 0.68. The most diffused items from the scale were HD Flatscreen TVs which 43 respondents owned, Wireless Home Networks which 39 respondents owned and Bluera Media Players which 31 respondents owned. The least diffused items were Touchscreen PCs which no household in the survey had adopted and Photovoltaic Tiles and Heat Pumps which only 1 household had so far adopted in both cases. The Most desired good was the Tablet PC with 15 respondents expecting to acquire one in the near future followed by Photovoltaic Tiles and GPS Navigation Systems with 14 and 12 respondents expecting to acquire them respectively. The least desired good was a Heat Pump with 45 households expressing no interest in acquiring it followed by Touchscreen PCs with 44 respondents, Underfloor Heating and 3D TVs both with 40 respondents stating no interest.

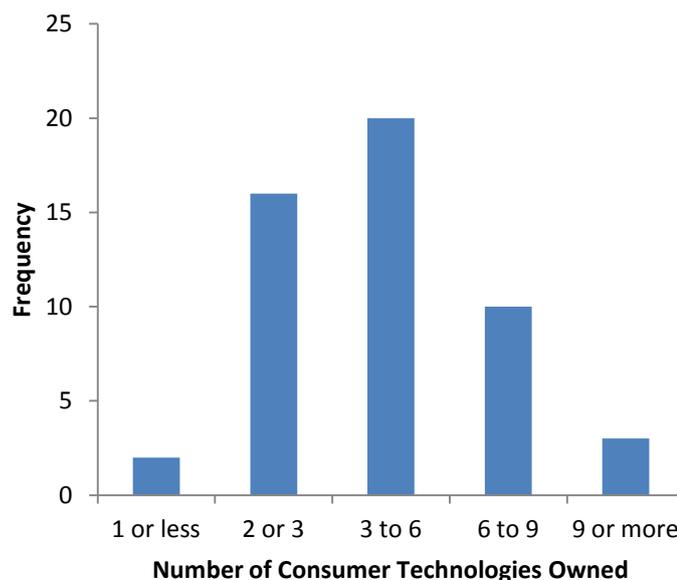


Figure 1: Aggregate Results from the Measure of Global Innovativeness

Figure 2 illustrates the aggregated results from the choice experiment displayed in pie chart format across all of the LEV options that were included in the questionnaire. The pie chart segments running anticlockwise denote a higher willingness to consider that powertrain for an individual's next vehicle purchase progressing to a lower willingness. All of the distributions of response in this choice experiment are negatively skewed with the intensity of the skewness increasing with the greater the degree of powertrain electrification.

In order to see how the 3 measures of innovation interacted with each other a correlation matrix was generated using Pearson's product moment correlation. The number of data entries included in this section has been reduced to 47 as some respondents did not fill in all of the sections included in this analysis. Only the respondents for who we have a complete data set on all variables have been included. With the data sample being rather small, finding statistically significant results proves more challenging, thus with a larger sample size we would expect to generate more statistically significant relationships.

As a large quantity of variables was included in the analysis the correlation matrix has been placed in the Appendix attached to the end of the paper as Table 5. To improve comprehension and interpretation, all the correlations that were insignificant at the 0.05 level have been removed. All factors scores from the innovativeness scales have been included using Regression extraction (see Thurstone, 1947, and DiStefano, et al., 2009, for a detailed description). Stated preferences for the four LEV options in the choice experiment have been included along with the number of consumer technologies owned and desired by a respondent.

