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The impact of environmental attitudes on responses to emissions charging and vehicle choice.

By

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TITLE: **The impact of environmental attitudes on responses to emissions charging and vehicle choice.**

ABSTRACT: While there has been extensive literature on the concept of congestion there have been very few studies that explore road pricing as a function of vehicle emissions. A growing global focus on environmental concerns, in particular the role of carbon emissions in global warming, has created a social atmosphere where attitudes towards the environment are a pre-eminent focus of news media. In stated choice experiments, such attitudes play a key role in determining willingness to pay measures. This paper employs a stated preference survey to examine motor vehicle purchasing in the presence of hypothetical annual and variable emissions surcharges. Using latent class modelling, it is shown that four classes of individuals exist, whose sensitivities to annual and variable emissions surcharging differs. Importantly it is also shown that these differences can be explained by environmental attitudes. The policy implications of this result are discussed, highlighting the usefulness of the modelling technique in the management of environmental policy.

KEY WORDS: ***Stated preference; emissions charging; vehicle choice; response bias.***

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1. Introduction

Pricing for road and vehicle use is not new. Fuel taxes, licence fees, car registration, parking taxes, tolls and congestion charges have existed for many years. Revenue obtained from such charges has typically been hypothecated to fund new transport infrastructure projects and to pay for the maintenance of existing transport infrastructure, with such funding arrangements representing one of the often stated objectives of road and vehicle charges (Litman 2008).

Given the negative externalities that exist with road use such as traffic congestion and pollution, several cities around the world have instituted charging regimes with the stated goal of congestion relief. In Singapore the implementation and subsequent development of the Area Licensing Scheme resulted in traffic volume into the restricted zone being reduced in excess of 30 percent despite increases in population and vehicle ownership over the period 1975 to 1988 (Keong 2002). In London, the introduction of the western extension of the Congestion Charge Zone resulted in a decrease of cars and cabs in the cordoned zone by approximately 21 percent in 2007 (compared to the 2005/06 pre charging conditions), with significant increases in public transport usage within the area (TFL 2008). Stockholm instituted a congestion charging system in 2006 which resulted in a bigger than forecast decrease in congestion (measured as "additional travel time"); near the cordon (where congestion was highest) 80-90% of the queues are gone and further out from the cordon there are also large effects with around 50% less queues (Eliasson and Hugosson 2006).

The observed traffic reduction in response to these schemes has resulted in growing interest in such policies, in particular what can be done to reduce externalities of traffic congestion whilst at the same time avoiding a political backlash (Hensher and Puckett 2007). Concurrently, a growing global focus on environmental concerns, in particular the role of carbon emissions in global warming, has meant that the fuel efficiency and pollution outputs of motor vehicles is becoming increasingly scrutinized, much more so than ever before. Many of the environmental problems, both real and perceived, stem from the use of transport infrastructure by passenger and freight vehicles, which are a source of local pollutants such as zinc, copper, lead, carbon monoxide and noise (Hensher and Button 2003). Accordingly, there has been a greater call for the better integration of policy with respect to a charging scheme to reduce CO_2 and local air pollution (Begg and Gray 2004).

One of the first variable pricing schemes specifically linked to pollution outcomes was launched in Milan in 2008. The stated objectives of the charging scheme are to reduce the number of vehicles entering the urban area by 30 percent, reduce primary emissions from traffic and transportation by 25 percent, and to promote more obsolete vehicles being excluded from the fleet (Croci 2007). Such environmental goals are not unrealistic, as the incidental impact of congestion charging in London meant that reduced traffic flows created positive environmental benefits. Compared to 2002 levels, as a result of the initial charging scheme implemented in 2003 NOX emissions in the charging zone were reduced by approximately 12.0 percent, PM10 emissions were reduced by approximately 11.9 percent, and there was a reduction in CO_2 emissions of 19.5 percent. This evidence suggests that the congestion charging schemes could assist in attaining targets on air pollution as well as those relating to climate change (Beevers and Carslaw 2005).

In Australia, like many countries, motor vehicles remain a major cause of air pollution in urban areas, with cars contributing 41.9 million tonnes of carbon dioxide or equivalent greenhouse gases, approximately eight percent of total national emissions in 2007, with trucks and light commercial vehicles contributing a further 19.0 million tonnes. Together, these represent 13 percent of Australia's total emissions, and since 1990 this figure has increased by 26.9 percent (Australian Greenhouse Office 2009). A recent Australian government report predicts that with no carbon price in place, transport emissions will nearly quadruple by 2100, but acknowledges that higher oil prices and an emissions price will increase the price of petroleum-based fuels, potentially lowering demand for them (Garnaut 2008). With the growing interest in examining the link between travel behaviour and climate change, this paper explores the role that that an emissions based charging scheme might play in the formation of preferences for automobile choice.

