Examining individuals preferences for hybrid electric and alternatively fuelled vehicles

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Abstract

This paper examines individuals motivations when purchasing vehicles, focusing upon what factors would encourage individuals to purchase hybrid electrical vehicle (HEV) or alternatively fuelled vehicle (AFV). AFVs in this paper refer to any cars run on alternatives to petrol and diesel. This research attempts to ascertain whether reductions in fuel costs, vehicle registration tax (VRT), or green house gas emissions would encourage individuals to purchase a HEV or an AFV instead of conventional vehicle. VRT is an Irish tax which is levied on the purchase of new vehicles. One of the motivations to conduct this research was to examine a new car tax and VRT scheme introduced by the Irish government in 2008. This new policy rewards the purchase of environmentally friendly cars, with lower VRT and car tax rates. To understand individuals' perceptions of these new taxes a survey was sent to recent customers of a car company in Ireland. The survey asked respondents about their recently purchased vehicle and how important they considered vehicle attributes such

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as environmental performance, fuel cost, and safety, before making their car purchase. The survey also contained a number of stated preference experiments which were designed to ascertain what factors influence individuals' decisions when purchasing their new car. The results showed that respondents did not rate green house gas emissions or VRT as crucial attributes when purchasing a new vehicle. The vehicle attributes that respondents rated most highly were reliability, automobile safety, fuel costs, and the cost price. The majority of respondents agreed that HEVs and AFVs are better for the environment, cheaper to run than conventional vehicles and would be the vehicle of choice in ten years time.

Keywords: Hybrid vehicles, alternative fuel, environment

1. Introduction

Transport in Ireland contributes a significant amount of Ireland's total carbon emissions. In 2008, the transport sector was responsible for 36% (17,014 kt CO_2) of Ireland's energy related CO_2 emissions; this was higher than any of the other sectors (Sustainable Energy Ireland, 2009). It should be noted that this figure includes fuel tourism. Ireland consumed nine million tonnes of oil in 2004, doubling its oil consumption since 1990 (Forfas, 2006). In 2002, Ireland was ranked the 3rd highest in the EU-25 in terms of oil consumption per-capita. Ireland's continuing dependence on oil is of urgent concern as the world's oil production will reach its peak in the near future. With increasing global demand and fluctuating oil prices, Ireland could find itself in a 'liquid fuels' crisis resulting in serious consequences for transportation (Forfas, 2006).

2. Background

The European Commission and the major automobile manufacturers in Europe are committed to developing more fuel efficient vehicles through improvements in vehicle technology (The European Commission, 1999). Major improvements have been made to the internal combustion engine (ICE) in the last few decades, by increasing fuel efficiency and reducing harmful emissions (MacLean and Lave, 2003). These improvements are set to continue with European Union proposed CO_2 emissions targets, set to reduce to the average emissions from new cars sold in Europe to 120g CO_2/km by 2012 (The European Commission, 2007). AFVs are being developed by the major car manufacturers in an attempt to find alternatives to traditional vehicles fuelled by petrol or diesel.

As transportation is one of the main categories responsible for both CO_2 emissions and oil consumption in Ireland, more fuel-efficient vehicles should be considered. An emerging technology is that of the hybrid electric vehicle (HEV). HEVs combine an internal combustion engine (ICE) with an electronic motor to provide vehicle propulsion. This combination produces a more fuel-efficient vehicle compared to conventional vehicles. Romm (2006) suggests that these vehicles have lower green house gas (GHG) emissions by on average 30-50% compared to conventional vehicles. Fontaras et.al (2008) found that HEVs could achieve 40% to 60% improvements in fuel efficiency when operating in urban conditions. HEVs have enjoyed significant commercial success since its introduction in 1997. The Toyotas Prius has been the most commercially successful HEV to date, with worldwide sales reaching 1 million vehicles in 2008 (Toyota Ireland, 2008). Brownstone et.al (2000) conducted a similar study in California which combined stated and revealed preference data develop a modelling framework that can predict the demand for HEVs and AFVs. Elements of this modelling approach have been applied in the models presented in section 5.

