A guide to: model building, specification, estimation, and refinement

Key concepts & study plan

Experimental design

Data collection & processing

Model specification & estimation

Interpretation & application

A guide to: model building

Steps in model building

1. Zero configuration model
2. Functional form
3. Investigate error structure assumptions
4. Study the data to prepare for model refinement
5. Test for differences across segments
6. Deterministic heterogeneity
7. Random heterogeneity
8. Attitudes and other soft factors

Each study is different, some steps may not apply or in a different order

Step 1: Zero configuration model

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Step 1: Zero configuration model

Motivation

- Always start with simple model
  - independent of topic, type of data, etc
- Aims:
  - determine that data works
  - create base model for later comparisons

Step 1: Zero configuration model

General base specification

- Three components:
  - Full set of alternative specific constants ($J-1$)
    - whether working with labelled or unlabelled choices
  - Dummy coded categorical variables
  - Linear specification for continuous variables
- No interactions, heterogeneity or non-linearity
  - and definitely no mixed logit!

Step 1: Zero configuration model

Diagnostics for base model

- Model fit
  - Compare model to two other 'naive' models
  - Purely random model, or $LL(0)$
    - is our model explaining anything?
  - Model with constants only, or $LL(C)$
    - are the explanatory variables explaining anything?
- Individual parameters
  - do all parameters have the expected sign?
  - can we reject null hypothesis that parameters are zero ($H_0 : \beta_k = 0$)?
- Is implied behaviour realistic?
  - Relative sensitivity to different attributes
  - Elasticities and/or marginal effects

Step 1: Zero configuration model

Iterative model building

- Gradually improve model specification
- Do this step by step, rather than immediately trying complex specification
- Specification decisions are based on:
  - model fit comparisons against current base model
  - reasonableness of results
  - comparison of MRS outputs and elasticities
- This point applies to all steps in this session

Step 2: Functional form

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Step 2: Functional form

Non-linear vs linear for continuous variables

- If number of levels is limited:
  - estimate model where a parameter is estimated for each level via dummy coding
  - then visually inspect linearity
- If number of levels is large:
  - contrast linear *vs* log *vs* box-cox *vs* polynomial
- Compare model fit to base model using statistical tests
- Especially important with RP data or pivoted SP data
  - often big gain in fit
  - and even changes in signs for some parameters

Step 2: Functional form

Levels for categorical variables

- Might see that some levels are not different from each other
- Would likely not collapse levels at this stage but keep in mind for later steps

Step 3: Investigate error structure assumptions

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Step 3: Investigate error structure assumptions

Nested Logit

- Choice between some alternatives is more deterministic than between others
- Allows for departure from *IIA* assumptions
- Relevant not just with labelled choice situations, but also with opt-out/status quo

Step 3: Investigate error structure assumptions

Multiplicative errors

- Relevant if there is scope for heteroskedasticity across observations
  - especially with data that mixes observations with big differences in explanatory variables
  - e.g. short journeys for some, long for others

Step 3: Investigate error structure assumptions

Heteroskedasticity across alternatives

- Is assumption about the amount of noise being the same across alternatives valid?
- RP data example:
  - might have more error for some alternatives as analyst does not capture all attributes
- SP data example:
  - might have more uncertainty for SQ if the attributes are lists as "as now"

Step 4: Study the data to prepare for model refinement

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Step 4: Study the data for model refinement

Possible segmentations

- Sample coming from different sources
  - e.g. online and CAPI, RP and SP
- Sample coming from different locations
  - e.g. multi-country
- Core sample segments where differences are of interest for policy
  - e.g. business *vs* leisure

Step 4: Study the data for model refinement

Possible individuals that are of concern

- Identify non-traders, lexicographic people, speeders etc
- But do not just remove them from the data
  - bad practice that is pretty common

Step 4: Study the data for model refinement

Insights for possible interactions

- Who chooses what in what settings?
- Can do this for socio-demographics, scenario variables, etc

Step 5: Test for differences across segments

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Step 5: Test for differences across segments

Separate models

- Estimate separate models for different segments
  - e.g. online *vs* CAPI, business *vs* leisure
- Insights:
  - statistical tests for model fit differences against generic model
  - compare results across segments to see if differences are in only some of the parameters
  - compare MRS outputs and elasticities

Step 5: Test for differences across segments

Scale differences only

- Estimate joint model but allow for scale differences
- Compare model to generic model
  - if test rejects generic model, could be evidence of scale heterogeneity
- But also compare model with scale differences to having separate models
  - if separate models reject model with scale difference only, then there are also differences in individual sensitivities

Step 5: Test for differences across segments

Outcomes

- Helps us form decisions on what to do about individual segments
  - keep separate models or joint model with interactions for some attributes only?
  - or a model with scale differences only?
- Can tell us what do about "suspicious individuals"
  - is their data really worse and should they really be removed?

Step 6: Deterministic heterogeneity

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Step 6: Deterministic heterogeneity

Aims and outline

- Likely to involve the most analyst work
- Aim is to link heterogeneity to observed characteristics of individual and/or scenario
- Gradually build up model complexity!

Step 6: Deterministic heterogeneity

How do we do this?

- Many possibilities
  - Separate parameters by group (e.g. male vs female)
  - Interactions with continuous covariates (e.g. income elasticity for cost sensitivity)
- Try to use an "intelligent approach"
  - Don't just throw 200 parameters at the model
  - Study the data and also use prior insights into likely heterogeneity

Step 6: Deterministic heterogeneity

Be mindful of confounding

- Heterogeneity may be in unexpected places
- Omitted heterogeneity will affect model quality and potentially bias other results
  - e.g. not accounting for heterogeneity in cost sensitivity may affect findings in terms of heterogeneity in other parameters

Step 7: Random heterogeneity

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Step 7: Random heterogeneity

Aims and outline

- Likely the step giving biggest gains in fit
- But often less insightful than deterministic heterogeneity
- Computationally demanding
- Easy to make mistakes
- The more we account for deterministic heterogeneity, the less scope remains for random heterogeneity

Step 7: Random heterogeneity

Decisions to make

- Mixed logit or latent class
- Which parameters are random?
- How are the models estimated?

Step 7: Random heterogeneity

Model building

- Same idea as with other steps
- Compare model to earlier models
- Compare fit and compare MRS
- Potentially conduct posterior analysis to get additional insights

Step 8: Attitudes and other soft factors

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Step 8: Attitudes and other soft factors

Aims and outline

- Much interest in attitudes
- Clear that they can influence choices
- Models can be specified to capture their role

Step 8: Attitudes and other soft factors

A word of warning

- Much more demanding type of model
- Potentially insights are quite limited
- Should not expect a model with attitudes to explain choices better

Generic points not covered

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Generic points not covered

Additional specification decisions

- Decision rules
  - Have focused on random utility
  - Many of the same points apply with other decision rules too
- Information processing
  - Large body of work in early 2000s looking at information processing
  - Can provide insights into how people use the information in choice situations
- WTP space
  - Relevant approach with mixture models
  - Essentially no reason to use without random heterogeneity

Generic points not covered

Estimation

- Estimation method
  - our focus is on classical estimation using maximum likelihood
  - many people also use Bayesian techniques
- Software
  - many options are available
  - all with strengths and weaknesses