Fast Polyhedral Adaptive Conjoint Estimation

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Changes in Product Development

• Product development – more rapid feedback more often.

• Larger numbers of “needs” or features.

• More dispersed and global.
On-line Market Research

- Increasing interest
  - General Mills: 60% of interviewing on-line
  - Procter & Gamble: investments in “MarketTools”
- Pre-recruited Web Panels
  - NFO Interactive
  - AOL
  - Knowledge Networks
  - Greenfield Online
  - Harris Interactive
  - ...
Conjoint Analysis

- One of the most used quantitative Market Research methods
- 30 years of existence and 150+ published articles
- Advantages:
  - detailed understanding of the respondent’s preferences
  - Allows designing “optimal” products
- Disadvantages:
  - complex to design and administer
  - Often requires long interviews
Conjoint analysis goes online: Polaroid’s I-Zone Camera
8 Questions

Ready for something a little different? Here's what to do:

1. We are going to show you 8 different pairs of cameras with some of the features and options we just showed you.
2. For each of the 8 pairs, compare the 2 different cameras.
3. Click on the white circle below to tell us how much you like one camera compared to the other.
4. Touch the yellow dots to see what each white circle means.
5. Try the example question below...

<table>
<thead>
<tr>
<th>Features</th>
<th>Camera A</th>
<th>Camera B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>$34.99</td>
<td>$24.99</td>
</tr>
<tr>
<td>Picture Removal</td>
<td>Manual</td>
<td>Automatic</td>
</tr>
<tr>
<td>Picture Taking</td>
<td>2 Step</td>
<td>1 Step</td>
</tr>
<tr>
<td>Styling Covers</td>
<td>Changeable</td>
<td>Permanent</td>
</tr>
</tbody>
</table>

Need the scale? Touch the yellow dot

I like A completely more than B
I like B completely more than A

Click on the feature icons for a reminder.
Issues with Online conjoint analysis

- Respondents burden is a bigger issue online:
  - Impatience
  - Wear out
- Not always enough to adapt traditional Market research methods to the Internet
- On the other hand, the Internet allows online computation, while the consumer is taking the questionnaire
- Questionnaire becomes a “dialogue” with the respondent: adaptive Conjoint Analysis
Purpose of “FastPACE”

• A new form of web-based Conjoint Analysis
• Shorter Interviews
• Better estimates of the consumers’ preferences
Approach

- Questions are designed adaptively in order to maximize information
- New estimation method, requiring fewer questions than traditional methods
Conjoint Analysis: an example

- Timbuk2 Designs (www.timbuk2.com)
Today: Timbuk2’s laptop bag
2000: Which is the “best” bag?

OR

OR

OR
9 features -> 9 design choices
And, finally,
Conjoint approach

- Objective: estimate the respondent’s Utility (~valuation) for each of the features (price is a feature)
- Model: total Utility of a bag = sum of the Utilities of its features

Ex: \[ U(\text{bag}) = U(\text{price}) + U(\text{flap closure}) + U(\text{handle}) + U(\text{palm holder}) + U(\text{logo}) + U(\text{mesh pocket}) \]
Example: Polaroid’s I-Zone camera

REGRESSION

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>Std. Error</th>
<th>t</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>15.509</td>
<td>5.672</td>
<td>2.734</td>
<td>.006</td>
</tr>
<tr>
<td>Price ($34.99 vs. 24.99)</td>
<td>22.645</td>
<td>3.043</td>
<td>7.441</td>
<td>.000</td>
</tr>
<tr>
<td>Removable Covers</td>
<td>21.151</td>
<td>3.164</td>
<td>6.685</td>
<td>.000</td>
</tr>
<tr>
<td>Picture Quality</td>
<td>30.505</td>
<td>6.334</td>
<td>4.816</td>
<td>.000</td>
</tr>
<tr>
<td>Auto vs. 2-step</td>
<td>-0.838</td>
<td>2.776</td>
<td>-0.302</td>
<td>.763</td>
</tr>
</tbody>
</table>

Dependent Variable = Relative Preference Between Pairs of Profiles
2 types of Conjoint questions

**PAIRED - COMPARISONS**

<table>
<thead>
<tr>
<th>Features</th>
<th>Camera A</th>
<th>Camera B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Picture Quality</td>
<td>Option A</td>
<td>Option B</td>
</tr>
<tr>
<td>Picture Taking</td>
<td>2 Step</td>
<td>1 Step</td>
</tr>
<tr>
<td>Styling Covers</td>
<td>Changeable</td>
<td>Permanent</td>
</tr>
</tbody>
</table>

