RANDOM REGRET AND RANDOM UTILITY IN THE HOUSEHOLD PURCHASE OF A MOTOR VEHICLE

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ABSTRACT

Random utility maximisation is the preeminent behavioural theory used to model choices. An alternative paradigm, however, is random regret minimisation. While the majority of the literature examines the choices of individuals, this paper compares the choices of groups, as well individuals, in both the utility maximisation and regret minimisation frameworks and explores the influence household members have with respect to an automobile purchase decision within an interactive agency choice experiment. Regret minimisation is shown to be the preferred behavioural mechanism for groups and individuals within groups who shoulder a high degree of responsibility for the choice of the group.

INTRODUCTION

Within the discrete choice literature, the predominant focus has been on understanding the choice processes of a single decision maker. This is true not only in the study of the choices they make, but also in how they process the available information and the choice task itself as well as the criteria applied to enable a choice to be made. Less represented in the literature on stated preference is the decision making behaviour of groups. The aim of this paper is to draw together to nascent streams of research within the literature; a comparison of differing decision making paradigms within individual and group decisions.

While a single decision maker is the predominant choice agent in the majority of discrete choice studies, many choices are made by groups of individuals, household units in particular. Moreover a preponderance of decisions with appreciable financial or emotional consequences, such as housing location, medical decisions, choice of school for children, or motor vehicle choice, are made by households. Recognising the importance of group behaviour, social psychologists have long been interested in the types and decisions made by groups (*1*,*2*,*3*). However, when looking at the field of transportation, only more recently has household behaviour been of interest. Early work examined the financially burdensome choice of residential location (*4*,*5*). Furthermore, activity travel patterns of households, which are dependent on the interaction of individual activities within the household, also provided formative examples of household choice studies (*6*,*7*). Typically these studies model household outcomes as a probabilistic outcome of household characteristics; for example grocery shopping during weekdays is most likely to be undertaken independently rather than jointly and women are more likely than men to complete the household's shopping (*8*).

While the outcomes of the decisions made by groups and how variations in the composition of a group affects these outcomes is of great interest, the way in which the preferences of individuals interact in order to facilitate a group choice has also garnered attention. Specifically, the examination of how much influence each agent brings to bear on the decision of the group has been investigated, albeit sparsely, in the marketing literature (*9*,*10*,*11*). These studies use a two stage approach, first collecting individual utilities then modelling group utility as a function of individual utilities and the power structure within the group. Specifically they describe an indirect household utility function as the summation of the utilities with each utility scaled by a "power" parameter that reflects the level of bargaining power of different members within the household. A small number of studies have explored the role of influence of household members in a transportation context. Revealed preference data has been used to examine household task and time allocations, finding that husbands exert a greater share of influence over household tasks (*12*). Alternative utility specifications such as iso-elastic utility functions that, given certain conditions, can represent a range of social welfare conditions allowing for the estimation of what is, in essence, the group's attitude to inequality (*13*). The examination of holiday location choice revealing that the majority of decisions within the context of holiday selection are dominated by one agent as opposed to being bargained choices (*14*), or the preference of females are predominant in the selection of which beach to visit (*15*).

An alternative approach, akin to these methods, that endogenises the preferences of other decision makers in the ultimate group decision, is interactive agency choice experiments. Developed by Hensher and colleagues and used to examine employer/employee choice of telecommuting (*16*), freight transportation (*17*) and automobile choice (*18*), the interactive agency choice experiment methodology enables ongoing collaboration between respondents (termed agents), as preference shifts are tracked from initial singularly held preferences to group choices, through a process of negotiation and revision. The iterative nature of the methodology allows the analyst to track how preference structures are modified from initial preferences, which may or may not be in conflict, through to the ultimate group agreement or stalemate. The process requires agents to make initial choices independently after which, if agent choice is not in agreement, information about the choices made is fed back to each agent who would then be required to revise (or retain) their choice. The feedback and revision process extends for as many passes as the researcher desires.

Common among all these studies, is the assumption that random utility maximisation (RUM) underpins the choice process of individuals and groups. That is to say, that the utility of the group is assumed to be a linear additive combination of the utilities of the individuals, where weights scale the contribution of each agent's utility such that influence is inferred through these weights. Implicit in the compensatory nature of this linear-additive specification of random utility theory is the assumption that if the choice of the group is disliked by one household member it can be counterbalanced by the satisfaction of another member. This assumption may be considered less reaistic with respects to the dynamic of a group, particularly a household, where it is for example unlikely that either a husband or a wife will live in a residential location that one them dislikes immensely because the other derives high utility from the choice. Note that three alternative decision making mechanisms have been examined (*19*); a minimum and maximum utility specification where the household maximises the utility of the member who has either the maximal or minimal utility among all group members and a multilinear function defined as the weighted sum of the individual utilities plus a multiplicative form of the individual utilities which are weighted by a factor equal to the groups desire to achieve equality in utilities. The outcome of these approaches, however, resulted in a series of complicated variations in both sign and value of model parameters, leading to difficulties in interpretation.