On the 1st July 2008, a new VRT and annual road tax systems were introduced in Ireland. The new system was introduced to encourage people to purchase vehicles with lower CO_2 emissions. The old VRT system was based on the engine capacity of the vehicle, with 3 levels based on engine size; 1) car up to 1400cc, 2) cars between 1,401 to 1,900cc, and 3) car over 1,900cc. The new CO_2 emissions related VRT rate is applicable to new and used imported cars. The new system was a seven band system, and the percentage tax paid is related to the CO_2 emissions of the vehicle, as shown in Table 1.

Table 1
Vehicle registration tax rates

CO_2 Emissions bands	**G CO_2/km**	**VRT Rates (percentage of vehicle purchase price)**
A	0 – 120g	14%
B	121 – 140g	16%
C	141 – 155g	20%
D	156 – 170g	24%
E	171 – 190g	28%
F	191 – 225g	32%
G	226g and over	36%

The results in Table 2 demonstrate the impact that the new tax rates have had on car purchasing in Ireland. These results based upon vehicle registration data show that since the change in tax rates there has been a dramatic increase in the purchase of new vehicles in the lower emissions range (Sustainable Energy Ireland, 2009). The results presented in Table 2 show that there has been almost a 30% increase in the purchase of lower emission cars since the introduction of the new taxation system.

Table 2
New vehicle shares grouped by emissions, 2005-2008(+2009 S1)

	Before tax changes					**After tax changes**	
CO_2 band	**2005**	**2006**	**2007**	**2008**	**Jan-June 2008**	**July – Dec 2008**	**Jan – June 2009**
A,B, &C	36%	41%	41%	50%	44%	73%	78%
D	28%	30%	25%	25%	28%	14%	13%
E, F & G	37%	29%	34%	25%	28%	13%	10%

Table 3 details the numbers of cars sold in Ireland between 2003 and 2008 (Central Statistics Office, 2009). The first year that information was collected on the purchase of HEVs and AFVs was 2008, so prior to this these vehicles were labelled as other. The results in Table 3 show that the percentage share of new petrol cars has fallen by 19 percent in the six year period. The results also show that HEVs and AFVs accounted for 3 percent of the total number of new cars purchased in 2008. One can also see that there has been a steady increase in the number of diesel cars sold in Ireland. This increase can be attributed to the lower cost of diesel in Ireland. The authors did consider including diesel cars in the stated choice experiments, but discounted this option as the focus of this research was to examine the preferences for the new entrants to the market.

Table 3
Number of new vehicles licensed by fuel type in 2003 - 2008

Fuel type	**2003**		**2004**		**2005**	
	N	**%**	**N**	**%**	**N**	**%**
Petrol	117,765	82	121,196	81	129,209	78
Diesel	25,217	18	28,209	19	36,750	22
Hybrid electric Vehicle	*	*	*	*	*	*
Alternatively fuelled vehicle	*	*	*	*	*	*
Other	10	0	230	0	311	0
Total	142,992	100	149,635	100	166,270	100
Fuel type	**2006**		**2007**		**2008**	
	N	**%**	**N**	**%**	**N**	**%**
Petrol	128,346	74	128,346	71	92,298	63
Diesel	44,010	26	50,560	28	50,283	34
Hybrid electric vehicle	*	*	*	*	1,182	1
Alternatively fuelled vehicle	*	*	*	*	2,701	2
Other	629	0	1,848	1	6	0
Total	173,273	100	180,754	100	146,470	100

The results in Table 4 detail the average CO_2 emissions from new passenger cars sold in Europe in grams of CO_2 per-kilometre. The results show that Ireland is very close to the European average in terms of CO_2 emissions per-kilometre. In the period since the introduction of the change in taxation CO_2 emissions per-kilometre has fallen to 147.7 in 2008 and down to 144.0 in the first six months of 2009 (Sustainable Energy Ireland, 2009).