Need the scale? Touch the yellow dot

*Click on the feature icons for a reminder.*

<table>
<thead>
<tr>
<th>Features</th>
<th>Camera M</th>
<th>Camera N</th>
<th>Camera P</th>
<th>Camera Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price</td>
<td>$34.99</td>
<td>$24.99</td>
<td>$34.99</td>
<td>None of these cameras.</td>
</tr>
<tr>
<td>Picture Removal</td>
<td>Manual</td>
<td>Automatic</td>
<td>Automatic</td>
<td></td>
</tr>
<tr>
<td>Picture Taking</td>
<td>2 Step</td>
<td>1 Step</td>
<td>2 Step</td>
<td></td>
</tr>
<tr>
<td>Styling Covers</td>
<td>Changeable</td>
<td>Permanent</td>
<td>Permanent</td>
<td></td>
</tr>
<tr>
<td>Picture Quality</td>
<td>Option B</td>
<td>Option A</td>
<td>Option B</td>
<td></td>
</tr>
<tr>
<td>Camera Opening</td>
<td>Slide Open</td>
<td>Fixed</td>
<td>Fixed</td>
<td></td>
</tr>
<tr>
<td>Light Selection</td>
<td>3 settings</td>
<td>Feedback</td>
<td>3 settings</td>
<td></td>
</tr>
</tbody>
</table>

I would purchase:
(click only one) 

- [ ]
- [x]
- [ ]
Questionnaires and Estimation in “Traditional” conjoint

- Except for one exception (Sawtooth ACA), questions are the same for all the respondents
- Data is analyzed using statistical techniques
- Estimation of the Utilities requires a sufficient number of questions
FastPACE and the polyhedral approach
PAIRED - COMPARISONS

“Do you prefer A or B?”

is equivalent to

“What is U(bag B) – U(bag A)?”

$U(bag \ B) - U(bag \ A) = 75$
PAIRED - COMPARISONS

Remember:

\[ U(\text{bag B}) - U(\text{bag A}) = U(\text{closure}) + U(\text{handle}) + U(\text{palm holder}) + U(\text{logo}) + U(\text{pocket}) \]

So we also have:

\[ U(\text{closure}) + U(\text{handle}) + U(\text{palm holder}) + U(\text{logo}) + U(\text{pocket}) = 75 \]
CHOICE - BASED - CONJOINT

“Which one is your favorite:

A

B

C

D

I would purchase: (click only one)

U(bag B) □ U(bag A);

U(bag B) □ U(bag C);

U(bag B) □ U(bag D);

3 inequalities
Combining all the information

• prior knowledge + conjoint questions = set of equalities and inequalities satisfied by the 10 Utilities
• Our estimate of the Utilities should satisfy all these “constraints”
• What are the estimates that satisfy all the constraints?
• What is the “best” estimate?
Polyhedral estimation

• The set defined by the constraints is a Polyhedron
• Our estimate is the center of this polyhedron
Choosing the next question

• A new question brings additional constraints
• This reduces the size of the Polyhedron
• The smaller the Polyhedron, the better the estimate
• Idea: choose the question that will give the smallest Polyhedron
Idea

BETTER THAN

Smaller Polyhedron
Longest axis
In 3-Dimensions

- Bounding ellipsoid
- Analytic center
- Longest axis of the ellipsoid

2-dimensional hyperplane (perpendicular to the longest axis of the ellipsoid)
CHOICE - BASED - CONJOINT

A

B

C

D

Inequality constraints
Choosing the 4 bags

Extreme points
Tests of FastPACE
Simulations

![Graph showing Mean Absolute Error vs Number of Questions]

- **FastPace**
- **ACA Benchmark**

The graph illustrates the Mean Absolute Error for two different models, FastPace and ACA Benchmark, as a function of the number of questions. The error decreases as the number of questions increases, with FastPace generally showing lower error compared to the ACA Benchmark.
Field Experiment
330 1st year MBA’s

Benchmark 1

Benchmark 2

FastPACE

$100 + $ change
Choose a bag to keep

The five available bags are illustrated below.
Please indicate your first, second, third, fourth and fifth choice.

<table>
<thead>
<tr>
<th>Features</th>
<th>First</th>
<th>Second</th>
<th>Third</th>
<th>Fourth</th>
<th>Fifth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>Large</td>
<td>Medium</td>
<td>Large</td>
<td>Medium</td>
<td>Large</td>
</tr>
<tr>
<td>Color</td>
<td>Red/Gray</td>
<td>Black</td>
<td>Red/Gray</td>
<td>Black</td>
<td>Red/Gray</td>
</tr>
<tr>
<td>Logo</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Handle</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>PDA</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Cell Phone</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Mesh Pocket</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sleeve Closure</td>
<td>Full Flap</td>
<td>Tab Velcro</td>
<td>Tab Velcro</td>
<td>Full Flap</td>
<td>Full Flap</td>
</tr>
<tr>
<td>Boot</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Price</td>
<td>$35</td>
<td>$70</td>
<td>$38</td>
<td>$97</td>
<td>$51</td>
</tr>
</tbody>
</table>
Prediction of the respondents’ choices

- FastPace
- ACA
- Fixed

Number of Questions

Average Choice Correlation
mitsloan.mit.edu/vc

- Working papers
- Presentations
- Demonstrations
- Open-source software (soon)