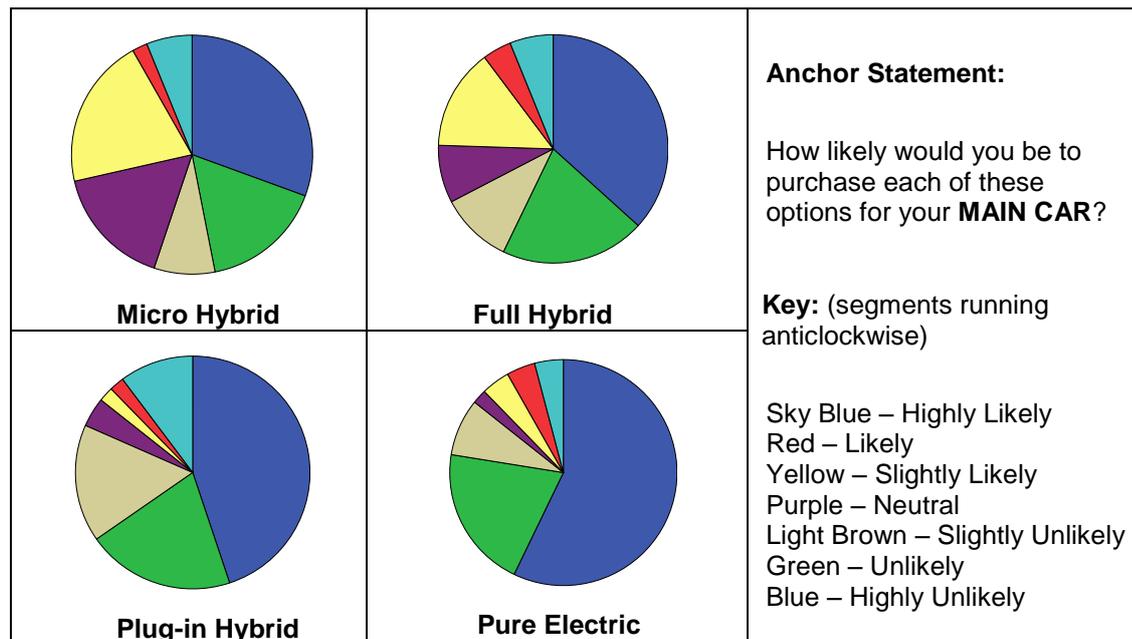


Figure 2: Aggregated Results from the Measure of Local Innovativeness

## Discussion

To begin with we will discuss the results from the Exploratory Factor Analysis. Looking at the components that came out of the factor analysis for the attitude characteristic scale, we see a number of patterns emerging from the data. The 5 components that have been extracted show mostly logical relationships. Taking each in turn we will describe their meanings.

Component 1 clearly attaches itself to the characteristics of decision making along with ambition, aspiration and, to a lesser extent, attitudes towards education and science. The concept of change underpins Component 2 whilst Component 3 clearly associates with the science and education statements that we would expect to exhibit a relationship. Component 4 includes the statement concerned with the self report on level of innovativeness and links this positively with aspiration for self improvement. The final Component is similar to Component 1 but specifically focuses on the construct of decision making and associates with a desire to be in control of decision making and having self confidence.

Shifting our attention to the communication characteristic scale, three rather focused components emerge from the statistical analysis. Component 1 clearly connects with the main social and communicative aspects of innovative behaviour. The statements included in Component 2 appear to be in disagreement with the first expressing a small social circle whilst the second emphasising a high degree of social engagement. On further reflection, this apparent conflict may be explained by considering the difference between friendship and interpersonal interaction. It is entirely conceivable for a person to possess a small social circle of friends yet engage with a wide variety of people. This may become clearer through the following example; a person may have a small friendship circle yet work in an environment that requires interaction with a wide social stratum of clients such as a nurse, bank clerk or sales representatives. The final component links engagement in social activities with the perception of being cosmopolitan.

In reviewing the scales together, it is quickly apparent that the personality characteristic scale is less coherent compared to the communication characteristic scale with attitude statements overlapping multiple components leading to a reduction in clarity. This is unsurprising as the previous research that has been conducted in this field has experienced similar challenges. In contrast, the communication characteristic scale appears more focused and easily interpretable. Looking at the components within the two scales and the statements they load onto, it is arguable that Component 4 from the attitude characteristic

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scale and Component 1 from the communication characteristic scale best represent the concept of innovativeness.

The measurement of observable innovativeness at the global level shows expected results with a large degree of respondents having between 2 and 6 consumer technologies with far fewer respondents either having almost no forms of consumer technology or greater than 9 items. It is clear that some of the forms of consumer technology included in this scale are further through their diffusion process compared to others. The measurement of global innovativeness using this cumulative technology owned measure does conform to Roger's theory in that the distribution of household technology in this sample follows a normally distributed trajectory.

Shifting our attention to the results from the choice experiment utilised to measure local innovativeness in the LEV market, we can clearly see a pattern whereby respondents are less likely to consider a powertrain the greater the level of electrification. This pattern is to be expected with individuals tending to become less venturesome the more advanced the technology is perceived to be. Micro Hybrids and, to a lesser extent, Full Hybrids are linked with higher preferences thus reinforcing the current thinking that Hybrids will act as a bridging technology between conventional ICE and pure EVs. Very few individuals expressed positive attitudes towards the Pure EV option with over 85% expressing negative preferences towards EVs with 57% expressing highly negative preferences. This result shows that pure EVs are unlikely to achieve a significant market penetration in the next vehicle cycle with only 4% of respondents stating they will be highly likely to choose a Pure EV powertrain in their next vehicle purchase.