An alternative behavioural paradigm emergent in the travel choice literature is random regret minimisation (RRM), where it is assumed that the choice of an individual is motivated by the desire to avoid a scenario where their chosen alternative is outperformed by one or more non-chosen alternatives on one or more attributes (*20*). While introduced as an approach for modelling individual decision-making, RRM can be translated to a group context as well: in a group decision-making setting, the RRM-approach postulates that the group aims to minimize group-regret, and that group regret emerges when a chosen alternative is considered less attractive than one or more non-chosen alternatives by one or more group members. It has been argued that, conceptually, the appeal of RRM in the group context is that the paradigm – rather than presupposing that the disutility of one household member can be fully compensated by the utility of another – postulates that the group would make compromises to ensure that no group member is highly unsatisfied with the choice (*21*).

The specific goal of this paper is to compare the traditional linear-additive RUM method for modelling group choices to the RRM approach, while estimating the degree of influence held by each agent. While RRM has shown promise in other applications (*20*,*21*), this represents the first attempt to model a group decision in the context of regret minimisation. The decision context is vehicle type choice, where respondents participated in an interactive agency choice experiment. The nature of the choice object, the motor vehicle, further lends itself to the RRM framework as it is suggested that regret minimisation is a particularly important (co-)determinant of decisions when choices are perceived as both difficult and important, and evaluated by others in the decision maker's social network (*22*). The paper is structured as follows: the methodology for estimating group choice via the interactive agency choice experiment is explained for both the RUM and RRM models; the choice experiment and survey approach is outlined; model results are presented; and the paper finishes with a discussion and conclusions.

METHODOLOGY

Modelling Group Decisions – Random Utility Maximisation

Consider a scenario where two agents are independently evaluating a choice task consisting of the same set of alternatives described by the same set of attributes and attribute levels. The interactive agency process, as displayed in Figure 1, begins with two such group members providing their initial choices independent of each other, which are then modelled. In the modelling process, utility functions are specified by the analyst which form the starting point for the analysis of the group decision:

$$V_{ai} = \alpha_{ai} + \sum_{k=1}^{K} (\beta_{ak} x_{ik}) \quad (2.1)$$

$$V_{bi} = \alpha_{bi} + \sum_{k=1}^{K} (\beta_{bk} x_{ik}) \quad (2.2)$$

where V_{ai} represents the observed utility derived by agent a for alternative i, α_{ai} represents a constant specific to alternative i (this value can also be generic across alternatives), x_{ik} is a vector of k design attributes associated with alternative i, β_{ak} is the corresponding vector of marginal (dis)utility parameters. Note that the total utility would be a summation of this observed utility plus an error term which captures unobserved utility. Under the RUM framework, the alternative with the highest total utility is the alternative chosen by that agent.

In the interactive agency process, the initial choices made by agents are compared. If the same alternative has been selected by both agents then it is inferred that this would be the alternative chosen by the group. Where agreement has been reached between the parties, the choice is said to be in equilibrium. After each pass, choice tasks where no equilibrium decision was reached are sent back to each agent for re-evaluation where one or more of the agents may revise their choice. This process continues until an equilibrium choice is reached or the analyst terminates the process. For the current study, three passes were set before the process was terminated as it was felt that an equilibrium outcome would be unlikely to be reached after additional passes.

For equilibrated choices, the same choice is observed for each member of the group (i.e., ignoring tasks where no agreement was reached). As such, the inferred utility of group g can be defined as:

$$V_{gi} = \alpha_{gi} + \sum_{k=1}^{K} (\beta_{gk} x_{ik}) \quad (2.3)$$

However, if the assumption is made that the group utility is a function of the individual preferences of each agent weighted by the level of influence of the agent (or perhaps in the case of a cooperative household, the agent's level of responsibility for the decision or the importance of the decision for one agent relative to the other) then it is possible to define the utility of group g as:

$$V_{gi} = \alpha_{gi} + \omega_a \left(V_{ai}\right) + (1-\omega_a)\left(V_{bi}\right), \quad (2.4)$$

which can be reformulated as:

$$V_{gi} = \alpha_{gi} + \omega_a \left(\sum_{k=1}^{K} (\beta_{aik} x_{ik}) \right) + (1 - \omega_a) \left(\sum_{k=1}^{K} (\beta_{bik} x_{ik}) \right), \qquad (2.5)$$

