Discrete Choice Experiments: opportunities and challenges

DataX Seminar Series

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Overview

What is DCE?
Choice modelling

• Choice modeling is the theory of individual decisions among discrete alternatives and its empirical derivatives in the form of measurement procedures and estimation methods.

• It models individuals’ choices and decisions about healthcare, transport, purchases, lifestyle, and other activities.
  o Determining factors of the choice (attributes of the object and characteristics of the individuals): prediction (e.g., demand)
  o Trade-offs between attributes: valuation (e.g., willingness to pay)

• Data: revealed preference (RP) vs stated preference (SP)

• RP: what people did

• SP: what people stated they would do
Discrete Choice Experiment (DCE)

- DCE is a SP method - other SP methods include ranking, rating, etc.
- A survey experiment approach
- Respondents are presented with a series of hypothetical, but realistic choice sets with each alternative described by a bundle of attributes, each with a different level. Respondents are then asked to choose their most preferred option
- Based on a premise that the choices people make are informative about what they value

<table>
<thead>
<tr>
<th></th>
<th>Treatment A</th>
<th>Treatment B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode of administration</td>
<td>6-month subcutaneous injection</td>
<td>Weekly oral tablet</td>
</tr>
<tr>
<td>Adverse effects of treatment</td>
<td>1 in 50 patients would suffer the adverse effect</td>
<td>Gastro-intestinal disorders</td>
</tr>
<tr>
<td>Treatment efficacy in reducing the risk of fracture</td>
<td>30%</td>
<td>40%</td>
</tr>
<tr>
<td>Out-of-pocket cost per year</td>
<td>520 Yuan per annum</td>
<td>26,000 Yuan per annum</td>
</tr>
</tbody>
</table>
A little bit of history: theory

- Choice modeling theory developed independently by economists (Daniel McFadden) and mathematical psychologists (Louis Leon Thurstone, Duncan Luce and Anthony Marley)

- Random utility theory: decision makers maximise their utility through choices

- Multinomial choice framework (conditional logit model)
A little bit of history: DCE

- In transport and marketing, conjoint analysis (configuration of goods using attributes) and design of experiments (using a small number of choice tasks to estimate preferences) were used to predict demand for new products in 1960s and 70s.

- In 1980s, Jordan Louviere and David Hensher formalized these methods based on random utility theory – the beginning of DCE

Design and Analysis of Simulated Choice or Allocation Experiments in Travel Choice Modeling

JORDAN J. LOUVIERE AND DAVID A. HENSHER

A new approach for modeling traveler trade-offs and choices is proposed, described, and illustrated. Based on research in psychology, marketing, and economics, a method for developing discrete choice models from controlled laboratory simulation experiments is developed and presented. The method borrows statistical theory from discrete choice theory in econometrics and from the design of statistical experiments to marry work in trade-off analysis with choice analysis. The method is illustrated by means of several travel-choice-related examples that involve choice of mode and destination. Recent evidence of validity in forecasting the actual behavior of real markets is reviewed in support of the approach.

Since the early 1970s, the study of revealed-choice behavior based on the random utility derivations of discrete choice theory in econometrics (1-5) has gained a following in the analysis and forecasting of travel behavior. If real choice data satisfy the conditions assumed in the statistical choice models, it is possible to derive aggregate-level trade-offs and to simultaneously forecast choice behavior. Hence, methods based on revealed choice have high external validity and practical applicability to strategic policy problems. Other approaches have recently gained attention--notably, laboratory simulation methods such as variations of conjoint measurement or trade-off analysis (7-9) and functional measurement (10-15), which are the primary methods of approach for developing quan-titative descriptions of multiattribute individual...
Usefulness of DCEs

Why do we use the DCE?
Revealed preference

Which one to choose?
What factors affect the choice of transportation method?

Attributes of the transportation method:
• Cost
• Speed
• Safety

Characteristics of the traveller:
• Gender
• Age
• Income
• Travel distance

How do these factors impact on the choice?
• Data collection for each travel with all the factors (need lots of observations)
Revealed preference issues

• Key variables (e.g. price) do not have variation

• Key variables are missing (potential endogeneity problems)

• The product is not available yet: no data at all
Why do we use DCEs?

• When revealed preference data is not available or of poor quality (little variations, data missing, etc.)

• DCEs generate choice data regardless of the existence of the products

• It is an experiment so we can ensure variations and control endogeneity

• It is a survey approach so we can always get the choice data and control/assess quality

• We can also collect a large number of individual characteristics to assess their impact on the choice (preference heterogeneity)
DCE applications

• Early applications: marketing, transportation, environment research

• Now widely used – whenever there is a need to assess people’s preferences and understand their needs.

