Bounding WTP distributions to reflect the ‘actual’ consideration set

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Bounding WTP distributions to reflect the ‘actual’ consideration set
When analysing discrete choice data, it is typically assumed that respondents consider all offered alternatives.

Respondent’s choices are expected to be based on the alternatives that provides them with the highest utility.

But it may be the case that respondents restrict their consideration set to those alternatives that do not exceed their maximum WTP.

Ignoring this is likely to be suboptimal, and perhaps lead to misguided inferences, as the model does not reflect actual choice behaviour.
**Presented choice set \( \neq \) actual choice set**

Do all respondents consider all alternatives?

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Choice? ○ ○ ○ ○ ○
Presented choice set ≠ actual choice set

Some may exclude the most expensive alternative(s).

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Choice?

Bounding WTP distributions to reflect the ‘actual’ consideration set
Presented choice set ≠ actual choice set

While others exclude alternative(s) beyond £10.

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Some may even choose among the cheapest alternative(s).

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Choice?:
- Option A: ○
- Option B: ○
- Option C: ○
- Option D: ○
Not unique to stated preferences

This behaviour is not just confined to stated preference methods—it reflects actual behaviour.

Bounding WTP distributions to reflect the ‘actual’ consideration set
Motivation

Our work is motivated by the fact that greater behavioural insights into the alternatives that actually have an influence on respondent’s choices should help at the analytical stage.

Failing to account for this processing strategy is likely to have implications on marginal WTP estimates.

Therefore, we explore this using a number of models.
Bounding WTP distributions to reflect the ‘actual’ consideration set
Utility in WTP-space

Where respondents are indexed by $n$, choice occasions by $t$, the price and non-price attributes are represented by $p$ and $x$ respectively, the utility in WTP-space of the chosen alternative $i$, can be written as:

$$U_{nit} = -\alpha p_{nit} + (\alpha w) x_{nit} + \varepsilon_{nit},$$

where:

- $\alpha$ and $w$ are parameters associated with price/scale and the marginal WTP estimates respectively; and,
- $\varepsilon$ is an iid type I extreme value (EV1) distributed error term, with constant variance of $\pi^2/6$. 

Bounding WTP distributions to reflect the ‘actual’ consideration set
Given these assumptions, the probability of the sequence of choices made by individual $n$ can be represented by the MNL model:

$$
\Pr (y_n|p_n, x_n) = \prod_{t=1}^{T_n} \frac{\exp (-\alpha p_{nit} + (\alpha w) x_{nit})}{\sum_{j=1}^{J} \exp (-\alpha p_{njt} + (\alpha w) x_{njt})},
$$

where:

- $y_n$ gives the sequence of choices over the $T_n$ choice occasions for respondent $n$, i.e., $y_n = \langle i_{n1}, i_{n2}, \ldots, i_{nT_n} \rangle$. 
The MNL model typically assumes that:

- All respondents consider all offered alternatives, including those that are priced higher than their maximum marginal WTP.
- All respondents share the same preferences.

These are (arguably) very strong assumptions, which may not hold in reality.
Choice set formation

Respondents may restrict their consideration set to alternatives that do not exceed their maximum marginal WTP.

A probabilistic model can be formulated to model this type of behaviour to help distinguish between:

i  The **deterministic choice set**, as generated by the experimental design.

ii  The respondent’s **actual consideration set**, from the alternatives offered in the choice experiment.

For this type of analysis we extend the **independent availability logit** (IAL) model.
IAL model

The probability of choice in the IAL model is given by:

\[ \Pr(y_n|p_n, x_n) = \sum_{s=1}^{S} \pi_s \Pr(y_n|C_s, p_n, x_n), \]

where:

- \( \Pr(y_n|C_s, p_n, x_n) \) is the conditional probability of the sequence of choices given the choice set is \( C_s \); 
- \( S \) is the set of subsets; and,
- \( \pi_s \) is the probability that \( C_s \) is the ‘true’ choice set.
IAL model

The model assumes that choice sets are latent and vary across the $S$ classes, while the conditional choice model is MNL:

$$\Pr (y_n|C_s, p_n, x_n) = \prod_{t=1}^{T_n} \frac{\exp (-\alpha p_{nit} + (\alpha w) x_{nit})}{\sum_{j \in C_s} \exp (-\alpha p_{njt} + (\alpha w) x_{njt})}.$$
Typically in an IAL model the number of classes, $S$, is determined as a function of the number of alternatives (i.e., $2^J$ possible choice sets).