where ω_a is the measure of influence of agent *a* possesses relative to agent *b*. In this specification the influence measures represented by ω_a, along with any alternative specific constant used by the analyst, are the only parameters that vary freely within the model. In other words: parameters reflecting the tastes of group members for the different attributes are taken from the estimated individual-level models (2.1 and 2.2). Values of ω_a range from zero to one, with a zero result representing influence being held solely by agent *b*, and a value of one equating to the situation where the utility of agent *a* is wholly representative of the group. The midpoint, 0.5, represents the situation where both agents contribute equally to the group's utility. To ensure that ω_a is bounded, this parameter can be defined as:

$$\omega_a = \frac{e^{(\theta)}}{1 + e^{(\theta)}} \qquad (2.6)$$

Modelling Group Decisions – Random Regret Minimisation

Under the assumptions of RUM, utility is generated by how "much" of each attribute is on offer and the importance of that attribute to the individual in the generation of (dis)utility. In contrast, under RRM individuals compare a considered alternative with each of the other available alternatives across each attribute, such that the chosen alternative is not outperformed by another other alternative on one or more attributes. If an alternative is defined by more than one attribute then it is likely that regret will be generated as there will generally be another alternative in the choice set that outperforms with respect to one attribute at least. Thus, under regret minimisation, the chosen alternative is the one that offers the least regret. The observed component of the regret for individuals *a* and *b* for alternative *i* can be defined as:

$$R_{ai} = \alpha_{ai} + \sum_{j \neq i} \sum_{k} \ln\left(1 + e^{\beta_{ak}(x_{jk} - x_{ik})}\right) \qquad (2.7)$$

$$R_{bi} = \alpha_{bi} + \sum_{j \neq i} \sum_{k} \ln\left(1 + e^{\beta_{bk}(x_{jk} - x_{ik})}\right) \qquad (2.8)$$

where β_k reflects the estimated potential regret generated by changes in attribute *k*, x_{ik} is the level of attribute *k* in alternative *i* and x_{jk} the level of attribute *k* in alternative *j*. This difference between the attribute levels is taken for all alternatives in the choice set, and the sum of these differences represent the total regret for the alternative under consideration. Consequently, it is not the attribute value itself, but the difference in the values for the attributes compared to the other alternatives that generates regret. Given the addition of iid errors (representing unobserved regret) whose negative is Extreme Value Type I-distributed, choice probabilities for alternatives are given by convenient logit-formulations. See Chorus (2012) for a more in-depth discussion of the RRM-model and its properties in the context of individual decision-making.

Similar to the RUM model (Equation 2.3), a straightforward formulation of the regret of the group can be defined as:

$$R_{gi} = \alpha_{gi} + \sum_{j \neq i} \sum_{k} \ln\left(1 + e^{\beta_{gk}(x_{jk} - x_{ik})}\right) \qquad (2.9)$$

Here, it is assumed that the group acts as if it were one entity, with its own preferences and tastes. Alternatively, the regret of the group can be supposed to be the sum of the individual regrets generated by each alternative, weighted by some values ω_a and $(1 - \omega_a)$ where ω_a represents the amount to which the regret of focal agent *a* is minimised relative to the regret of the other agent. This represents the RRM-based equivalent of equation 2.4:

$$R_{gi} = \alpha_{gi} + \sum_{j \neq i} \ln(1 + e^{\omega_a (R_{ai} - R_{aj})}) + \sum_{j \neq i} \ln(1 + e^{(1-\omega_a)(R_{bi} - R_{bj})}) \qquad (2.10)$$

Here, R_{ai} and R_{bi} are defined as in equations 2.7 and 2.8, and R_{aj} and R_{bj} are derived accordingly. The difference between this household regret function and the individual-level regret functions presented in Equations 2.8 and 2.9 can be put as follows: the individual-level regret functions refer to individuals weighing the performance of different alternatives in terms of their attributes. Weights represent the importance of attributes. In contrast, the household level formulation of the regret function given in Equation 2.10 refers to a household weighing the performance of different alternatives in terms of the regret they generate for particular household members. Weights represent the importance or bargaining power of those members. The weight ω_a can similarly be defined per Equation (2.7) to ensure it is bounded between zero and one.