• One of the most popular methods in healthcare research (where revealed preference data are often not available)

• Application examples:
  • Patient preference for medical treatments or healthcare services
  • Preference for healthcare priority setting (value judgement)
  • Consumer preference for health insurance products
  • Job preference of healthcare workers
Cast study 1

Patient preference for pharmaceutical treatments
Chinese patients’ preference for pharmaceutical treatments of osteoporosis: a discrete choice experiment

Lei Si, Liduan Tu, Ya Xie, Andrew J. Palmer, Yuanyuan Gu, Xujie Zheng, Jamin Li, Qing Lv, Jun Qi, Zhiming Lin, Mingsheng Chen, Jieruo Gu & Mickaël Hilgmann

Archives of Osteoporosis 14, Article number: 85 (2019) | Cite this article
390 Accesses | 0 Altmetric | Metrics

Abstract

Summary

While adherence to osteoporosis treatment is low, patients’ preference for osteoporosis treatment is unknown in Chinese patients. Chinese patients are willing to receive treatments with higher clinical efficacy and lower out-of-pocket cost. In addition, annual intravenous infusion and 6-month subcutaneous injection are preferred over weekly oral tablets.

Purpose

This study was performed to elicit Chinese patients’ preferences for osteoporosis medication treatment and to investigate the heterogeneities of the preferences in subgroups.
## Attributes and levels

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment efficacy in reducing the risk of fracture</td>
<td>20%</td>
<td>30%</td>
<td>40%</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Out-of-pocket cost per year, RMB Yuan(^a)</td>
<td>520</td>
<td>2600</td>
<td>4160</td>
<td>5200</td>
<td>26,000</td>
</tr>
<tr>
<td>Adverse effects of treatment(^b)</td>
<td>Flu-like symptoms</td>
<td>Skin reactions</td>
<td>Gastrointestinal disorders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mode of administration</td>
<td>Daily oral tablet</td>
<td>Daily nasal spray</td>
<td>6-month subcutaneous injection</td>
<td>Yearly intravenous infusion</td>
<td>Weekly oral tablet</td>
</tr>
</tbody>
</table>

\(^a\)One RMB Yuan = 0.15 US dollars in 2018

\(^b\)Adverse effects of treatment were assumed to occur in 1 of every 50 patients undergoing treatment. Each of these adverse effects was relatively mild, disappeared after a few days and had no long-term or severe consequences.
# A choice set

<table>
<thead>
<tr>
<th>Mode of administration</th>
<th>Treatment A</th>
<th>Treatment B</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Weekly oral tablet</td>
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<td>Gastro-intestinal disorders</td>
<td>Flu-like symptoms</td>
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<tr>
<td>Treatment efficacy in reducing the risk of fracture</td>
<td>30%</td>
<td>40%</td>
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<tr>
<td>Out-of-pocket cost per year</td>
<td>520 Yuan per annum</td>
<td>26,000 Yuan per annum</td>
</tr>
</tbody>
</table>

Which treatment would you choose? (Tick one box only)

- Treatment A
- Treatment B
- No treatment
Case study 2

Value judgement in health care priority setting: whose life is more valuable?
The relative value of different QALY types

Emily Lancsar\textsuperscript{a,\ast}, Yuanyuan Gu\textsuperscript{b}, Dorte Gyrd-Hansen\textsuperscript{c}, Jim Butler\textsuperscript{d}, Julie Ratcliffe\textsuperscript{e}, Liliana Bulfone\textsuperscript{f}, Cam Donaldson\textsuperscript{g}

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\begin{abstract}
The oft-applied assumption in the use of Quality Adjusted Life Years (QALYs) in economic evaluation, that all QALYs are valued equally, has been questioned from the outset. The literature has focused on differential values of a QALY based on equity considerations such as the characteristics of the beneficiaries of the QALYs. However, a key characteristic which may affect the value of a QALY is the type of QALY itself. QALY gains can be generated purely by gains in survival, purely by improvements in quality of life, or by changes in both. Using a discrete choice experiment and a new methodological approach to the derivation of relative weights, we undertake the first direct and systematic exploration of the relative weight accorded different QALY types and do so in the presence of equity considerations; age and severity. Results provide new evidence against the normative starting point that all QALYs are valued equally.
\end{abstract}
# Attributes and levels