We are interested in exploring whether respondents restrict their choice set on the basis of the cost attribute.

- Respondents may rationally restrict their consideration set to include only those alternatives that do not exceed their maximum marginal WTP.
Choice set formation and the cost attribute

Consider the example where there are four cost levels, $p = \{\text{\£0, \£1, \£2, \£3}\}$, four types of behaviour can be identified.
Consider the example where there are four cost levels, $p = \{£0, £1, £2, £3\}$, four types of behaviour can be identified.

### Class 1

A subset whose actual choice set is the same as the set offered in the choice experiment (i.e., $C_{s=1} = \{A,B,C,SQ\}$).

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Bounding WTP distributions to reflect the ‘actual’ consideration set
Choice set formation and the cost attribute

Consider the example where there are four cost levels, \( p = \{\£0, \£1, \£2, \£3\} \), four types of behaviour can be identified.

### Class 2

A subset who restrict their actual choice set to include alternatives that cost less than \( \£3 \) (i.e., \( C_{s=2} = \{B, C, SQ\} \)).

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Choice set formation and the cost attribute

Consider the example where there are four cost levels, \( p = \{£0, £1, £2, £3\} \), four types of behaviour can be identified.

### Class 3

A subset who restrict their actual choice set to include alternatives that cost less than £2 (i.e., \( C_{s=3} = \{B, SQ\} \)).

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Bounding WTP distributions to reflect the ‘actual’ consideration set
Choice set formation and the cost attribute

Consider the example where there are four cost levels, \( p = \{\text{£0}, \text{£1}, \text{£2}, \text{£3}\} \), four types of behaviour can be identified.

Class 4

A subset who restrict their actual choice set to include alternatives that cost less than £1 (i.e., \( C_{s=4} = \{\text{SQ}\} \)).

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Bounds of the aggregate marginal WTP

These patterns can be dealt with using an IAL model with four classes (i.e., each class describes a unique consideration set).

An especially important feature of the insight into the cost level(s) of the restricted choice sets is that it gives an indication of the bounds of the aggregate marginal WTP values.
Bounds of the aggregate marginal WTP

These patterns can be dealt with using an IAL model with four classes (i.e., each class describes a unique consideration set).

An especially important feature of the insight into the cost level(s) of the restricted choice sets is that it gives an indication of the bounds of the aggregate marginal WTP values.

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<td>3 ≤ w_{1s=1} + w_{2s=1} &lt; ∞</td>
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Class 2

\[ 2 \leq w_{1s=2} + w_{2s=2} < 3 \]

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Bounding WTP distributions to reflect the ‘actual’ consideration set
Bounds of the aggregate marginal WTP

These patterns can be dealt with using an IAL model with four classes (i.e., each class describes a unique consideration set).

An especially important feature of the insight into the cost level(s) of the restricted choice sets is that it gives an indication of the bounds of the aggregate marginal WTP values.

Class 3

\[ 1 \leq w_{1s=3} + w_{2s=3} < 2 \]

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Bounding WTP distributions to reflect the ‘actual’ consideration set
Bounds of the aggregate marginal WTP

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An especially important feature of the insight into the cost level(s) of the restricted choice sets is that it gives an indication of the bounds of the aggregate marginal WTP values.

Class 4

\[ 0 \leq w_{1s=1} + w_{2s=1} < 1 \]

But no trade-offs!

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IAL model with bounded marginal WTP

We adjust the IAL model with class-specific marginal WTP values:

\[
\text{Pr}(y_n|p_n, x_n) = \sum_{s=1}^{S} \pi_s \prod_{t=1}^{T_n} \frac{\exp\left(-\alpha p_{nit} + (\alpha w_s) x_{nit}\right)}{\sum_{j \in C_s} \exp\left(-\alpha p_{nit} + (\alpha w_s) x_{nit}\right)},
\]

where:

- \(p_{ls} \leq \sum_{\forall K} w_{ns} < p_{us}\) restrictions are imposed to ensure that the aggregated marginal WTP estimates are within lower and upper the bounds (\(p_{ls}\) and \(p_{us}\) respectively) implied by the consideration set.
We are also interested in capturing the heterogeneity in respondents’ marginal WTP within consideration set classes.