Looking at the relationships to emerge from the correlation analysis we observe some interesting interactions in the data. Unsurprisingly, the stated preferences for the four LEV options included all share positive correlations with each other. If we have been successful in measuring the same construct in both attitude scales then we would expect a relationship to emerge between some of the factors. Going against the descriptive analysis we outlined above, only attitude factor 2 shares a significant relationship to any of the communication factors. This is somewhat disappointing though attitude factor 2 does correlate with all of the communication factors. Looking at the interaction between the two innovativeness scales and preferences towards LEVs we only identify 2 significant relationships. Attitude factor 2 shares a positive correlation with preferences towards Plug-in Hybrid Vehicles whilst communication factor 2 shares a negative correlation with preferences towards Pure Electric Vehicles. The local measure of innovativeness in the vehicle market (preferences towards LEVs) shares no significant relationships to either of the measures of global innovativeness (owned and desired consumer technology). Investigating the interaction between innate innovativeness and global innovativeness, again we observe the attitude factor 2 shares a significant relationship with both owned and desired consumer technology and that communication factors 1 and 2 share relationships with owned consumer technology.

As expected from the descriptive analysis of the innovativeness scales, the communication scale displays a higher level of interaction compared to the attitude scale. Both communication factors 1 and 2 seem to be well connected to the other variables whilst, somewhat surprisingly, attitude factor 2 emerges as the most interconnected factor from the attitude scale. We identify little interaction between the innate innovativeness scales and the measure of local innovativeness represented by respondents stated preference towards LEVs. We attain relatively more success in the interaction between the innate innovativeness scales and the measures of global innovativeness. From this we put forward the tentative conclusion that a relationship does exist between innate and adoptive innovativeness and that it has been partly measured through this methodology. Local innovativeness in the LEV market appears to be a more challenging concept to understand. It can be proposed that innovativeness has yet to be switched on in the LEV market. Rather than being a disappointment, this possibility opens up new avenues of investigation such as what are the mechanisms that would switch on this construct in this market?

### **Further Research**

Whilst some of the results presented in this paper appear interesting, it is clear a certain degree of fuzz appears in the scales so far applied. To a degree, this has been a continuous challenge when applying attitude scales in this field of research. Undoubtedly, refinements could be made to the scales to improve their effectiveness in measuring the construct of individual innate innovativeness. With an increase in sample size it is believed a more solid impression can be attained relating to what statements work well and which ones can be removed or altered.

Developing a robust framework to illustrate the interaction between the different levels of innovativeness should be an endeavour highlighted for future investigation. Intuitively, one would predict that measures related to these levels should share a strong relationship though this has not substantially emerged in this research project so far. It can be put forward that any relationships that exists in this area may be complex, non-linear in nature and situation dependent. With this in mind, perhaps the application of statistical techniques may not be the best method in investigating this area and a more qualitative inquiry may prove more fruitful.

The measurement of global innovativeness could be improved through the introduction of a temporal component indicating exactly when an individual adopted an innovation. Some of the consumer technologies included in the list provided to respondents are more progressed in their diffusions than others, this can lead to a less refined indication of a person's adoptive innovativeness. Whilst this potential improvement strategy has its merit, it would also prove more cognitively challenging for respondents to firstly think if they possess the stated form of consumer technology and then remember exactly when they purchased it. Undoubtedly, this increases the possibility of recall error with some respondents being more capable of remembering with greater accuracy when they adopted an innovation. To overcome this limitation, a more objective measure would be required such as sales receipts or invoices.

### **Summary**

This introductory research project has attempted to determine the influence the concept of innovativeness has over an individual's preferences towards LEVs. The results presented include a 3 tier measurement of innovativeness including observable adoption and psychological measures. This methodological framework has been developed predominantly from the marketing field of research, most notably the work of E. M. Rogers.

It is clear that innovativeness at a psychological level proves challenging to measure. The two attitude scales developed in this research project appear to go some way to attaching to the concept of innovativeness but prove to be partial and in places unclear. More objective measures of adoptive innovativeness may appear more robust though also suffer from their own limitations linked to recall errors and misrepresentations. The interaction between our measures of innovativeness and preference towards LEVs proves weak and inconclusive. More clarity emerges from the relationship the scales possess between each other and also the measure of global innovativeness.

Clearly refinements to the measurement process are required. In relation to the attempt made here to measure innate psychological innovativeness, the communication characteristic scale appears to have achieved more success in its clarity of factor output and level of relationship with the other measures of innovativeness. From the attitude characteristic scale, factor 2 demonstrates potential in its ability to measure innovativeness though improvements are needed in both scales. Whilst the measure of global innovativeness can be improved by the addition of a temporal component, it proves more challenging to enhance the measure of local innovativeness in the LEV market. Being a forward looking rather than retrospective analysis, we will be reliant on stated preference in this regard though clearly how you position the exercise will have an influence over the results. Innovativeness can be somewhat of a fleeting and elusive concept with its level being highly dependent on situational and environmental variables. Indeed, it would be a rare occurrence to identify an individual what was universally innovative regardless of the context.