With respect to many policies evaluation studies, stated preference methods have become a preferred approach to examine the preferences of individuals and organisations in a choice setting and in estimating willingness to pay for specific attributes. However, concern exists as to the nature of responses given in the hypothetical nature of many stated preference studies (Carson and Groves 2007, Hensher 2010). Evidence has been found of strategic misrepresentation by respondents (Carson et al. 2009), that the reference point used by respondents is revised as a result completing the choice tasks (DeShazo 2002) and that respondent preferences themselves are revised as a result of a learning process over the sequence of the choice tasks themselves (Bateman 2008, Day and Pinto 2010).

In wider terms, such deviation from real market evidence is referred to in the literature as hypothetical bias, a bias associated with the hypothetical nature of many stated preference techniques in both the payment for and presence of the attribute in question. As a consequence of such bias many practitioners believe that individuals tend to overstate their economic valuation of a good by a factor of two or three in the context of stated preference surveys (Murphy et al. 2005). While the majority of studies indicate an over-representation of willingness to pay, the impact of hypothetical bias is inconsistent: the magnitude of hypothetical bias is statistically less for willingness-to-pay as compared to willingness-to-accept applications (List 2001); willingness-to-pay values derived in the stated preference experiment are undervalued in comparison to the results from revealed preference studies (Wardman 2001, Brownstone and Small 2005); or there is no evidence of differences in willingness-to-pay values between hypothetical and actual choice experiments (Carlsson and Martinsson 2001, Lusk and Schroeder 2004).

Whilst efforts to study the influence of hypothetical bias have been confined largely, but not exclusively, to environmental and resource applications, there has been a growing recognition of this phenomenon within transport related literature. Detailed overview of differences obtained between willingness-to-pay values from different survey methodologies and offers potential strategies to more closely align stated preference surveys to real market activity are available (Hensher 2010), but while econometric theory can partially explain this phenomenon, psychological explanations are equally as important in explaining the divergence between real and experimental valuations, particularly in the context of environmental attributes.

In many of the environmental applications of stated preference methods, the hypothetical facet of the experiment entails the loss of some right, privilege or possession that may have been in the ownership of the individual for some time (for instance the imposition of an emissions charge in this study represents a hereto unexperienced cost on the otherwise “free use” of an individuals motor vehicle). In such experiments, the prospect of losing some object or right after it has been possessed for an extended period of time represents a loss, may incentivise respondents to engage in strategically biased behaviour that is dependent on their attitudes and beliefs with respect to the loss to ensure such a policy is not viable. The converse is also true, in that individuals expressing high levels of environmental concern and pro-environment attitudes often display behaviours and actions that have low levels of congruency with their expressed views (Olli et al. 2001), with several studies providing empirical evidence of unreasonably large willingness to pay valuations obtained where the purpose of the study is transparent and/or contentious and the likelihood of paying for the improvement is small (Wardman and Whelan 2001, Wardman and Shires 2003).

A growing global focus on environmental concerns, in particular the role of carbon emissions in global warming, has created a social atmosphere where attitudes towards the environment are a pre-eminent focus of news media. The growing interest in examining the link between travel behaviour and climate change in conjunction with the biases that may exist with respect to an individual's behaviour has formed the motivation for this research. Using advanced choice modelling techniques, this paper not only examines the role of vehicle emissions charging, obtained from the stated preference experiment, but also explores how divergent attitudes towards the environment influences motor vehicle choice, in particular how they impact upon willingness to pay for vehicle emissions. The remainder of the paper is structured as follows. In the following section a review of the development of the stated preference survey is given, with particular reference to the vehicle surcharge component of the study. Section 3 provides a brief overview of the empirical methods employed in the analysis of the survey data. Section 4 describes the general characteristics of the data under analysis and discusses the results of the empirical modelling. Finally, Section 5 provides discussion and concluding remarks, highlighting directions of future research.

2. Methodology

2.1 Development of the survey

Extensive thought was given to the focus of the study, given the growing social and political interest in identifying possible ways to reduce emissions from automobile ownership and use. It was decided that an ability to establish the elasticity of demand for low emitting vehicles with respect to a CO_2 emission charge per kilometre or per annum per vehicle was of fundamental interest in this context.

The choice set of interest was narrowed down to fuel type alternatives - petrol, diesel or hybrid. It was deemed that a labelled choice experiment was most appropriate for this research given the interest in estimating alternative-specific effects for each of the fuel types, as well as the calculation of market shares and demand elasticities. Numerous sources have expressed uncertainty about which fuels will be commercially viable in the future (e.g., Australian Emissions Trading Scheme workshop on June 27, 2007 in Sydney), or have debated which fuel source will provide greater future reductions (e.g., the commercialisation of the relatively unexplored fuel cell technology as the most appropriate strategy (Sperling and Gordon 2009)). As such, in the choice experiment, the hybrid alternative will not be referred to with respect to a specific fuel type, since the focus is on establishing the influence of various pricing and performance and emission regimes regardless of what the fuel is. The hybrid alternative will simply reflect a vehicle option that is cleaner with respect to emission levels.