For this reason, we treat $\tilde{\alpha}_n$ and $\tilde{w}_n$ as continuously distributed random terms entering the WTP-space utility function.
Latent class random parameters logit

The unconditional choice probability is the integral of the logit formula over all possible values of $\tilde{\alpha}_n$ and $\tilde{w}_n$ weighted by the class probabilities to also integrate out the different $C_{sn}$:

$$
\Pr(y_n|w_n, p_n, x_n, \Omega) = \sum_{s=1}^{S} \pi_s \int \prod_{t=1}^{T_n} \frac{\exp(-\tilde{\alpha}_n p_{nit} + (\tilde{\alpha}_n \tilde{w}_{sn}) x_{nit})}{\sum_{j \in C_{sn}} \exp(-\tilde{\alpha}_n p_{nit} + (\tilde{\alpha}_n \tilde{w}_{sn}) x_{nit})} f(\Theta_{ns}|\Omega_s) \, d(\Theta_{ns}).
$$

In this combined latent class random parameters logit (LC-RPL) specification, parameters of the distributions (i.e., $\Omega_s$) and probabilities associated with each consideration set based on WTP thresholds are obtained.
Model estimation

We compare four model specifications:

1. MNL;
2. IC-IAL;
3. RPL; and,
4. LC-RPL-IAL.
### Model estimation

**MNL**

Parameter for price/scale, $\alpha$, and marginal WTP parameters, $w_k$.

The deterministic choice set is assumed.

Bounding WTP distributions to reflect the ‘actual’ consideration set.
Model estimation

**LC-IAL**

So that the class-specific marginal WTP distributions, $w_{ks}$, respect the bounds implied by the consideration set they are estimated subject to $p_{ls} \leq \sum_{\forall K} w_{ks} < p_{us}$. 

Bounding WTP distributions to reflect the ‘actual’ consideration set
RPL

\( \tilde{\alpha} \) is specified as having a log-Normal distribution.

The marginal WTP distributions, \( \tilde{w}_k \), are specified as having Uniform distributions:

\[
\tilde{w}_k = a_k + (b_k - a_k) v_k,
\]

where \( v \) is a draw from a standard Uniform distribution and where \( a_k \) and \( b_k \) are lower and upper limits respectively, subject to \( 0 \leq a_k \leq b_k \).

The deterministic choice set is assumed.

Bounding WTP distributions to reflect the ‘actual’ consideration set
Model estimation

LC-RPL-IAL

\( \tilde{\alpha} \) is specified as having a log-Normal distribution.

So that the class-specific marginal WTP distributions, \( \tilde{w}_{k_s} \), respect the bounds implied by the consideration set, we opt for Uniform distributions:

\[
\tilde{w}_{k_s} = a_{k_s} + (b_{k_s} - a_{k_s}) \nu_{k_s},
\]

where \( \nu \) is a draw from a standard Uniform distribution and where \( a_{k_s} \) and \( b_{k_s} \) are lower and upper limits respectively, subject to \( 0 \leq a_{k_s} \leq b_{k_s} \) and

\[
p_{l_s} \leq \sum_{\forall K} a_{k_s} \leq \sum_{\forall K} b_{k_s} < p_{u_s}.
\]
Introduction

Background

Motivation

Modelling approach

Background notation

Accounting for endogenous WTP bounds

Accounting for the heterogeneity in marginal WTP

Model estimation

Case-study

Results

Overview

Marginal WTP estimates

Conclusions

Bounding WTP distributions to reflect the ‘actual’ consideration set
The case-study explored the WTP for value-added services to chicken meat.

Attributes:

- **Food testing standards** (enhanced *versus* current standard);
- **Traceability standards** (enhanced *versus* current standard);
- **Animal health/welfare standards** (enhanced *versus* current standard);
- **Region of origin** (British Isles *versus* outside British Isles); and,
- **Price** (ranging between £2.00 and £4.50 in £0.50 increments).
Experimental design and data collection

The final design (obtained via a Bayesian efficient experimental design) comprised of two blocks of 8 choices tasks.

The choice data was collected during September 2010 via an on-line survey.

In total, 622 respondents residing in Great Britain were recruited, resulting in 4,976 observations for model estimation.
Bounding WTP distributions to reflect the ‘actual’ consideration set
## Overview

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<th>RPL</th>
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<td>AIC</td>
<td>8,349.230</td>
<td>7,598.850</td>
<td>7,169.918</td>
<td>7,269.936</td>
</tr>
<tr>
<td>BIC</td>
<td>8,388.043</td>
<td>7,839.688</td>
<td>7,248.042</td>
<td>7,641.146</td>
</tr>
</tbody>
</table>

Bounding WTP distributions to reflect the ‘actual’ consideration set
# Class probabilities