Table 4
Average CO_2 Emissions from New Passenger Cars (Grams CO_2 per Kilometre) (EEA, 2009)

	2002	**2003**	**2004**	**2005**	**2006**	**2007**
Belgium	160	157	155.4	154.1	152.8	151.7
Czech Republic	-	-	152.9	154.2	153.1	-
Germany	176.2	174.7	173.7	172.2	171.3	168.3
Denmark	168.8	167.8	164.7	162.6	161.4	158.7
Estonia	-	-	177.7	182.4	181.4	-
Greece	166.6	167.7	167.6	166.2	165.3	163.9
Spain	155.3	155.9	154.2	154.2	154.5	152.1
Finland	176	177.1	178.5	178.2	177.9	176.1
France	155.7	153.9	152	151.2	148.9	148.4
Hungary	-	-	157.3	155.2	153.5	153.9
Ireland	163.1	165.5	166.4	165.6	165.1	160.5
Italy	155.5	151.8	149	148.5	148.2	145.5
Lithuania	-	-	186.2	185	162.3	175.3
Luxemburg	172.6	172.3	168.5	167.4	167	164.6
Latvia	-	-	191.1	185.9	181.8	-
Netherlands	171.2	172.3	169.7	168.7	165.5	163.6
Poland	-	-	153	154.1	154.8	-
Portugal	152.9	148.9	146.1	143.9	144	143.2
Sweden	196.8	197.1	195.8	192.4	187.3	180.1
Slovenia	-	-	151.6	156.1	154.2	155.2
Slovak Republic	-	-	-	156.3	150.9	-
United Kingdom	173.6	171.5	170.2	168.5	166.5	163.5
EU Average	167.5	166.7	165.8	164.7	162.2	160.3

3. Preferences for alternative fuel vehicles

Potoglou and Kanaroglou (2007) conducted a study to examine the factors that would encourage individuals to buy low carbon vehicles using a stated preference approach. Respondents in this study were asked to choose between purchasing a conventional vehicle, a HEV and an AFV with a varying set of attributes and attribute levels. A nested logit model was used to analyse the results. The study concluded that reduced monetary costs, purchase tax relives, and low emission rates would encourage people to buy environmentally cleaner vehicles. The study found that incentives such as free parking and permission to drive on high occupancy vehicle lanes were not significant (Potoglou and Kanaroglou, 2007). This study also found that the probability of buying a HEV was higher if the individual belonged to a middle income class (Potoglou, 2007).

Dagsvik et al (2002) conducted a study in Norway to ascertain the demand for AFVs. Respondents, in this study, were asked to rank hypothetical vehicles with specific attributes with different attribute levels. Vehicles studied were battery electric vehicles, HEVs, and conventional vehicles. This study found that AFVs would appear to be competitive with conventional fuelled vehicles, provided that the infrastructure is in place for the refuelling. Driving range is seen as an important attribute, and that this needs to improve for battery electric vehicles to be competitive.

Molin et al 2007 conducted a study which assessed individuals' perceptions of hydrogen fuel cell vehicles, AFVs, HEVs and petrol vehicles. Results from this study suggested that the main three attributes of concern to respondents were fuel price, availability of alternative fuels and the range of the vehicle. The study found that on average the conventional vehicles were preferred to AFVs. Out of the three AFVs, the hydrogen fuel cell was the most preferred, followed by biofuel vehicles.

4. Survey design

4.1 Survey layout

The purpose of the survey was to examine how fuel costs, VRT, and CO_2 emissions impact upon vehicle purchasing decisions. The survey included five sections which asked respondents about their preferences for purchasing HEVs and AFVs.

The first section of the survey asked responded about their current car, and if they were aware of the new VRT and annual road tax rate changes. Respondents' attitudes towards a number of car attributes were examined in section two. The third section of the survey asked respondents about environmental issues. The fourth section of the survey presented respondents with a number of stated preference scenarios. In these scenarios respondents were asked to choose between purchasing a standard car, an AFV or a HEV. The final section of the survey asked respondents age and socio-economic details.

4.2 Stated preference design

Each respondent to the survey was asked to complete six stated preference scenarios. In these scenarios respondents were asked to choose between purchasing a conventional vehicle, a HEV or an AFV. The three vehicle alternatives were defined by the percentage change in three attributes; fuel costs, VRT, and CO_2 emissions. Table 6 details the attributes and attribute levels used in the stated preference design. A fractional factorial design was used, which resulted in 36 scenarios to be evaluated. Six versions of the survey were used, each containing six stated preference scenarios.