Following the specification of the alternatives, consideration was given to the selection of attributes to use within the choice experiment. Nine attributes were included in the experiment, which were identified via a review of the available literature on vehicle purchasing, as well as through preliminary analysis of secondary data sources. Table 1 displays the levels that have been selected for each attribute. Note that the purchase price for the hybrid alternative is $3,000 more at each level in order to recognise that hybrid technology is currently more expensive than conventional fuel engines.

Table 1: Attribute levels for stated choice experiment

	Levels	1	2	3	4	5
Purchase Price	*Small*	$15,000	$18,750	$22,500	$26,250	$30,000
	Small Luxury	$30,000	$33,750	$37,500	$41,250	$45,000
	Medium	$30,000	$35,000	$40,000	$45,000	$50,000
	Medium Luxury	$70,000	$77,500	$85,000	$92,500	$100,000
	Large	$40,000	$47,500	$55,000	$62,500	$70,000
	Large Luxury	$90,000	$100,000	$110,000	$120,000	$130,000
Fuel Price	*Pivot*	-25%	-10%	0%	10%	25%
Registration	*Pivot*	-25%	-10%	0%	10%	25%
Annual Emissions Charge	Pivot off fuel efficiency of alternative. Each fuel efficiency had five possible values, with the average of the range increasing as fuel efficiency decreased					
Variable Emissions Charge	Pivot off fuel efficiency of alternative. Each fuel efficiency had five possible values, with the average of the range increasing as fuel efficiency decreased					
Fuel Efficiency (L / 100km)	*Small*	6	7	8	9	10
	Medium	7	9	11	13	15
	Large	7	9	11	13	15
Engine Size (cyl)	*Small*	4	6			
	Medium	4	6			
	Large	6	8			
Seating Capacity	*Small*	2	4			
	Medium	4	5			
	Large	5	6			
Country of Manufacture	*Random Allocation*	Japan	Europe	South Korea	Australia	USA

Two attributes requiring particular attention relate to the mechanism via which vehicle emissions charges will be implemented. We test two approaches, a surcharge that is paid annually, and a variable charge that is a function of how much the vehicle is used. Both charges are a function of a vehicle's fuel efficiency given that improved fuel economy is strongly associated with lower levels of vehicle emissions. In this study, it is conceptualised that the annual emissions surcharge will be an additional cost at the point of vehicle purchase, with the desire to minimise this cost resulting in the choice of a more fuel efficient vehicle. The variable cost will then act as a modifier of behaviour, determining how much a chosen vehicle is used. In short, the annual surcharge is hypothesised to be the key environmental driver of vehicle choice, while the variable charge is the key driver of vehicle use.

2.2 Experimental design

In establishing the choice profiles shown to respondents, a D-efficient design was used (Rose and Bliemer 2008). A reference alternative is included in the experimental design to add to the relevance and comprehension of the attribute levels being assessed by the individual respondents (Rose et al. 2008), and can be used to reduce hypothetical bias in stated preference surveys (Hensher 2010). In the process of designing the experiment, there were a number of conditions on the interaction of the attributes and alternatives, complicating the design process. First, the annual and variable surcharge that is applied to an alternative is conditional on the type of fuel used and the fuel efficiency of the vehicle in question. Second, if the reference alternative is petrol (diesel), the petrol (diesel) fuelled alternative must have the same fuel price as the reference alternative. Third, the annual and variable surcharge for the hybrid alternative cannot be higher than that of another vehicle when the alternative vehicle has the same fuel efficiency rating or is more inefficient than the hybrid. Finally, to ensure that respondents faced a realistic choice set, given the size of the reference alternative, one of the remaining alternatives was randomly selected and restricted to be the same size as the reference, another was allowed to vary plus/minus one body size, and the third was allowed to vary freely. Respondents were required to complete a series of choice sets, with each choice set containing three alternatives described by all of the attributes listed in Table 1, and were asked to rank their selections from most preferred to least preferred.

2.3 Attitudinal and demographic information

In addition to the choice observations, pertinent demographic information was collected to aid in the decomposition of preference structures. Age, gender, employment status, number of hours worked in a typical week, annual income, the number of years a driver's license has been held, the average number of kilometres driven per week, and the number of children in the household was collected. Additional to this, information was collected on the attitudes that respondents held towards global warming, emissions charging and the role of the motor vehicle. Developed via in-depth interviews and refined via two pilot studies, seven attitudinal questions were deemed relevant to respondents with respect to emissions charging. Asked on a seven-point Likert scale (where 1 equals *Strongly Disagree*, 4 equals *Neutral* and 7 equals *Strongly Agree*) the questions are as follows:

(em1) Climate change important issue

(em2) Vehicles are a main cause of climate change

(em3) People should be encouraged to use environmentally friend transport

(em4) The Government should implement carbon reduction policies

(em5) Drivers of high CO_2 emitting cars should pay more

(em6) Vehicle emissions charge is fair to all road users

(em7) A vehicle emissions charge is effective way to reduce vehicle based CO2

3. Empirical methods

The objective of this paper is to identify response bias as a result of attitudes related to the environment. Consequently, latent class modelling has several advantages in this instance most specifically being able to link taste heterogeneity to socio-demographic and attitudinal indicators rather than simply knowing that a given sensitivity follows a certain (assumed) random distribution in the sample population as is the case with, for example, the mixed multinomial logit. As detailed and rigorous description of this model can be found in other papers (Greene and Hensher 2003), here we provide only a brief introduction. The primary difference between the LC and MMNL models is in how preference heterogeneity is treated. In the LC model formulation, parameter heterogeneity is modelled with discrete rather than continuous distributions as with the MMNL model. These discrete distributions are often referred to as classes. According to the model, each individual resides up to a probability in a 'latent' class, c. In estimating the model, there exist a fixed number of classes, C, where the number of classes is defined a priori by the analyst. Estimates consist of the class specific parameters and for each respondent, a set of probabilities defined over the classes. Within each class, the parameters and choice probabilities are assumed to be generated by MNL models.

As such, the utility functions of the LC model differ to other models, in that there now exist several utility functions that require estimation. Firstly, there exist the class specific utility functions, which we represent as

$$U_{nsj|c} = V_{nsj|c} + \varepsilon_{nsj|c}. \quad \textbf{(1)}$$

Class membership is not directly observed, instead being modelled up to a probability using a class assignment model. Typically, the class assignment model is specified as an MNL model, which requires that an additional utility specification be defined. These additional sets of utility functions are used to help distinguish respondents in terms of class membership. We represent the class assignment model utility function as

$$U_{nc} = \delta_c h_n + \varepsilon_{nc}, \quad \textbf{(2)}$$

where h_n represents a set of observable characteristics used to separate sampled respondents into different latent classes and δ_c associated parameters. For purposes of model identification, at least one (typically the last) utility function is normalised to zero. If no utility function is directly specified by the analyst, then only class specific constants are used in the model to allocate respondents, up to a probability, into the different latent classes. Note that subscript s has been omitted from Equation (2). This is because the characteristics contained in the vector h_n must remain constant within each choice task, s, and hence the class assignment model in effect assigns respondents (or other choice invariant objects) and not choice situations to the different classes.

4. Empirical results

4.1 Descriptive statistics

The data was collected over a four month period in the second half of 2009. An eligible respondent had to have purchased a brand new vehicle in 2007, 2008 or 2009, ensuring that they would be familiar with the processes involved in purchasing a new vehicle. A total of 401 surveys were completed. The final sample used in model estimation herein comprises 3,172 choice observations from 650 respondents. In terms of the socioeconomic profile of the sample, 51 percent are female and 49 percent are male, the average age of respondents is 46.2 years, who work an average of 30.4 hours per week in mostly a fulltime (58%) or part time (17%) capacity, with an average personal income of between $50,000 and $60,000 per annum. 99 percent of respondents hold a drivers license and have done so for an average of 26.2 years.

Table 2 summarises the descriptive statistics of the attribute levels for the recent purchase in conjunction with the levels for the chosen alternatives. Petrol is the fuel type that dominates the most recently purchased vehicle. Within the choice task however, the spread of fuel types selected is more uniform, indicating that consumers are not rigid in their preference for fuel type, and that the incentives included in the experience to test switching might have been successful. Similarly, engine capacity has a greater spread for the chosen alternative, compared to the recent purchase where it is dominated by four cylinder vehicles. However, it is worth noting that we allowed engine capacity and fuel efficiency to vary randomly so that any future technological advances in engine efficiency would not be absent in the composition of the experiment. The difference in the seating capacity attribute reveals that individuals may be opting into smaller vehicles in the choice task compared to their most recent purchase, perhaps in response to the charges applied. It is also worth noting that the average price of the chosen alternative is approximately $10,000 more than the current vehicle, indicating that individuals are theoretically prepared to pay more for vehicles of a different, more efficient and less expensive fuel source, given the attributes presented in the choice task.