<table>
<thead>
<tr>
<th>Attributes (Short name)</th>
<th>Levels</th>
</tr>
</thead>
</table>
| Age of people who will receive this treatment if treatment is funded ("age") | Infant (0–12 months)  
Child (1–12 years)  
Teen (13–17 years)  
Young adult (18–29 years)  
Adult (30–49 years)  
Older adult (50–59 years)  
Senior (60–74 years)  
Older senior (75+ years)  
5% (very severe health problems) |
| Quality of Life (QoL) without this treatment ("QoL")       | 30% (severe health problems)  
60% (moderate health problems)  
90% (mild health problems) |
| Remaining life expectancy (LE) without this treatment ("LE") | 0–3 months  
4 months–2 years  
3–5 years  
The medical condition has no effect on LE |
| Average number of QALYs gained per person with this treatment ("QALY") | 0.01 of a QALY  
0.5 of a QALY  
1 QALY  
4 QALYs  
Life extension |
| Type of QALYs gained with this treatment ("Type")           | Improvement in QoL  
Mixture of life extension and improvement in QoL  
Life extension but with reduced QoL |
A choice set

Below are two treatments for people with medical conditions. Given that only one treatment can be funded, which treatment would you choose to fund *so it's available to you and all Australians?*

<table>
<thead>
<tr>
<th></th>
<th>Treatment A</th>
<th>Treatment B</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age of the people who will receive this treatment if funded</strong></td>
<td>Adult (30-49 years)</td>
<td>Young adult (18-29 years)</td>
</tr>
<tr>
<td><strong>Quality of life without this treatment</strong></td>
<td>5% (very severe health problems)</td>
<td>60% (moderate health problems)</td>
</tr>
<tr>
<td><strong>Remaining life expectancy without this treatment</strong></td>
<td>4 months – 2 years</td>
<td>0-3 months</td>
</tr>
<tr>
<td><strong>Average number of QALYs gained per person with this treatment</strong></td>
<td>0.5 of a QALY</td>
<td>0.5 of a QALY</td>
</tr>
<tr>
<td><strong>Type of QALYs gained with this treatment are due to</strong></td>
<td>Life extension</td>
<td>Mixture of life extension and improvement in quality of life</td>
</tr>
</tbody>
</table>

**Fund this?**
Case study 3

Medical Brain Drain: Italian young doctors’ job preferences
Medical Brain Drain – Assessing the Role of Job Attributes and Individual Traits

Marco Bertoni
Debdeep Chattopadhyay
Yuanyuan Gu

JUNE 2023
### Attributes and levels

**Table 1: Job attributes and their levels**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Italy</td>
</tr>
<tr>
<td></td>
<td>Your favourite European foreign country</td>
</tr>
<tr>
<td>Annual net income (PPP adjusted)</td>
<td>€20,000</td>
</tr>
<tr>
<td></td>
<td>€30,000</td>
</tr>
<tr>
<td></td>
<td>€40,000</td>
</tr>
<tr>
<td></td>
<td>€50,000</td>
</tr>
<tr>
<td></td>
<td>€60,000</td>
</tr>
<tr>
<td></td>
<td>€75,000</td>
</tr>
<tr>
<td>Job security</td>
<td>2-year fixed term contract, non-renewable</td>
</tr>
<tr>
<td></td>
<td>2-year fixed term contract with 50% renewal probability</td>
</tr>
<tr>
<td></td>
<td>Permanent job</td>
</tr>
<tr>
<td>Professional development opportunities</td>
<td>Limited opportunities for research and training</td>
</tr>
<tr>
<td></td>
<td>Some opportunities for research and training</td>
</tr>
<tr>
<td></td>
<td>Good opportunities for research and training</td>
</tr>
<tr>
<td>Working conditions</td>
<td>High workload with frequent overtime work and nightshifts</td>
</tr>
<tr>
<td></td>
<td>Adequate workload with little overtime work and nightshifts</td>
</tr>
<tr>
<td>Match of skills with job content</td>
<td>Your skills are higher than required by the job</td>
</tr>
<tr>
<td></td>
<td>Your skills are exactly matched to what is required by the job</td>
</tr>
<tr>
<td></td>
<td>Some of your skills are lower than required by the job and need further development</td>
</tr>
</tbody>
</table>
Imagine that you have just completed your preferred specialization course and are faced with the following job offers for hospital doctor positions in your specialization. Which would you choose: A, B, or neither of the two?