Table 6
Attributes and attribute levels of vehicle alternatives

Attributes	**Conventional vehicles**	**HEV**	**AVF**
Fuel costs	0%	-10%	+20%
	-10%	-25%	-20%
	-20%	-50%	-50%
VRT	0%	-20%	-20%
	-10%	-50%	-50%
	-15%	-75%	-75%
CO_2 Emissions	0%	-30%	-30%
	-10%	-50%	-50%
	-40%	-80%	-80%

5. Survey results

5.1 Summary results

500 paper copies of the questionnaire were delivered to customers of a car company throughout Ireland in March 2008. The recipients of the survey had purchased a new car 6 months prior to receiving the survey. 168 questionnaires were returned, resulting in a response rate of 34%. One should note that the sample collected may not be

necessarily representative of the population of car buyers in Ireland. Currently data is not collected on the demographics of car buyers in Ireland, therefore one can not validate the sample collected. As a result of this inability to validate the sample readers should be mindful that these results may be subject to self-selection bias.

5.2 Characteristics of respondents

Table 7 presents the main characteristics of the respondents to the survey. 60% of respondents to the survey were male and 40% female (see Table 7). 23% of respondents are aged 26 – 35 and 33% are aged 36 – 45 (see Table 7). 31% of respondents indicated that they did not want to revel there income. 22% of respondents indicated that they earned €40,000 to €59,999, 15% said they earned €60,000 - €79,999 (see Table 7). Table 7 also presents the details on the highest level of education the respondents had completed at the time of the survey. 25% of respondents had received a primary degree and 33% had received a non-degree third level qualification.

Table 7
Characteristics of respondents

	N	%
Gender		
Male	100	60
Female	68	40
Age		
17-25	5	3
26-35	39	23
36-45	56	33
46-55	41	24
56-65	17	10
66+	10	6
Income		
Less than €19,999	2	1
€20,000 - €39,999	17	10
€40,000 - €59,999	37	22
€60,000 - €79,999	25	15
€80,000 - €99,999	17	10
€100,000+	19	11
Did not wish to answer	51	31
Education level		
Doctorate (PhD)	5	3
Masters Degree	14	10
Primary Degree	42	25
Third Level (Non-degree)	56	33
Professional Qualification	36	21
Primary / Secondary	13	8

5.3 Factors that effect respondents car purchasing decisions

Respondents were asked to rate, between 'very important' to 'not important', twelve different attributes of a motor vehicle. Values were assigned to each of the ratings, and an average rating taken for all respondents to each attribute. 'Very important' was given a value of 4, therefore the higher the raking, the greater the importance of the attribute. Table 8 presents the results of this ranking exercise.

The attribute that ranked as the most important to the respondents was reliability followed by safety and vehicle price. The alternative fuel attribute was found to be the least important to the respondents. The VRT was ranked in ninth place followed by CO_2 emissions in tenth place. Annual road tax was also shown to have little influence upon an individual's car purchasing decision.

Table 8
Factors that effect respondents car purchasing decisions

Rank	Attributes	Average score
1	Reliability	3.76
2	Safety	3.75
3	Price	3.15
4	Style/Appearance/Image	3.11
5	Size of Car/Internal Space	3.08
6	Fuel consumption	2.81
7	Performance/Power	2.66
8	Brand name	2.48
9	Vehicle registration tax	2.48
10	CO_2 Emissions	2.44
11	Road tax	2.25
12	Alternative fuel	2.23

The following analysis compares age and income with respondents' importance rating given to fuel cost, VRT, and CO_2 emissions. Table 9 compares age against the rating of the car attributes of fuel costs, VRT and CO_2 emissions. The results show that fuel costs are most important to those aged 17-25 and 46-65. Respondents in the age groups 26-35, 36-45 and 46-55 all placed a similar importance on VRT when purchasing a new car. Respondents aged 36-45 and those aged 46-55 were found to rank CO_2 emissions higher than those in the other age groups.