Besides using either the RUM-approach or the RRM-approach, another option would be to allow for a hybrid form of decision-making where individuals choose based on regret-minimization premises while household integrate regrets in a linear-additive fashion. That is, rather than minimising the regret of the regrets as implied by Equation (2.10), the group may simply attempt to maximise linear-additive utility by choosing the alternative that offers the smallest weighted regret. This behavioural specification can be estimated in the RUM framework by multiplying the total regrets by minus one, and thus transforming the alternative that generated the least regret to the alternative that generates the most utility. Consequently, the group utility can be defined as:

$$V_{gi}^{R} = \omega_a(-R_{ai}) + (1 - \omega_a)(-R_{bi}) \qquad (2.11)$$

Note that this situation is the equivalent of Equation (2.4), with individual regrets being used rather than individual utilities.

EMPIRICAL DATA

The data for the current study was collected in Australia in 2009 as part of a larger project[1] designed to assess changes in vehicle purchasing behaviour in response to a vehicle emissions charging scheme, specifically the elasticity of demand for low emitting vehicles with respect to a CO_2 emission charge per kilometre and/or per annum per vehicle. A labelled choice experiment was most appropriate for this research given the interest in estimating alternative-specific effects for each of the fuel types used in the 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, and that the hybrid alternative is defined as a fuel source that is cleaner with respect to emission levels, rather than a specific type of fuel.

TABLE 1 Attribute Levels for Stated Choice Experiment

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

[1] Note that a previous study (*26*) also compared the RRM- and RUM-paradigms based on data collected in the context of this project. In contrast with this study, Hensher et al. (in press) focus on individual decision-making only.

In establishing the choice profiles shown to respondents, a D-efficient design was used (*23*). A reference alternative, the recent purchase, is included in the experimental design to add to the relevance and comprehension of the attribute levels being assessed by the individual respondents (*24*), and can be used to reduce hypothetical bias in stated preference surveys (*25*). An efficient experimental design requires optimisation over the values in the reference alternative. However, given that the exact specification of the vehicle each respondent recently purchased is not known *a priori*, it is not possible to present each respondent with a fully optimised design. However, an approximate method was used whereby all recent purchases were defined as being one of six different body sizes (small, small luxury, medium, medium luxury, large, large luxury) and one of two fuel types (petrol or diesel). While it is possible that a design be individually tailored to each respondent, the complexity of the response task led us to pivot the elements of the choice tasks around the reference alternative, but to optimise the underlying design based on the averages for each possible vehicle class to which a recent purchase could belong.

TABLE 2 Average Vehicle used for Design Optimisation

	Small		**Medium**		**Large**	
	Petrol	**Diesel**	**Petrol**	**Diesel**	**Petrol**	**Diesel**
Purchase Price	$25,000	$28,000	$33,000	$36,000	$40,000	$43,000
Fuel Price	$1.50	$1.65	$1.50	$1.65	$1.50	$1.65
Registration (incl. CTP)	$600	$600	$600	$600	$600	$600
Annual Emissions Charge*	--	--	--	--	--	--
Variable Emissions Charge*	--	--	--	--	--	--
Fuel Efficiency	8	8	10	8	12	10
Engine Capacity	4	4	4	4	6	6
Seating Capacity	4	4	5	5	5	5
Country of Manufacture	Japan	Europe	Japan	Europe	Australia	Europe
D-error	***0.012484***	***0.012343***	***0.012837***	***0.013201***	***0.014396***	***0.013616***

	Small Luxury		**Medium Luxury**		**Large Luxury**	
	Petrol	**Diesel**	**Petrol**	**Diesel**	**Petrol**	**Diesel**
Purchase Price	$31,000	$33,000	$45,000	$47,000	$75,000	$78,000
Fuel Price	$1.50	$1.65	$1.50	$1.65	$1.50	$1.65
Registration (incl. CTP)	$600	$600	$600	$600	$600	$600
Annual Emissions Charge*	--	--	--	--	--	--
Variable Emissions Charge*	--	--	--	--	--	--
Fuel Efficiency	8	8	10	8	12	10
Engine Capacity	4	4	4	4	6	6
Seating Capacity	4	4	5	5	5	5
Country of Manufacture	Japan	Europe	Japan	Europe	Australia	Europe
D-error	***0.013345***	***0.012756***	***0.013386***	***0.012485***	***0.016423***	***0.014807***

* Note that no values for the annual or variable charges were provided as inputs into the design, rather given the five levels linked to the fuel efficiency specified for the average vehicle outlined in Table Two, the allocation of these charges over the design was random, such that the D-error was minimised.

Consequently, each respondent received choice tasks from one of twelve possible designs, depending on what category their most recent purchase could be assigned to. Table 2 shows the "average vehicle" that was used for each category in generating each experimental design, and the d-error associated with each design. In calculating each design, an analytical approach was used whereby the asymptotic variance-covariance matrix was derived via the second derivatives of the log-likelihood function of the model to be estimated. To optimise this design, different combinations of attributes are trialled, and the design with the minimised d-error after repeated iterations is used. The iterations were allowed to run uninterrupted for several days.