<table>
<thead>
<tr>
<th>Professional development Opportunity</th>
<th>Job A</th>
<th>Job B</th>
<th>Opt-Out</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good opportunities for further research and training</td>
<td>Limited opportunities for further research and training</td>
<td></td>
</tr>
<tr>
<td>Income (PPP adjusted)</td>
<td>€40,000</td>
<td>€40,000</td>
<td></td>
</tr>
<tr>
<td>Job security</td>
<td>Permanent position</td>
<td>2-year temporary contract with 50% chance of a permanent position afterward</td>
<td></td>
</tr>
<tr>
<td>Working Conditions</td>
<td>High workload with frequent overtime work and night shifts</td>
<td>Adequate workload with little overtime work and night shifts</td>
<td></td>
</tr>
<tr>
<td>Match of skills with job content</td>
<td>Your skills are exactly matched to what is required by the job</td>
<td>Some of your skills are lower than required by the job and need further development</td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td>Your favourite foreign European country</td>
<td>Italy</td>
<td></td>
</tr>
<tr>
<td>Which would you choose?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Current DCE projects

<table>
<thead>
<tr>
<th>Topic</th>
<th>Funders</th>
<th>Team members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saving men ‘under the radar’ by understanding their preferences for suicide prevention service</td>
<td>MRFF</td>
<td>Anam Bilgrami, Noura Saba, Henry Cutler, et al</td>
</tr>
<tr>
<td>A priority-setting framework for value-based healthcare: Evidence from Australia</td>
<td>MRFF</td>
<td>Mona Aghdaee, Olukorede Abiona, Henry Cutler</td>
</tr>
<tr>
<td>Hearing and vision support design to improve quality of life for people living with dementia receiving home care services</td>
<td>MRFF</td>
<td>Piers Dawes, Sabrina Lenzen, Melinda Toomey (UQ)</td>
</tr>
<tr>
<td>Australians' preferences for mental healthcare services</td>
<td>ARC DP</td>
<td>Kompal Sinha, Lisa Magnani, Francesco Chirico, et al</td>
</tr>
<tr>
<td>Attraction and retention of workforce for the early childhood education and care sector</td>
<td>ACT Education Directorate</td>
<td>Sheila Degotardi, Jun Gu, Rebecca Mitchell, et al</td>
</tr>
<tr>
<td>EQ-5D with the hearing “bolt-on” items: developing a new quality of life measure for hearing impairment</td>
<td>Cochlear, MQ</td>
<td>Bonny Parkinson, Rajan Sharma, Henry Cutler, et al</td>
</tr>
<tr>
<td>Patient preferences for Knee Replacement Surgery in Australia</td>
<td>Johnson &amp; Johnson Medical, MQ</td>
<td>Mutsa Gumbie (J&amp;J), Henry Cutler, Kompal Sinha</td>
</tr>
</tbody>
</table>
DCE Design

How to construct DCE choice sets?
Step 1: attributes and levels

Products to choose are defined using attributes and their levels

• Attributes must be conceptually mutually exclusive

How to select attributes and levels?

• Literature view
• Focus groups
• Interviews

How many attributes and levels?

• Attributes: 3-7
• Levels: 2-8
Step 2: experimental design

A large number of combinations
• Three attributes, each with four levels: $4 \times 4 \times 4 = 64$ possible products
• Experimental design needed to reduce the burden

Experimental design methods:
• Orthogonal design
• Efficiency design

Experimental design software:
• Ngene
• Sawtooth Software
Step 2: experimental design

Within a choice set

- 2~3 alternatives/options
- Forced choice: more efficient but may induce bias
- Unforced choice: opt-out, status quo

Too many choice sets generated:

- Blocking
- 8~16 choice sets per block
- e.g., 30 choice sets => 3 blocks with 10 choice sets each block
DCE data analysis

Multinomial choice models and beyond
Random utility theory

The utility gained from choosing product 1 for individual n: $U_{n1} = V_{n1} + \epsilon_{n1}$

- $V_{n1}$ is the systematic utility component
- $\epsilon_{n1}$ is the stochastic utility component

Decision makers maximise their utility through choices

- If $U_{n1} > U_{n2}$, the individual n will choose product 1 over product 2

We observe the choices, not the utilities. But based on the random utility theory, we may use statistical models to estimate the utility function given the choices.
The conditional logit

\[ U_{i1} = \alpha_1 + \text{Income}_{i1}\beta + \text{Country}_{i1}\gamma + \varepsilon_{i1} \]
\[ U_{i2} = \alpha_2 + \text{Income}_{i2}\beta + \text{Country}_{i2}\gamma + \varepsilon_{i2} \]
\[ U_{i3} = \alpha_3 + \varepsilon_{i3} \]

- We estimate the utility function based on data and assumptions of the stochastic components