Table 9
Cross tabulation between age and fuel cost, VRT and CO_2 emissions

Ages	Fuel Costs	VRT	CO_2 emissions
17-25	3.33	2.00	1.67
26-35	2.62	2.59	2.05
36-45	2.91	2.46	2.56
46-55	3.03	2.49	2.88
56-65	2.76	2.81	2.53
66+	2.22	1.57	1.75

Table 10 compares income level against fuel costs, VRT and CO_2 emissions. Respondents earning less than €19,999 and those earning €20,000-€39,999 were found to be the most concerned about fuel costs when purchasing a new car. Individuals earning €20,000-€39,999 and €60,000-€79,999 were found to be more concerned with VRT levels when purchasing a car. The rankings for CO_2 emissions show that as income increases, respondents are less concerned with low CO_2 emissions (see Table 10).

Table 10
Cross tabulation between income and fuel cost, VRT and CO_2 emissions

Income	Fuel Costs	VRT	CO_2 emissions
Less than €19,000	3.00	2.50	3.00
€20,000 - €39,999	3.47	2.71	2.76
€40,000 - €59,999	2.89	2.61	2.28
€60,000 - €79,999	2.75	3.00	2.52
€80,000 - €99,999	2.65	1.69	2.24
€100,000+	2.37	2.16	2.50

5.4 Opinions of HEVs

In the survey respondents were asked whether they agreed or disagreed with a number of statements related to HEVs. Table 11 details the percentage of respondents who replied that they thought that ‘hybrid vehicles are better for the environment than conventional vehicles’. The majority of respondents believed that HEV vehicles are better for the environment than conventional vehicles, with 34% of respondents ‘strongly agreeing’ with this statement and 45% ‘agreeing’. 40% of respondents agreed that HEVs were cheaper to run compared to conventional cars. However, 35% of respondents neither agreed nor disagreed that they were cheaper to run. This finding suggests that individuals may not be fully aware of the benefits of HEVs. 43% of respondents said that they thought HEVs would be the car of choice in the next 10 years (see Table 11).

Table 11
Opinions of HEVs

	Strongly agree	**Agree**	**Neither**	**Disagree**	**Strongly disagree**
HEVs are better for the environment than conventional vehicles	34%	45%	16%	3%	2%
HEVs are cheaper to run than conventional vehicles	12%	40%	35%	9%	4%
HEVs will be the car of choice in the next ten years	12%	43%	31%	11%	3%

N = 168

5.5 Opinions of AFVs

The survey also required that respondents to provide an opinion on AFVs. Respondents were asked whether they agreed or disagreed with the statements, from 'strongly agree' to 'strongly disagree'. 38% of respondents 'strongly agreed' and 42% 'agreed' that AFVs were better for the environment (see Table 12). A total of 6% of respondents disagreed with this statement, with 14% neither agreeing nor disagreeing. 8% of respondents 'strongly agreed' and 27% 'agreed' that AFVs were cheaper to run than conventional vehicles. As with the responses to the same statement for HEVs, 40% of respondents had no opinion, which suggests that respondents were generally unsure as to whether AFVs were more efficient to run. 10% of respondents 'strongly agreed' and 45% 'agreed' that AFVs would be the car of choice in ten years time.

Table 12
Opinions of AFVs

	Strongly agree	**Agree**	**Neither**	**Disagree**	**Strongly disagree**
AFVs are better for the environment than conventional vehicles	38%	42%	14%	5%	1%
AFVs are cheaper to run than conventional vehicles	8%	27%	40%	19%	6%
AFVs will be the car of choice in the next ten years	10%	45%	26%	15%	4%

N = 168

As not all filling stations supply biofuel, an important consideration when purchasing an AFV is how far one has to travel to purchase biofuel. To this extent respondents were then asked whether they would make a detour to purchase alternative fuels. 56% said that they would detour 5 km to purchase biofuels while 18% said that they would detour 10km (see Table 13). 26% of the respondents said that they would not detour to purchase biofuel.

Table 13
Willingness to detour to an alternative fuel filling station

	Would not detour	**5 – 10km**	**10km +**
What is the maximum number of kilometres you would be willing to detour to buy alternative fuels	26%	56%	18%

N = 168

The issue of detouring and the lack of availability of biofuel was one of the main concerns aired by respondents in the qualitative responses to the survey. Of the 36 qualitative responses to the survey, over 50% of these responses related to the inability of the respondent to source a local filling station that sold bio-fuel. The following comment was made by a respondent to the survey; '*I recently purchased a flexifuel car to try and influence CO_2 emissions etc. However, I find it very difficult to locate garage/filling station who sells biofuel. Selling car agents should advise car buyers of biofuel garages within a 20km radius'*. Many of the other qualitative responses to the survey made similar statements.