Table 2: Recent purchase and chosen alternative

Attribute		**Recent Purchase**	**Chosen Alternative**
Size of Vehicle	*Small*	42%	43%
	Medium	25%	30%
	Large	34%	27%
Fuel Type	*Petrol*	93%	39%
	Diesel	7%	26%
	Hybrid	--	36%
Engine Capacity (cyl)	*4*	76%	42%
	6	21%	46%
	8	3%	12%
Seating Capacity	*2*	6%	20%
	4	12%	40%
	5	72%	24%
	6 or more	9%	16%
Country of Manufacture	*Japan*	36%	20%
	Europe	45%	22%
	South Korea	10%	22%
	Australia	8%	18%
	USA	1%	18%
Purchase Price		$32,245 ($14,963)	$44,300 ($23,700)
Fuel Price		$1.22 ($0.07)	$1.22 ($0.22)
Registration		$856.51 ($468.19)	$863.89 ($497.67)
Annual Emissions Charge		--	$202.80 ($198.00)
Variable Emissions Charge		--	$0.15 ($0.14)
Fuel Efficiency (l/100km)		8.9 (2.0)	9.7 (2.8)

With respect to attitudes to the environment and vehicle emissions, significant differences were found between the mean responses for the question ($F_{6,641}$=108.828). Figure 1 presents the mean value for each question. Post-hoc analysis via Tukey HSD was used to examine were attitudinal strength differed. Circled means on Figure 1 indicate homogenous levels of agreement with the statements, responses in separate circles indicate significant mean differences.

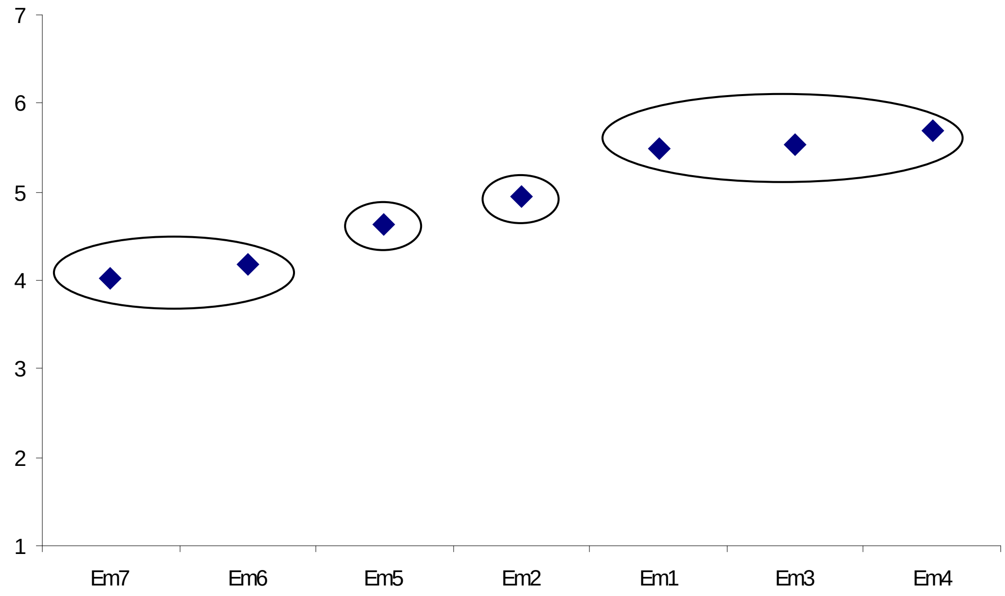

Figure 1: Attitudinal question mean values in homogenous subsets

On average, respondents were neutral in their attitudes towards vehicle emissions charging being fair to all road users (em6), and that it is an effective way to reduce vehicle based CO_2 (em7).They were significantly more agreeing to the statement that drivers of higher CO_2 emitting cars should pay more (em5), and again more in agreement with the statement that vehicles are a main cause of climate change (em2). Lastly, the average respondent was significantly more likely to agree that climate change is an important issue (em1), that people should be encouraged to use more environmentally friendly transit (em3), and that the Government should implement carbon reduction policies (em4) - unsurprising in Australia given the level of general support for a carbon pollution reduction scheme. These results point towards a general level of agreement with climate change being an issue, and that initiatives that mitigate its effects need to be explored. In turn, an a priori expectation is that there would be positive attitudes towards government action against climate change, and thus an over-estimation bias with respect to willingness to pay measures to reduce carbon emissions, using similar rationale to others (*20*,*21*).

4.2 Stated preference analysis

The latent class model, unlike the mixed multinomial logit which specifies the random parameters to follow a continuous joint distribution, assumes that a discrete number of classes are sufficient to account for preference heterogeneity across classes. Therefore, the unobserved heterogeneity is captured by these latent classes in the population, each of which is associated with a different parameter vector in the corresponding utility function. Consequently, being able to link taste heterogeneity to socio-demographic and environmental attitudinal indicators rather than simply knowing that a given sensitivity follows a certain (assumed) random distribution in the sample population making it useful for the analysis of taste heterogeneity (Hess et al. 2009). In this paper we present two models for comparison, one where the attitudinal questions are used and one where they are not.

Specifying the number of classes is an iterative process, whereby successive models incorporating different number of classes in conjunction with the refinement of the class specific parameters, such that the Akaike Information Criteria (AIC) and Consistent AIC (CAIC) are minimised (Louviere et al. 2008). Consideration should also be given to the application of the model, making sure that the number of classes specified is meaningful and practicable. Using these results, reported in Table 4, in conjunction with the interpretability of the model results themselves, it was decided that three classes would be the preferred number within this data. Table 5 presents the latent class model results.