- Normal distribution => multinomial probit

- Gumbel distribution => multinomial/conditional logit

- \( \Pr (\text{choosing alt 1}) \)
  \[ = \frac{\exp (\alpha_1 + \text{Income}_{i1}\beta + \text{Country}_{i1}\gamma)}{\exp (\alpha_1 + \text{Income}_{i1}\beta + \text{Country}_{i1}\gamma) + \exp (\alpha_2 + \text{Income}_{i2}\beta + \text{Country}_{i2}\gamma) + \exp (\alpha_3)} \]
  \[ = \frac{\exp (\alpha_1 - \alpha_3 + \text{Income}_{i1}\beta + \text{Country}_{i1}\gamma)}{\exp (\alpha_1 - \alpha_3 + \text{Income}_{i1}\beta + \text{Country}_{i1}\gamma) + \exp (\alpha_2 - \alpha_3 + \text{Income}_{i2}\beta + \text{Country}_{i2}\gamma) + 1} \]
The mixed logit

• Conditional logit limitations:
  o Independence of Irrelevant Alternatives (IIA) assumption
  o Preference homogeneity

• Preference heterogeneity: random parameters $\alpha_i, \beta_i, \gamma_i$ – unobserved heterogeneity

• Which should be random?

• Which random distributions?

• Are they correlated?
  o MSL: cannot accommodate many
  o Bayesian: can accommodate full correlations – the prior for the covariance matrix needs to carefully chosen
Willingness to pay (WTP)

- WTP for country (to stay in Italy) = $\gamma_i / \beta_i$

- mean ($\gamma_i / \beta_i$) does NOT equal to mean ($\gamma_i$)/mean of ($\beta_i$)

- Easy way out: fixing the coefficient of income

- Simulation: draw a random sample from the distribution of $\gamma_i$ and $\beta_i$ and generate the empirical distribution of $\gamma_i / \beta_i$

- Extreme values: trim, median
Willingness to pay space

\[ U = \beta_i (\alpha_i/\beta_i + \text{Income} + \text{Country}^{*} \gamma_i/\beta_i) + \epsilon \]

- \( \beta_i \sim \text{log-normal distribution} \)

- WTP space: directly estimate \( \gamma_i/\beta_i \)

Table 4: Baseline WTP-space mixed logit estimates. Mean and SD.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income ($\alpha_i$)</td>
<td>0.126***</td>
<td>0.106***</td>
</tr>
<tr>
<td></td>
<td>(0.009)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>Job location WTP - reference: Italy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Favourite foreign EUR country</td>
<td>-13,515***</td>
<td>17,216***</td>
</tr>
<tr>
<td></td>
<td>(1.298)</td>
<td>(1.501)</td>
</tr>
</tbody>
</table>

Figure 1: WTP distribution for jobs located in respondents’ favourite European country.

Notes: The vertical bar indicates the mean of the distribution.
Observed heterogeneity (interactions)
Challenges in modelling heterogeneity

• How to use individual characteristics to explain heterogeneity
  
  o Interactions
  o Regress the estimated WTP on individual characteristics
  o Latent class and then identify the profile for each class

• The mixing distribution may not be normal
  
  o Latent class logit
  o The mixed-mixed logit: a discrete mixture-of-normals heterogeneity distribution
  o Flexible mixing distribution


• The correlations between preference parameters may not be trivial
Application of machine learning methods

- Learning Multinomial Logit (L-MNL): divide the systematic part of the utility specification into (1) a knowledge-driven part, and (2) a data-driven one, which learns a new representation from available explanatory variables.

- Use machine learning techniques to discover the interaction between alternative attributes and individual characteristics

- Gaussian process latent class choice models
Thank you!

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Please check MUCHE website for our projects and HDR program:

Issues of DCEs

It is a survey and asks people to choose under hypothetical scenarios

- Poor quality data (not taken seriously, driven by money)
- Hypothetical bias (what they say differs from what they will do)
- Cognitively demanding (using heuristics)

Potential solutions:

- To ensure respondents are engaged with the survey (cheap talk, oath, incentives)
- To test quality (repeat test, dominant choice test)
- To avoid complex design (not too many attributes and choice sets)
- To accommodate uncertainty or other behaviours in econometric modelling (attribute non attendance)
Practical challenges

It can be very costly!

You need to learn and do many things:
- Literature review
- Focus group/interview
- Experimental design
- Survey design
- Data collection
- Econometric analysis

It takes much longer time than research using secondary data and can be risky
- Need to prepare for mistakes and failures
- Better work with experienced researchers first