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**Appendix**

	<b>OPTION 1</b>	<b>OPTION 2</b>	<b>OPTION 3</b>	<b>OPTION 4</b>	<b>OPTION 5</b>	<b>OPTION 6</b>
	<b>Petrol</b>	<b>Diesel</b>	<b>Micro Hybrid</b>	<b>Full Hybrid</b>	<b>Plug-in Hybrid</b>	<b>Pure Electric</b>
<b>Total Range</b>	300 miles	300 miles	300 miles	300 miles	300 miles	100 miles
<b>Electric Range</b>	0 miles	0 miles	0 miles	10 miles	20 miles	100 miles
<b>Purchase Price</b>	£12 000	£15 000	£18 000	£20 000	£23 000	£25 000
<b>Operating Cost</b>	£1000 per annum	£850 per annum	£650 per annum	£500 per annum	£300 per annum	£150 per annum
<b>CO2 Emission</b>	130 grams per km	110 grams per km	100 grams per km	90 grams per km	85 grams per km	75 grams per km
<b>Brake Horse Power</b>	110	100	90	90	90	80
<b>Miles per Gallon</b>	30	40	60	70	100	150

**Figure 3: Illustration of the Questionnaire Local Innovativeness Measure based on a Choice Experiment**

Consumer Technology	Correlations		
	Own Now	Intend to Own	Intend to Own
A. Smart Phone (such as Apple iPhone, Samsung Galaxy S, HTC Desire)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B. HD Flat Screen TV (Can be Plasma, LCD, LED but must be HD ready)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C. HD Satellite (such as Sky HD or Freesat)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D. Netbook (mini laptop PC with a screen size of 8-10 inches)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
E. Photovoltaic Tiles/Solar Tiles (used in home energy/heat generation)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
F. Heat Pump (used to draw heat from underground/the air to heat homes)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
G. 3D Ready TV	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
H. Media Centre PC (a computer connected to your TV)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I. Wireless Home Network	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
J. Underfloor Heating System	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
K. Tablet PC (such as an Apple iPad or Samsung Galaxy Tab)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
L. Combination Boiler (only heating the water as it is needed)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
M. GPS Navigation System	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
N. BlueRay Media Player	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
O. Touchscreen PC	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
P. eReader (such as an Amazon Kindle or Sony Reader)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Q. Digital Camcorder	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 4: Illustration of the Questionnaire Global Innovativeness Measure based on Consumer Technology

Table 5: Correlation Matrix including (1) LEV preferences as a measure of local innovativeness, (2) Factor Scores from the two innate innovativeness scales and (3) quantity of consumer technology owned and desired as a measure of global innovativeness

		Correlations													
		Micro	Full	Plug	Pure	Att1	Att2	Att3	Att4	Att5	Comm1	Comm2	Comm3	Owned	Desired
Micro	Pearson R		.649**	.257*	.292*										
	Sig. (1-tailed)		.000	.041	.023										
Full	Pearson R	.649**		.495**	.484**										
	Sig. (1-tailed)	.000		.000	.000										
Plug	Pearson R	.257*	.495**		.652**		.301*								
	Sig. (1-tailed)	.041	.000		.000		.020								
Pure	Pearson R	.292*	.484**	.652**								-.339**			
	Sig. (1-tailed)	.023	.000	.000								.010			
Attitude Factor 1	Pearson R										.248*				
	Sig. (1-tailed)										.046				
Attitude Factor 2	Pearson R			.301*							.346**	-.268*	-.245*	.286*	.284*
	Sig. (1-tailed)			.020							.009	.035	.049	.025	.026
Attitude Factor 3	Pearson R											-.394**	.347**		
	Sig. (1-tailed)											.003	.008		
Attitude Factor 4	Pearson R										.282*				
	Sig. (1-tailed)										.027				
Attitude Factor 5	Pearson R													-.288*	
	Sig. (1-tailed)													.025	

Comm	Pearson R					.248*	.346**		.282*					.295*
Factor 1	Sig. (1-tailed)					.046	.009		.027					.022
Comm	Pearson R													
Factor 2	Sig. (1-tailed)													
Comm	Pearson R													
Factor 3	Sig. (1-tailed)													
Owned	Pearson													
	Correlation													
	Sig. (1-tailed)													
Desired	Pearson R													
	Sig. (1-tailed)													

\*\* . Correlation is significant at the 0.01 level (1-tailed).

\* . Correlation is significant at the 0.05 level (1-tailed).