Table 4: Class selection criteria – No attitudinal questions

Classes	2	3	4	5
LL	-2968.924	-2849.321	-2775.372	-2740.676
ρ^2	0.143	0.177	0.199	0.209
BIC	1.963	1.931	1.927	1.948
AIC	1.904	1.838	1.802	1.791
CAIC	5703.752	5357.252	5102.06	4925.374

Table 5: LCM model results – No attitudinal questions

Class Specific Parameters	**Class 1**		**Class 2**		**Class 3**	
	Par.	**(*t*-ratio)**	**Par.**	**(*t*-ratio)**	**Par.**	**(*t*-ratio)**
Petrol Constant	3.125	(12.478)	-0.520	(-3.626)	-0.327	(-5.567)
Diesel Constant	-0.049	(-0.213)	-0.923	(-6.331)	-0.224	(-4.465)
Price	-0.030	(-7.320)	-0.089	(-10.242)	-0.019	(-15.736)
Fuel Price	-1.359	(-3.116)	-1.155	(-4.132)	-0.212	(-1.766)
Registration	-0.001	(-2.062)	-0.001	(-2.885)	0.000	(-2.255)
Fuel Efficiency	-0.068	(-1.976)	-0.124	(-4.395)	0.010	(0.910)
Engine Capacity	-0.111	(-1.527)	-0.036	(-0.701)	-0.083	(-4.074)
Seating Capacity	-0.063	(-0.684)	0.166	(2.417)	0.391	(14.476)
Japanese	1.422	(5.138)	0.277	(1.407)	-0.024	(-0.320)
European	1.184	(4.588)	0.446	(2.385)	-0.080	(-1.059)
South Korean	0.062	(0.238)	0.363	(1.939)	-0.370	(-4.509)
American	1.133	(4.188)	0.087	(0.442)	-0.008	(-0.105)
Variable Surcharge	0.256	(0.379)	-0.316	(-0.591)	-0.969	(-4.743)
Annual Surcharge	0.000	(-0.109)	-0.001	(-2.883)	-0.001	(-7.035)
Class Probabilities						

Class Assignment Parameters	**Class 2**		**Class 3**	
	Par.	**(*t*-ratio)**	**Par.**	**(*t*-ratio)**
Constant	2.315	(3.409)	2.673	(4.149)
Age	-0.026	(-1.955)	-0.028	(-2.263)
No. Children	0.008	(2.354)	0.007	(2.208)

Tables 6 and 7 provide the results of modelling that includes the attitudinal questions in the class assignment process. The first immediate difference is that using the attitudinal questions allowed for the estimation of a fourth latent class when without these questions the fourth class contained only one percent of the sample. Comparing the results in Table 4 to those in Table 6, it can be seen that using these questions improves the model fit across all four variations in the number of classes specified. While sensitivities to variable and annual surcharges in the model presented in Table 5 differ on a class by class basis, there is very little context to explain why those classes differ. To assess the behavioural implications of these differences, the elasticities from each model are also provided in Table 8. These contrasts show several significantly different estimates of elasticity between the two models. Consequently, applications of these two models would result in quite different predictive results.

Table 6: Class selection criteria – Attitudinal questions included

Classes	2	3	4	5
LL	-2955.857	-2816.435	-2741.504	-2702.942
ρ^2	0.146	0.186	0.209	0.219
BIC	1.968	1.935	1.943	1.976
AIC	1.898	1.824	1.790	1.780
CAIC	5677.618	5291.48	5034.324	4849.906

Table 7: LCM model results – Attitudinal questions included

Class Specific Parameters	**Class 1**		**Class 2**		**Class 3**		**Class 4**	
	Par.	**(*t*-ratio)**	**Par.**	**(*t*-ratio)**	**Par.**	**(*t*-ratio)**	**Par.**	**(*t*-ratio)**
Petrol Constant	0.209	(2.731)	-1.113	(-10.299)	4.306	(11.241)	-0.229	(-1.460)
Diesel Constant	0.459	(6.552)	-1.694	(-14.548)	0.741	(2.345)	-0.864	(-5.248)
Price	-0.023	(-15.579)	-0.027	(-10.693)	-0.026	(-4.731)	-0.098	(-10.032)
Fuel Price	-0.437	(-3.102)	-0.009	(-0.036)	-2.038	(-3.415)	-1.367	(-4.394)
Registration	-0.001	(-2.934)	0.000	(-0.298)	-0.001	(-2.192)	-0.001	(-2.677)
Fuel Efficiency	0.027	(2.080)	-0.069	(-3.396)	-0.026	(-0.560)	-0.148	(-4.412)
Engine Capacity	-0.076	(-3.128)	-0.119	(-2.984)	-0.083	(-0.874)	-0.051	(-0.899)
Seating Capacity	0.502	(14.253)	0.185	(3.915)	-0.176	(-1.387)	0.158	(2.044)
Japanese	0.223	(2.489)	-0.499	(-3.344)	0.299	(0.792)	0.445	(1.978)
European	0.203	(2.197)	-0.526	(-3.322)	1.213	(3.603)	0.495	(2.360)
South Korean	-0.233	(-2.395)	-0.549	(-3.729)	0.254	(0.696)	0.434	(2.039)
American	0.067	(0.701)	-0.121	(-0.780)	1.242	(3.525)	0.131	(0.584)
Variable Surcharge	-0.916	(-3.836)	-1.295	(-3.148)	-1.310	(-1.579)	-0.188	(-0.314)
Annual Surcharge	-0.001	(-4.864)	-0.002	(-7.408)	-0.001	(-0.825)	-0.001	(-2.317)
Class Probabilities	***36%***		***13%***		***21%***		***31%***	