5.6 Stated preference results

This section presents the results of the stated preference scenarios. The purpose of the stated preference survey was to ascertain whether reductions in changes in fuel costs, VRT and CO_2 emissions could encourage individuals to buy HEVs or AFVs. Both multinomial logit (MNL) and nested multinomial logit (NMNL) models were estimated using ALOGIT, the results of which are presented in Table 14.

The utility functions for the three vehicle alternatives are as follows:

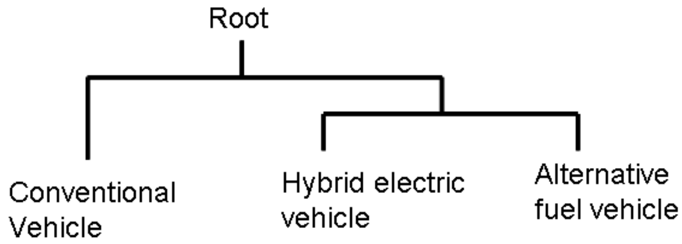
$U_{conventional} = \alpha 1(\text{fuel costs}) + \alpha 2(\text{VRT}) + \alpha 3(CO_2 \text{ emissions})$ (1)

$U_{HEV} = \alpha 4(\text{fuel costs}) + \alpha 5(\text{VRT}) + \alpha 6(CO_2 \text{ emissions})$ (2)

$U_{AVF} = \alpha 4(\text{fuel costs}) + \alpha 5(\text{VRT}) + \alpha 6(CO_2 \text{ emissions})$ (3)

$U_{conventional}$, U_{HEV} and U_{AFV} are the utilities derived from the conventional vehicles, HEVs and AFVs respectively. Fuels costs, VRT and CO_2 emissions are the attributes which define each of the vehicles presented to the respondent. As shown in Table 2, the coefficients for fuel costs, VRT, and CO_2 emissions were negative, which implies that potential buyers would prefer lower cost vehicles that produce less CO_2 emissions. The first model, presented in Table 14 (MNL Model 1), was estimated using a traditional MNL approach. This model is referred to as the base model as the coefficients examined refer directly to the utility equations. While the ρ^2 (0) value of 0.266 and a ρ^2 (c) value of 0.121 indicate a reasonable model fit, some of the variables were not significant. To improve the model performance a NMNL model was estimated using the structure detailed in Figure 1.

Figure 1
NMNL Model structure



The NMNL Model 2, presented in Table 14, follows the nested structure defined above. The results of this model demonstrate an improved model fit compared to the MNL Model 1, and all of the coefficients were found to be statistically significant. The interpretation of the results from the base model presented in the following paragraphs is taken from this NMNL model.

The results from the base NMNL model indicate compliance with economic theory. For example, intuitively one would expect that motoring costs to result in greater disutility for motorists, thus a lower probability of choosing that particular alternative.

The negative sign for fuel costs suggests that as the cost of fuel increases the likelihood of an associated vehicle type being selected decreases. Alternative specific coefficients for fuel costs were estimated for the three vehicle type alternative and the results indicate that fuel cost is not valued equally across all three vehicle types. The fuel cost associated with hybrid vehicles is most onerous with a coefficient value of -0.046. The fuel costs associated with both conventional and alternative fuel vehicles are valued equally, with a coefficient value of -0.025. The results imply that a greater disutility is associated with the fuel costs of hybrid vehicles than for either of the other two vehicle types. This makes intuitive sense as it is likely that one of the reasons as customer would choose a hybrid vehicle is for its fuel economy; therefore if the fuel cost is higher than for other vehicles they would be reluctant to choose a hybrid.

The negative sign for the vehicle tax coefficients, like the fuel cost coefficients, indicates that as vehicle tax increases the probability that an individual will select this option will decrease. An increase in vehicle tax was found to have the greatest impact on those that selected the conventional vehicle followed by those that selected to purchase an AFV. An increase in vehicle tax was shown to have the least impact on those that selected the HEV option. This result is interesting, in that many governments used lower vehicle tax to encourage the purchase of HEVs and these results demonstrates that this has little impact on the decision to purchase a HEV.

