Assessment of Hypothetical Bias in the Estimation of the VOT Using SP and SP-off-RP Data

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Agenda

1. Problem
2. Experiment
3. Results
4. Conclusion
Context

- **Choice models**
  - Understand behavior
  - Estimated using empirical observations
  - Retrieve the relative importance of attributes

- **Various applications**
  - Predict behavior
  - Design incentives
  - *Willingness to pay (VOT)*
RP vs SP

- Revealed Preference (RP) choice model
  - Limited range of attributes types and variance
  - Expensive
  - True behavior
- Stated Preference (SP) choice model
  - Any range of attributes types and variance
  - Relatively inexpensive
  - Hypothetical bias
Hypothetical Bias

• Transportation
  – SP Value of Time (VOT) ~50% of RP’s
  – Brownstone & Small (2005), Issacson (2007)
  – From neglecting true scheduling constraints?

• Marketing
  – WTP for goods overestimated ~35%
  – Murphy et al. (2005) [review of 28 studies]
  – From neglecting true budget constraints?
Curbing Hypothetical Bias

- Cheap Talk: mixed results
- Monetary Incentives: positive results
- Pivoting: negative results
- SP-off-RP: Not investigated yet

Goals:
- Confirm hypothetical bias in SP experiments
- Assess SP-off-RP experiments ability to correct it
SP-off-RP: the best of both worlds

• Train&Wilson (2008)
• First collect RP data
  – Alternatives in SP are the same of the RP
  – SP attributes shifted to change RP choice
    • e.g. chosen RP alternative worsened in 10% and non-chosen RP alts. improved in 15%
• Endogeneity: Inconsistent estimators
  – Train&Wilson FIML method rarely applied
  – Guevara&Hess LIML (robust and easy)
SP-off-RP: Example
van Cranenburgh et al. (2014)

• Vacation destination choice model
  – RP: Elicit six alternatives considered on a previous vacation period + the choice
  – SP: All attributes of RP alternatives varied, except for the destinations, enhancing realism
Methodology

- Revealed Preferences: VOT (RP)
  - Self-reported alternatives, self-reported attributes and choice of recent commute
  - Ex-post recalculation of attributes from Google-Maps
- SP-off-RP: VOT (SP-off-RP)
  - Generate 4 profiles varying self-reported RP attribs.
- Stated Preference: VOT (SP)
  - Generate 4 exogenous car & transit profiles

➢ Order randomized to avoid learn./tired. bias
➢ Compare VOT(SP-off-RP) & (SP) with (RP)
➢ Perform out-of-sample analysis
SP-off-RP Design

- Seek variance yet realism on automatic display
- **Same** self-reported RP choice-set
- Randomly choose which attributes to vary
  - only cost
  - only time
  - only cost and waiting time
  - only cost and travel time
  - cost, time and waiting time
- RP chosen alternative worsened in $U(1.2, 2)$
- RP non-chosen improved in $U\left(\frac{1}{2}; \frac{1}{1.2}\right)$
## SP-off-RP Design: Example

### Experiment

<table>
<thead>
<tr>
<th>RP</th>
<th>Cost</th>
<th>Travel time</th>
<th>Waiting time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>$3.000</td>
<td>25</td>
<td>0</td>
</tr>
<tr>
<td>Transit</td>
<td>$700</td>
<td>40</td>
<td>7</td>
</tr>
<tr>
<td>Bicycle</td>
<td>$0</td>
<td>45</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SP-off-RP</th>
<th>Cost</th>
<th>Travel time</th>
<th>Waiting time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car ( U(1.2 ; 2) )</td>
<td>$3.800</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Transit ( U(\frac{1}{2} ; \frac{1}{1.2}) )</td>
<td>$500</td>
<td>32</td>
<td>7</td>
</tr>
<tr>
<td>Bicycle ( U(\frac{1}{2} ; \frac{1}{1.2}) )</td>
<td>$0</td>
<td>35</td>
<td>0</td>
</tr>
</tbody>
</table>
## Analysis

- Compare VOT estimates obtained from each experiment, reporting confidence interval
- Likelihood ratio test to check whether pairs of estimates are the same for time and cost
Analysis

- Compare VOT estimates obtained from each experiment, reporting confidence interval
- Likelihood ratio test to check whether pairs of estimates are the same for time and cost

\[
\begin{align*}
\beta_k^{RP} & \quad \text{RP Data} \\
\beta_k^{SP} & \quad \text{SP Data}
\end{align*}
\]
Analysis

• 80/20 out-of-sample analysis predicting RP choices. SP constants recalibrated (Train, 2009)

\[ N \]

\[ \beta^{SP}_j \quad \beta^{SP-off-RP}_j \]

• Sample:
  – 322 individuals (322 RP, 1228 SP and SP-off-RP)
  – 80% students, 12% workers, 8% others
## Value of Time

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</tr>
</thead>
<tbody>
<tr>
<td>Student - High Income</td>
<td>RP: 5.190** (1.690)</td>
<td>SP: 2.580*** (290)</td>
<td>SP-off-RP: 7.050*** (1.620)</td>
</tr>
<tr>
<td>Student - Low Income</td>
<td>RP: 2.320** (890)</td>
<td>SP: 2.150*** (230)</td>
<td>SP-off-RP: 3.030*** (590)</td>
</tr>
</tbody>
</table>

*In Chilean pesos per hour (680 pesos/US Dollar)*  
***p<0.001, **p<0.01, *p<0.05

### Overall:
- VOT(SP) 53% of RP, in line with literature
- VOT(SP-off-RP) ~ RP
• RP larger variance due to smaller sample size
• SP-off-RP shows smaller empirical bias than SP
### Likelihood Ratio Tests

\[ \Delta L = -2 (L_R - L_U) \sim \chi^2_g \]

Null hypothesis: No hypothetical bias. Models share coefficients, besides scale and ASCs (\(\Delta L = 0\))

<table>
<thead>
<tr>
<th></th>
<th>RP v/s SP</th>
<th>RP v/s SP-off-RP</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\Delta L)</td>
<td>17.6</td>
<td>5.12</td>
</tr>
<tr>
<td>p-value</td>
<td>0.00731</td>
<td>0.530</td>
</tr>
<tr>
<td>Null Hypothetical Bias?</td>
<td>✗</td>
<td>✓</td>
</tr>
</tbody>
</table>
80-20 Out-of-Sample Analysis

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</thead>
<tbody>
<tr>
<td>SP</td>
<td>Average Hit-rate</td>
<td>68%</td>
<td>Average Likelihood</td>
</tr>
<tr>
<td>SP-off -RP</td>
<td>73%</td>
<td>59%</td>
<td>124</td>
</tr>
</tbody>
</table>

1000 repetitions
Significant differences (pvalue<0.001)
Conclusions

- **Stated Preferences (SP)**
  - VOT 53% of RP
  - Strong evidence suggesting abandoning SP-alone approach

- **SP-off-RP**
  - Results closer to RP (equality cannot be discarded)
  - Almost as inexpensive and flexible as SP without the bias
  - **More evidence is needed**

- **Future Work: Why SP-off-RP seem to work?**
  - Attribute levels, trade-off or both? (Hensher, 2004)
  - Compare activity at the brain level (Camerer&Mobbs, 2017)
  - Contrast with other methods (e.g. ACA, pivoting, etc.)
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