<table>
<thead>
<tr>
<th></th>
<th>MNL est.</th>
<th>MNL t-rat.</th>
<th>LC-IAL est.</th>
<th>LC-IAL t-rat.</th>
<th>RPL est.</th>
<th>RPL t-rat.</th>
<th>LC-RPL-IAL est.</th>
<th>LC-RPL-IAL t-rat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_{C_s=1}$</td>
<td>1.000</td>
<td>fixed</td>
<td>0.888</td>
<td>2.88$^a$</td>
<td>1.000</td>
<td>fixed</td>
<td>0.864</td>
<td>3.77$^a$</td>
</tr>
<tr>
<td>$\pi_{C_s=2}$</td>
<td>0.053</td>
<td>4.48</td>
<td></td>
<td></td>
<td>0.032</td>
<td>4.65</td>
<td>0.012</td>
<td>2.29</td>
</tr>
<tr>
<td>$\pi_{C_s=3}$</td>
<td>0.019</td>
<td>2.66</td>
<td></td>
<td></td>
<td>0.012</td>
<td>2.29</td>
<td>0.057</td>
<td>22.11</td>
</tr>
<tr>
<td>$\pi_{C_s=4}$</td>
<td>&lt;0.001</td>
<td>&lt;0.01</td>
<td></td>
<td></td>
<td>0.004</td>
<td>1.63</td>
<td>0.013</td>
<td>2.71</td>
</tr>
<tr>
<td>$\pi_{C_s=5}$</td>
<td>0.009</td>
<td>1.82</td>
<td></td>
<td></td>
<td>0.004</td>
<td>1.63</td>
<td>0.013</td>
<td>2.71</td>
</tr>
<tr>
<td>$\pi_{C_s=6}$</td>
<td>0.009</td>
<td>1.23</td>
<td></td>
<td></td>
<td>0.009</td>
<td>1.23</td>
<td>0.018</td>
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<tr>
<td>$\pi_{C_s=7}$</td>
<td>0.020</td>
<td>2.63</td>
<td></td>
<td></td>
<td>0.020</td>
<td>2.63</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^a$ t-ratios for $\pi_{C_s=1}$ test $H_0 : \pi = 1$.

**Class 1:** actual choice set included alternatives priced up to and including £4.50 (i.e., is the same as the set offered in the choice experiment);

**Class 2:** actual choice set only included alternatives priced up to and including £4.00;

**Class 3:** actual choice set only included alternatives priced up to and including £3.50;

**Class 4:** actual choice set only included alternatives priced up to and including £3.00;

**Class 5:** actual choice set only included alternatives priced up to and including £2.50;

**Class 6:** actual choice set only included alternatives priced up to and including £2.00; and,

**Class 7:** actual choice set is confined to the zero-priced ‘buy none’ alternative.
Marginal WTPs

All four models produce very similar central tendency statistics for all attributes.

However, we find large differences in marginal WTP distributions for the baseline chicken product.

- Both the LC-IAL and LC-RPL-IAL models identify the realistic situation of a mass who would be willing to pay £0.
- The RPL model led to exaggerated central tendency statistics of marginal WTP.
- The upper tail of the marginal WTP distribution becomes less extreme as we move from the RPL model to the LC-RPL-IAL model.
Aggregated marginal WTP (£ per pack of chicken)

Bounding WTP distributions to reflect the ‘actual’ consideration set
Introduction

- Background
- Motivation

Modelling approach

- Background notation
- Accounting for endogenous WTP bounds
- Accounting for the heterogeneity in marginal WTP
- Model estimation

Case-study

Results

- Overview
- Marginal WTP estimates

Conclusions

Bounding WTP distributions to reflect the ‘actual’ consideration set
Our results suggest that a share of respondents do not attend to all alternatives.

- These respondents restrict their ‘actual’ consideration set to only those that do not exceed their maximum WTP.

The repercussions on the estimated marginal WTP distributions are substantive.

- The marginal WTP distribution for a ‘premium’ chicken product is, on average, up to 20 per cent lower when actual consideration sets and WTP thresholds are accounted for.
Conclusions

While specific to this dataset, this result highlights the problem of ignoring the fact that even a small proportion of respondents eliminate alternatives that exceed their maximum WTP.

We feel our results highlight the need for further research in this area.

However, we acknowledge the confounding between heterogeneity and processing.

- This makes it difficult to identify whether the latent classes reflect threshold behaviour or preference heterogeneity.
- However, it would seem illogical not to bound marginal WTP where it is believed that respondents only considered alternatives that lie within their cost threshold.
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