To ensure respondents were presented with realistic and sensible choice scenarios, a number of caveats were placed on the design. 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 task, 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 tasks, with each choice task 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. As part of the choice task, respondents were able to indicate which alternatives within each task they found unacceptable. Such a question allows for models to be estimated where alternatives over which no trading behaviour occurred can be removed. An example of the choice screen is shown in Figure 1.

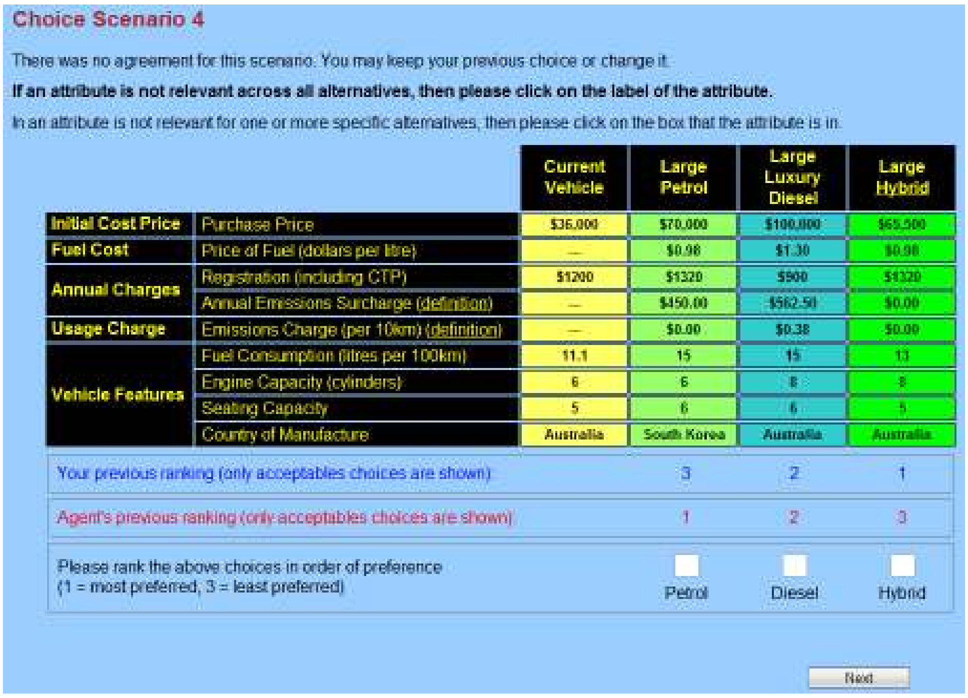

FIGURE 1 Stated Preference Task

The survey was administered to both individuals and households with a total of 131 individual respondents completing eight choice tasks each for a total of 1048 observations. With respect to households, 235 paired respondents completed four choice tasks independently (940 observations) which formed the initial choices that were comprised the starting point for the interactive agency choice experiment. Within the household, the primary agent was defined as the individual for whom the vehicle was being purchased or who would use it the most, and the partner of the primary agent was defined as secondary agent. The models estimated in this paper are estimated on four samples: individual respondents (1048 choice observations); primary respondents (940 choice observations); secondary respondents (940 choice observations); group choices from the interactive process (940 choice observations).

RESULTS

Given the exploratory nature of this paper, the random regret and random utility models are estimated as multinomial logit. The results for the individual respondents are presented in Table 3. With respect to the household dyads, Primary responses are presented in Table 4 and the Secondary in Table 5. Table 6 displays the choices made by groups via the interactive process but without power-function specification (that is, results are based on models presented in Equations 2.3 and 2.9 respectively). In all instances, extensive investigation was conducted into the influences of socio-demographic characteristics and potential interactions between the choice attributes. Across all tables, the parameters are of the expected sign.

TABLE 3 Individual Respondents

	RUM		RRM	
	Par.	**t-stat.**	**Par.**	**t-stat.**
Vehicle Price	-0.038	-8.30	-0.024	-12.67
Fuel Price	-0.568	-2.90	-0.365	-2.91
Registration	-0.001	-2.17	0.000	-2.18
Annual Emissions Surcharge	-0.001	-4.43	-0.001	-4.46
Variable Emissions Surcharge	-0.846	-2.49	-0.514	-2.41
Fuel Efficiency	-0.069	-3.84	-0.046	-4.02
Seating Capacity	0.254	6.17	0.166	6.83
Australian Manufactured	-0.319	-1.97	-0.203	-2.04
Diesel Specific Constant	-0.976	-5.86	-0.586	-7.04
Diesel European Manufactured	0.434	2.41	0.288	2.41
Vehicle Price interacted with:				
Household Income ($'000)	0.0001	1.98	0.00003	2.83
Respondent Age	0.0002	2.73	0.0001	3.00
Japan Manufactured	-0.007	-2.04	-0.005	-2.21