Table 7: LCM model results – Attitudinal questions included (cont.)

Class Assignment Parameters	**Class 2**		**Class 3**		**Class 4**	
	Par.	**(*t*-ratio)**	**Par.**	**(*t*-ratio)**	**Par.**	**(*t*-ratio)**
Constant	-4.892	(-3.576)	-2.531	(-2.600)	-2.766	(-2.867)
Age	0.026	(1.870)	0.057	(3.749)	0.017	(1.419)
Em1	0.129	(0.843)	-0.105	(-0.831)	-0.282	(-2.228)
Em2	0.189	(1.484)	0.359	(2.689)	0.612	(4.249)
Em3	0.158	(0.862)	-0.412	(-2.800)	-0.021	(-0.139)
Em5	0.277	(2.301)	-0.142	(-1.222)	0.221	(2.093)
Em7	-0.200	(-1.939)	0.056	(0.479)	-0.141	(-1.456)
No. Children	-0.002	(-0.658)	-0.009	(-2.513)	0.002	(0.457)

Table 8: Direct elasticity contrasts

	Petrol				
	No Attitudes		Attitudes		(t-diff)
	Mean	Std Dev	Mean	Std Dev	
Price	-0.672	0.784	-0.662	0.841	(0.490)
Fuel Price	-0.288	0.224	-0.308	0.298	(3.020)
Registration	-0.198	0.218	-0.192	0.228	(1.072)
Fuel Efficiency	-0.151	0.141	-0.149	0.196	(0.466)
Variable Surcharge	-0.046	0.071	-0.056	0.086	(5.047)
Annual Surcharge	-0.100	0.135	-0.111	0.162	(2.936)

	Diesel				
	No Attitudes		Attitudes		(t-diff)
	Mean	Std Dev	Mean	Std Dev	
Price	-0.988	0.864	-0.987	0.990	(0.043)
Fuel Price	-0.393	0.240	-0.451	0.336	(7.906)
Registration	-0.291	0.252	-0.304	0.303	(1.857)
Fuel Efficiency	-0.188	0.187	-0.179	0.266	(1.558)
Variable Surcharge	-0.069	0.103	-0.072	0.109	(1.126)
Annual Surcharge	-0.137	0.166	-0.136	0.173	(0.235)

	Hybrid				
	No Attitudes		Attitudes		(t-diff)
	Mean	Std Dev	Mean	Std Dev	
Price	-0.953	1.132	-0.912	1.407	(1.278)
Fuel Price	-0.332	0.231	-0.324	0.300	(1.189)
Registration	-0.240	0.229	-0.212	0.242	(4.730)
Fuel Efficiency	-0.160	0.176	-0.196	0.252	(6.592)
Variable Surcharge	-0.032	0.092	-0.033	0.108	(0.397)
Annual Surcharge	-0.058	0.118	-0.069	0.171	(2.980)

Given the generally better model fit and the richer information on how the classes differ, the latent class model using the attitudinal questions is felt to be the superior option. Referring to Table 7, tefre are four discrete classes within the sample with each class having different sensitivities to the attributes in the vehicle choice task. Five of the seven emissions attitude questions play a significant role in assigning individual respondents to one of the four underlying classes. Age of the respondent and the number of children in the household are the only demographic roles significant in discriminating between classes. The base class is Class 1, which signifies a class of individuals who are sensitive to both the variable and annual emissions surcharges. They also have a stronger preference relative to other classes for vehicles with a larger seating capacity and prefer diesel fuelled vehicles. Given these unique characteristics, this group can be termed “Diesel Drivers”.