The emissions coefficient was estimated to be positive. This result demonstrates that as the emissions reduction increases so too does the benefit derived from this reduction. The respondents that purchased an AFV were found to derive the greatest benefit from a reduction in vehicle emissions followed by those that selected the HEV option. As one might expect those that selected the conventional vehicle option were found to derive the lowest benefit from a change reduction in emissions.

A comparison between the three vehicle choices demonstrates that fuel cost was most important to those that chose a conventional vehicle or a AFV, whereas those that indicated that they would purchase a HEV emissions was the most important factor. Interestingly the vehicle tax coefficient was found to have the least impact on those individuals that indicated they would purchase a HEV or an AFV.

The third model (NMNL Model 3) examines the impact of a number of vehicle specific characteristics on the choice of vehicle. The variables examined in this model are taken from the results in Table 8. Each of the vehicle specific characteristics are dummy variables taking the value of 1 if the respondent indicated the vehicle specific characteristic was either important or very important to the individual, and 0 otherwise.

The coefficient estimate for vehicle reliability is statistically significant. The positive value implies that respondents who valued reliability as being important are more likely to choose an AVF alternative when faced with choosing between a conventional, hybrid or alternative fuel vehicles.

The coefficient estimated to examine the impact that vehicle fuel consumption was estimated to be negative and significant. This negative value indicates that those that chose the conventional fuel alternative placed a lower significance on fuel efficiency, compared to those that chose the other two options. This result is as one would expect. Price coefficient was found to be positive and significant. This result indicates that those that selected the AFV variable were found to place a greater emphasis on vehicle price compared to the other two options. The vehicle emissions coefficient was found to be positive and significant. Those that chose the HEV option were shown to be place a greater value on a lower emission vehicle compared to the other two options. The final vehicle characteristic examined was vehicle performance. This coefficient was found to be positive and significant for those that selected the conventional vehicle option. This finding demonstrates that individuals that chose the HEV and AFV were less concerned with vehicle performance than those that selected the conventional vehicle option.

The final model presented in Table 14 (NMNL Model 4) examines a number of demographic characteristics. The first variable examined in model NMNL Model 4 represents respondents' willingness to detour to a different filling station to purchase alternative fuels. This variable is a categorical variable the value of which increases in relation to how far the respondent said they would detour to purchase an alternative fuel. The detour coefficient was estimated to be negative (-.644) when interacted with the conventional vehicle utility equation. This result suggests that respondents were not willing to detour to buy an alternative fuel instead of petrol, compared to those that chose the AVF and HEV options.

The gender variable is a dummy variable which takes a value of 1 if the respondent is a male, and 0 if the respondent is female. The variable was placed in the HEV option. The coefficient is negative (-.134) for those individuals that selected the HEV option implying that all else being equal, males are unlikely to choose a hybrid vehicle compared to the sample as a whole

The age coefficient is a categorical variable ranging in values from 1 to 5, the values increase with the respondents age. The age variable produced a coefficient of 0.203, suggesting that as age increases respondents would derive a greater utility from purchasing an AFV. This is similar to the findings presented in Potoglou and Kanaroglou (2007). The income coefficient was found to be positive and significant when matched with the HEV option. This suggests that individuals that selected the HEV option were more likely to have a higher income, compared to those that selected the other two options. The final coefficient examined in this model is a dummy variable that takes a value of 1 if the respondent currently owned a car with a cc of less than 1900, and 0 otherwise. The value of this coefficient was found to be positive when interacted with the HEV option which indicates that individuals that selected this option this option were more likely to currently own a car with a cc of 1900 or less, compared to those that selected the other two options.