	Model Fit	
Log-Likelihood (Constants only)	-1137.478	
Log-Likelihood (Model)	-981.707	-981.908
AIC	1.898	1.899
Sample	1048	

TABLE 4 Primary Respondents

	RUM		RRM	
	Par.	**t-stat.**	**Par.**	**t-stat.**
Vehicle Price	-0.028	-11.86	-0.019	-12.43
Fuel Price	-0.375	-1.91	-0.242	-1.90
Annual Emissions Surcharge	-0.001	-4.06	-0.001	-4.24
Variable Emissions Surcharge	-0.566	-1.71	-0.355	-1.69
Seating Capacity	0.233	5.57	0.158	6.36
Japan Manufactured	0.355	3.48	0.232	3.44
Diesel European Manufactured	0.348	1.79	0.238	1.85
Fuel Efficiency interacted with Engine Cylinders:				
Petrol Specific	0.004	2.61	0.003	2.69
Diesel Specific	-0.005	-2.63	-0.003	-2.88

	Model Fit	
Log-Likelihood (Constants only)	-1024.646	
Log-Likelihood (Model)	-916.762	-914.288
AIC	1.970	1.964
Sample	940	

TABLE 5 Secondary Respondents

	RUM		RRM	
	Par.	**t-stat.**	**Par.**	**t-stat.**
Vehicle Price	-0.027	-11.42	-0.017	-11.73
Fuel Price	-0.536	-2.72	-0.340	-2.66
Annual Emissions Surcharge	-0.001	-2.64	0.000	-2.68
Seating Capacity	0.163	4.07	0.108	4.45
Diesel Specific Constant	-0.349	-2.30	-0.231	-2.49
Hybrid Japan Manufactured	0.343	2.01	0.230	2.01
Diesel - Employment (1=Full-time)	-0.122	-1.86	-0.078	-1.96
Hybrid - Gender (Male=1)	-0.407	-3.43	-0.266	-3.62

	Model Fit	
Log-Likelihood (Constants only)	-1012.81	
Log-Likelihood (Model)	-918.496	-918.506
AIC	1.971	1.971
Sample	940	

TABLE 6 Group Responses

	RUM		RRM	
	Par.	**t-stat.**	**Par.**	**t-stat.**
Vehicle Price	-0.033	-12.63	-0.023	-13.08
Fuel Price	-0.392	-1.93	-0.248	-1.91
Annual Emissions Surcharge	-0.001	-3.18	-0.001	-3.34
Variable Emissions Surcharge	-0.829	-2.51	-0.518	-2.53
Engine Cylinders	-0.099	-2.69	-0.065	-2.80
Seating Capacity	0.330	7.40	0.217	8.44
Petrol Specific Constant	0.316	3.63	0.217	3.77
Hybrid Japan Manufactured	2.058	3.87	1.404	8.33
Diesel Australian Manufactured	-0.394	-2.13	-0.255	-2.25
Diesel South Korea Manufactured	-0.451	-2.10	-0.283	-2.20
Vehicle Price interacted with:				
Japan Manufactured	-0.033	-3.11	-0.018	-7.23

	Model Fit	
Log-Likelihood (Constants only)	-1022.746	
Log-Likelihood (Model)	-876.458	-873.993
AIC	1.888	1.883
Sample	940	

With respect to the performance of the regret minimisation specification relative to utility maximisation, tests of the model fits tailored for the comparison of non-nested models (*27*) revealed significant differences for the primary respondent and group response models. In both instances RRM performed significantly better than RUM (p-value = 0.013 for both the primary and group models). The finding that the two models (RRM and RUM) perform equally well in the context of choices made by secondary agents while the former outperforms the latter in the context of choices made by primary agents is fully in line with the notion, highlighted in the introduction, that regret minimization is a particularly important (co-)determinant of choices when the decision-maker considers the choice to be important (*22*). Furthermore, the result that the two models (RRM and RUM) perform equally well in the context of choices made by individuals while the former outperforms the latter in the context of choices made by groups is in line with the notion, also highlighted in the introduction, that regret minimization is a particularly important (co-) determinant of choices when the decision-making entity considers the choice to be difficult (*22*); one may safely assume that a household may consider it more difficult to make a joint vehicle purchase decision than does an individual.