Individuals in Class 2 are the most sensitive class to both the annual and variable emissions surcharge. They have the strongest preference for fuel efficient cars and vehicles with smaller engine capacities, and also prefer hybrid engines to both petrol and diesel. They also have a preference for cars with more seating capacity that are manufactured in Australia. Compared to those in Class 1, individuals who agree with the statement “drivers of high CO_2 emitting cars should pay more” but disagree that “a vehicle emissions charge is an effective way to reduce vehicle based CO_2.” It is hypothesised that this group may not agree with a vehicle based charge as the modelling indicates that they are relatively more sensitive to it. These individuals could be termed “Cost Conscious Cynics”.

Individuals within Class 3 are invariant to both the variable and the annual surcharge. This class has a strong preference for petrol cars over hybrid, and a preference diesel relative to hybrid technology. They have a preference for vehicles built in Europe or America relative to Australia. Interestingly, Class 3 is the only class for which seating capacity is not a significant determinant of choice. In terms of the people who are more likely to belong to this group, it is the latent class for which age and the number of children play a significant role. The members of this class are more likely to be older and conversely have a fewer number of children, perhaps indicating that the need to perform family duties is not as strong a consideration in the selection of a motor vehicle for this class. It is not unreasonable to hypothesise that the disposable income within this group may be higher as they no longer have dependents and are more likely to own their own home (also reflected by the lack of significance for the price of fuel or the cost of registration in their decision), meaning that any additional cost of using a motor vehicle is of relatively smaller consequence, as reflected by the insignificant impact of the variable and annual emissions charges. Given the disagree that people should be encouraged to use environmentally friendly transportations combined with their lack of sensitivity to many cost related attributes of vehicle ownership, these individuals could be thought of as "Car Lovers".

Lastly, individuals in Class 4 have a preference for hybrid vehicles, and prefer Japanese, European or South Korean vehicles relative to Australian manufacturing. They are more sensitive to the price of a motor vehicle compared to other classes and are sensitive to both the annual and variable surcharge. They agree that vehicles are the main cause of climate change and that drivers of high CO_2 emitting cars should pay more. Consequently, these characteristics suggest that this group could be thought of as "Car Critics".

5. Discussion and conclusion

This paper uses a latent class modelling to not only accommodate the preference heterogeneity but to explore determinant factors that may influence the sensitivity of individuals. Importantly, it is found that model fits are improved by incorporating attitudinal data in modelling process. A major finding is the revelation of four latent classes of individuals with differing preference structures, whose responses to the emissions charging variables differ. Members of Class 1 are sensitive to the annual surcharge and the variable surcharge; individuals in Class 2 are also sensitive to both the annual and variable charges, but are also more sensitive to these policies than individuals in other classes; Class 3 on the other hand are invariant to either charge; and Class 4 only report a sensitivity with respect to annual surcharges.

Crucially, class membership and thus behavioural responses to the charging schemes, is a function of the environmental attitudes held by individuals. Previous studies have found that results are influenced by environmental attitudes (Kotchen and Reiling 2000) and while many studies suggest that such statistics will be higher than behavioural data would specify (Wardman and Whelan 2001, Wardman and Shires 2003), the exact direction of any bias is unknown (Hensher 2010). In this study, the varying combinations of attitudes that are significant in determining class membership indicate that the interplay of attitudes and attribute significance is complex in turn indicating that, in this study, the exact influence of environmental attitudes is unclear. However, in the context of the questions used here, no one latent class can be defined entirely by entirely pro-environmental attitudes perhaps indicating that any inflationary bias on the parameter estimates may be mitigated.

Moreover, from a policy standpoint we have identified that several classes of individuals exist, informing policy makers that any discussion of emissions charging regimes should be had in light of these disparate behavioural classes, understanding that the attitudes of individuals play a significant role in determining class membership and thus changes in such attitudes can impact on their behaviour with respect to the schemes. For example, the "Cost Conscious Cynic" may not be in favour of surcharges as they don't see climate change as an issue and are sensitive to the costs of driving hence they may be biased against emissions surcharging. Policy makers could address benefits of charging by means other than climate change such as increases in public transport provisions and incentives for manufacturers to improve fuel consumption which would result in a reduction of vehicle operating costs. The class of individuals termed “Car Critics” is only a relatively small segment perhaps indicating true support for charging is small. This group may potentially represent socially desirable responders. On the other hand, “Car Lovers” are a relatively large segment. Their general lack of agreement with encouragement for environmentally friendly transit may be a proxy for a dislike of public transportation. Policy makers may find it beneficial to address benefits of charging by means other than climate change such as resulting decreases in congestion inherent in increases in vehicle costs, or the resultant revenue stream from emissions charging being used to provide better public transportation which may attract current road users to this mode of transit.

In future research we will be exploring the role of attitudes in further detail. Past research has indicated that wider socio-psychological factors influence behaviour, for example altruistic motives to others of the current generation (McConnell 1983, Randall and Stoll 1983); or ethical beliefs and feelings of moral responsibility (Spash 1997, Kotchen and Reiling 1998). Understanding the impact of socio-psychological attitudes will also be done in a wider context of choice behaviour.

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