Table 14
Model results

	MNL Model 1		NMNL Model 2		NMNL Model 3		NMNL Model 4	
	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
Fuel Costs (1)	-.020	-1.4	-.025	-2.6	-.023	-3.1	-.040	-4.1
Vehicle Tax (1)	-.063	-1.2	-.021	-3.1	-.021	-2.0	-.039	-2.7
Emissions (1)	.015	2.3	.012	2.7	.014	2.9	.026	4.0
Fuel Costs (2)	-.045	-11.3	-.046	-7.3	-.051	-7.1	-.062	-10.8
Vehicle Tax (2)	-.012	-4.2	-.010	-2.5	-.013	-2.1	-.014	-3.9
Emissions (2)	.085	3.0	.096	2.6	.093	2.7	.092	3.1
Fuel Costs (3)	-.025	-5.1	-.025	-6.4	-.026	-6.3	-.030	-9.0
Vehicle Tax (3)	-.017	-6.3	-017	-4.1	-.016	-3.5	-.022	-6.3
Emissions (3)	.022	2.8	.023	4.6	.020	4.3	.026	6.8
Reliability (3)	-	-	-	-	.555	7.1	-	-
Fuel consumption (1)	-	-	-	-	-1.119	-3.5	-	-
Price (2)	-	-	-	-	.123	1.9	-	-
Emissions (3)	-	-	-	-	.519	3.1	-	-
Performance (1)	-	-	-	-	1.025	3.1	-	-
Logsum	-	-	-	-	.662	7.5	.814	4.5
	-	-	-	-	-	-	-	-
Detour (1)	-	-	-	-	-	-	-.644	-9.0
Gender (2)	-	-	-	-	-	-	-.134	-2.1
Age (3)	-	-	-	-	-	-	.203	2.6
Household income (2)	-	-	-	-	-	-	.414	4.1
Current car cc >1900cc (2)	-	-	-	-	-	-	.427	2.5
	-	-	-	-	-		-	-
	-	-	-	-	-	-	-	-
ρ^2 (0)	.266		.273		.291		.403	
^{2} (c)	.121		.132		.131		.265	
Final Likelihood	-876.514		-845.646		-830.114		-632.804	

(1): Conventional vehicles, (2): Hybrid electric vehicles, (3): Alternative fuel vehicle

6. Discussion and conclusions

The results presented in this paper provide an insight into the motivations of individuals before they purchase a new vehicle and how they might be persuaded to purchase an environmentally friendly option. Respondents were asked which vehicle attributes they considered important before purchasing their vehicle. VRT and CO_2 emissions were not considered important attributes by the respondents. However, fuel consumption was considered important given that it was ranked 6th out of 12 attributes in this survey.

The majority of respondents agreed that HEVs are better for the environment and cheaper to run than conventional vehicles but that they were more expensive to buy than conventional vehicles. Most respondents agreed that HEVs would be the car of choice in ten years time. Respondents were also positive about AFVs attributes, believing that they were better for the environment than conventional vehicles. There was some dispute as to whether they are cheaper to run, with nearly as many people agreeing with this statement as disagreeing with it.

The stated preference modelling revealed that for all three vehicle types the utility derived from the vehicle increased as fuel costs, VRT and CO_2 emissions decreased. The coefficient for fuel cost was found to have the biggest impact upon the HEV option. As one of the benefits of HEVs is that they have excellent fuel economy, it makes intuitive sense that this coefficient is larger than the other two options. The stated preference modelling also demonstrated that lower CO_2 emissions and lower VRT; increase the utility derived from HEVs and AFVs. However, fuel costs were more significant then the other two attributes, with the exception of emissions for those that selected HEV. These results correspond with the ranking exercise, where VRT and CO_2 emissions were ranked in low positions, as compared to fuel costs which were ranked in the top half of the twelve attributes.

The results from this study have shown that respondents place a higher utility on reductions on fuel costs compared to reductions in VRT and CO_2 emissions. If the adoption of HEVs or AFVs is seen as publicly desirable then the fuel costs of these vehicles will have to be competitive/lower when compared with that available to conventional vehicles. A major concern of respondents was the scarcity of outlets selling biofuel. One respondent wrote *'The relative lack of availability of biofuel has been a factor since I bought the car. Good intentions only go so far if you can't get* *the fuel'*. This is the 'chicken and egg' problem, in that people will not buy AFVs until the fuel is widely available.

Acknowledgements

The authors would like to thank the referees sincerely for their helpful suggestions to improve the original manuscript.

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