The parameter estimates from each of the model types are not directly comparable due to the obvious difference between what each parameter represents in the random utility versus random regret framework, but also due to differences in scale across each of the response typologies. To provide a comparative evaluation of the results from the two decision making paradigms, mean elasticities[2] are presented in Table 7. While many of the elasticities appear to be similar initially, quite large differences exist if one is to consider the percentage of different between the estimates; especially with respect to vehicle price. Generally the elasticities from the RRM model are higher than those of RUM, but this is not exclusively the case. In light of these results the Hensher et al. (in press) finding, that the RUM model is not a good approximation to the RRM model if random regret is a preferred representation of behavioural response, is reinforced.

TABLE 7 Mean Direct Elasticity Contrasts

Individual Respondents	**RUM**			**RRM**		
	Petrol	**Diesel**	**Hybrid**	**Petrol**	**Diesel**	**Hybrid**
Vehicle price ($)	-0.885	-1.110	-0.990	-1.244	-1.001	-0.839
Fuel price ($/L)	-0.369	-0.443	-0.361	-0.363	-0.455	-0.405
Annual emissions surcharge ($)	-0.153	-0.153	-0.613	-0.155	-0.150	-0.074
Variable emission surcharge($/km)	-0.086	-0.090	-0.040	-0.085	-0.082	-0.044
Registration Fee ($ per annum)	-0.259	-0.316	-0.254	-0.270	-0.314	-0.277
Fuel efficiency (litres per 100 km)	-0.356	-0.431	-0.346	-0.415	-0.409	-0.412
Primary Respondents	**RUM**			**RRM**		
	Petrol	**Diesel**	**Hybrid**	**Petrol**	**Diesel**	**Hybrid**
Vehicle price ($)	-0.714	-0.839	-0.884	-1.085	-0.281	-0.121
Fuel price ($/L)	-0.255	-0.300	-0.278	-0.265	-0.290	-0.298
Annual emissions surcharge ($)	-0.155	-0.148	-0.072	-0.176	-0.142	-0.080
Variable emission surcharge($/km)	-0.062	-0.060	-0.029	-0.064	-0.058	-0.030
Registration Fee ($ per annum)	---	---	---	---	---	---
Fuel efficiency (litres per 100 km)	---	---	---	---	---	---
Secondary Respondents	**RUM**			**RRM**		
	Petrol	**Diesel**	**Hybrid**	**Petrol**	**Diesel**	**Hybrid**
Vehicle price ($)	-0.649	-0.837	-0.833	-0.955	-0.304	-0.118
Fuel price ($/L)	-0.352	-0.455	-0.392	-0.364	-0.417	-0.421
Annual emissions surcharge ($)	-0.089	-0.096	-0.042	-0.097	-0.090	-0.045
Variable emission surcharge($/km)	---	---	---	---	---	---
Registration Fee ($ per annum)	---	---	---	---	---	---
Fuel efficiency (litres per 100 km)	---	---	---	---	---	---
Group Responses	**RUM**			**RRM**		
	Petrol	**Diesel**	**Hybrid**	**Petrol**	**Diesel**	**Hybrid**
Vehicle price ($)	-0.785	-0.965	-0.957	-1.259	-0.253	-1.452
Fuel price ($/L)	-0.253	-0.304	-0.275	-0.263	-0.293	-0.291
Annual emissions surcharge ($)	-0.112	-0.111	-0.052	-0.128	-0.110	-0.058
Variable emission surcharge($/km)	-0.086	-0.085	-0.040	-0.091	-0.083	-0.042
Registration Fee ($ per annum)	---	---	---	---	---	---
Fuel efficiency (litres per 100 km)	---	---	---	---	---	---

[2] Mean elasticities are obtained from probability weighting the respondent-specific elasticities, where the probability weight relates to the probability of choosing a particular alternative in a choice set setting. The elasticities for random regret minimisation are derived and discussed in detail by Hensher et al. (in press).

To investigate the role that each agent plays within the household choice of a motor vehicle, global power weights were estimated using the three different specifications described in Section 2 (i.e., based on Equations 2.4/2.5 for the linear-additive RUM-model, 2.10 for the RRM-model, and 2.11 for the hybrid model which supposes RRM at the individual level and linear-additive RUM-based integration of regrets at the household level). These results are presented in Table 7. Recalling that the larger the power weight, the more influence the focal agent has in the determination of the group choice, in all modelling frameworks the primary agent is shown to have significantly more influence than the secondary agent. This result provides support for the conclusion that the primary agent is largely responsible for the group decision.

In terms of how well each approach performs, both the RUM and combined RRM-RUM model outperform the pure RRM approach. The hybrid RRM-RUM model achieves the best model fit (the difference with the RUM-model being significant at a 5%-level), suggesting that individuals first identify the regret generated by each alternative and that the group subsequently – in a process of negotiation –maximises the utility of the group by selecting the alternative, weighted by influence, that generates the least regret as whole.

TABLE 8 Power Weight Comparisons

Model	Power Weight	t-stat (diff 0.5)	Log-Likelihood	AIC
RRM (Eq. 2.10)	0.754	2.77	-905.806	1.929
RUM (Eq. 2.4/2.5)	0.850	3.12	-897.517	1.912
RRM-RUM (Eq. 2.11)	0.858	3.15	-894.272	1.905

In other words, the best fitting model with power-weights assumes RRM at the level of the individuals, and RUM at the group level (integration of the individual regrets). This suggests that the individuals when making their decisions have been anticipating the group decision to be made in the end, and as such have been incorporating this accountability-factor in their decision-making at the individual level giving rise to regret minimization. In this light is interesting to note that the RRM-model predicts the occurrence of so-called compromise effects in the sense that alternatives that have an in-between performance on all attributes (rather than having a strong performance on some attributes and a poor performance on others) are assigned a higher choice probability in the context of RRM-models than in the context of linear-additive RUM-models. In other words, our results suggest that when making their individual-level decisions, group members tend to pick compromise alternatives with an in-between performance on all attributes, possibly anticipating that such choices are more easy to defend in a forthcoming negotiation process than choices for alternatives with a more extreme performance on different attributes. This line of argumentation is in line with the notion that regret minimization and the search for compromise alternatives are particularly important (co-)determinants of choices when the individual anticipates being held accountable for his or her choice later on (*28*,*22*).

Despite the intuitive interpretation of obtained results concerning the relative model fit of RRM, RUM, and Hybrid approaches, it should be kept in mind that differences in model fit – although mostly statistically significant – are small. Therefore, results and interpretations presented here should best be considered preliminary, rather than final. Future empirical research is needed to study to what extent our results can replicated in the context of other datasets.

DISCUSSION AND CONCLUSION

Regret minimisation has been shown to influence decision making at the physiological and neurological level (*29*) and to be a prime motivation when the decision is risky (*30*). The household decision of which automobile to purchase, in the context of differing preferences, qualifies as such a risky decision given the cost and durable nature of the purchase. This paper examines the role of regret minimisation in group decision making, the first to do so within the wider literature with respect to this subject. In a broad summary, regret minimisation is shown to be the preferred behavioural mechanism for groups and individuals within groups who shoulder a high degree of responsibility for the choice of the group. In contrast, there is no difference between regret minimisation and utility maximisation specifications for individuals and group respondents with a lesser role in the ultimate group decision. These results are consistent with the axiom that regret minimization is a motivating factor when the choice being made is considered difficult by those making it (*22*). It is not unreasonable to assume that a household, who likely has conflicting preferences to equilibrate, finds the vehicle purchase decision more difficult than an individual who need only satisfy themself: recent research has shown that group choices are more stochastic than those of individuals (*31*). Furthermore, the analysis of influence in this paper reveals that the primary agent, the individual in the group for whom the vehicle is primarily being purchased, has a great deal of influence and responsibility for the household choice. Any individual with the responsibility for such a high cost purchase is likely to find the choice a difficult one to make, much more so than the secondary agent who plays a minimal role in the group decision.

The role of responsibility and the requirement that decisions be justified has been shown to impact significantly on decision making (*32*), with people in such positions often anticipating potential criticisms of their choices (*33*,*34*) and exhibit significantly higher risk aversion (*35*). In such situations, regret minimisation is an intuitively appealing behavioural process, as the choice that minimises the differences across all alternatives on offer is likely to represent the “safe” choice for the group; a choice that is perhaps more easily justified to others. Given the preliminary evidence presented in this paper, it is recommended that further examination of the role of regret minimisation in group decisions where one or more agents may exhibit high degrees of responsibility be conducted. In this study, the vehicle choice task is such that the attributes are largely tangible or objective vehicle features. For such attributes (fuel efficiency, body type, number of seats) it is easier to generate a criterion particularly in the instance of clarity over what is or isn’t desirable. For example, a respondent might easily specify that the vehicle be petrol, use no more than 11 litres per 100 kilometres and seats at least four adults. Future studies should seek to examine more subjective attributes (such as styling, comfort or status) as it is hypothesised that regret minimisation will be a stronger influence under these conditions, even more so for group choices where the subjective opinion of social groups are a motivating factor. Currently, work is being undertaken to extend the regret minimisation framework into attribute specific influence measures, a non-trivial exercise in the estimation of the pure random regret minimisation influence model.

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