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Are people deterministic?

Exploring decision rules with the use of individual level models

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Individual level models

- Modelling preference heterogeneity
  - Mixed logit and other sample-level models
    - Possible to recover respondent-specific posterior distributions
  - Estimating independent individual level (IL) models
    - A separate model (set of coefficients) for each individual
- This paper
  - IL models using maximum likelihood estimator
    - Reasons for the cases of non-convergence
  - Explore respondents' decision rules
    - Lexicographic, other deterministic
  - The influence of design (efficient, optimal-in-difference)

Elicitation formats used to deal with data intensity required for IL models

- Full ranking
  - Beggs et al. (1981), Chapman et al. (1984)
    - Significant improvement over specification with identical coefficients
    - Almost 50% of the IL models 'did not converge'
  - Statistical differences in preferences across ranking stages even after controlling for the scale differences (Hausman and Ruud, 1987; Ben-Akiva et al., 1991)
- Best-worst
  - More consistent responses to extreme options (Flynn et al., 2007; Marley 2009)
  - Louviere et al. (2008)
    - Optimal-in-difference design (Street et al. 2007) + weighted least squares estimator
  - WLS estimator not efficient
  - Best-worst elicitation does assure preference stability (Giergiczny et al., 2013)
- Best choice

Data patterns and the existence of a finite ML estimator

- The problem of existence, finiteness and uniqueness of ML estimators
  - LL function of the MNL model is globally concave in β
  - Some cases – ML estimate does not exist or is reached at the boundary of parameters space
- What can we expect?
  - Lexicographic preferences
    - No utility function to represent such preferences
  - Fully deterministic respondents

$$U_{ij} = \beta_1 X_{1ij} + \beta_2 X_{2ij} + \ldots + u_{ij} / \sigma$$

$$V_{ij} = \sigma\beta_1 X_{1ij} + \sigma\beta_2 X_{2ij} + \ldots + \varepsilon_{ij}$$

Data patterns and the existence of a finite ML estimator

- Patterns of data points
  - Complete separation

$$\underset{t=1,\ldots,T}{\forall} \; \underset{l \neq Y_t}{\forall} \; \beta_{Y_t}' X_t > \beta_l' X_t$$

  - Quasi-complete separation

$$\underset{t=1,\ldots,T}{\forall} \; \underset{l \neq Y_t}{\forall} \; \beta_{Y_t}' X_t \geq \beta_l' X_t$$

  - Overlap

$$\underset{t=1,\ldots,T}{\exists} \; \underset{l \neq Y_t}{\exists} \; \beta_{Y_t}' X_t < \beta_l' X_t$$

Patterns of data points LL functions and choice probabilities

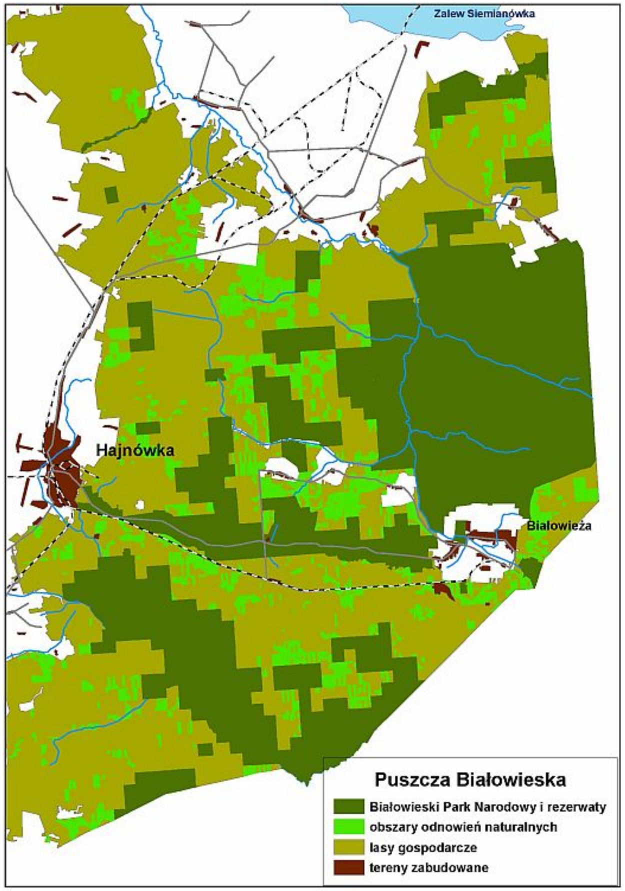
- Complete separation
  - Respondents deterministic
  - One or more attributes enough to make perfect predictions
    - If no alternatives with the same levels in the choice sets and one attribute enough to make predictions – lexicographic* preferences
  - Probabilities approach 0 or 1, LL approaches 0
  - Optimization algorithm does not converge
- Quasi-complete separation
  - As above but at least one choice situation in which equal choice probabilities
  - LL approaches some negative constant
  - Optimization algorithm does not converge

Patterns of data points LL functions and choice probabilities

- Overlap
  - Full overlap
    - Individual makes trade-offs for all attributes
    - Optimization routine converges
  - Partial overlap
    - As above, but individual does not make trade-offs for at least one attribute (e.g., never chooses the SQ alternative)
    - Optimization routine does not converge
      - (e.g., LL can be made arbitrarily better by decreasing the SQ parameter)
      - Other (traded) parameter estimates ok (can be significant) and useful

Data

- Czajkowski, M., Bartczak, A., Giergiczny, M., Navrud, S., and Żylicz, T., 2014. Providing Preference-Based Support for Forest Ecosystem Service Management. *Forest Policy and Economics*, 39:1-12.
- The Białowieża Forest
  - Introducing passive protection to enhance the level of naturalness
    - National Park, and the nature reserves
    - Second-growth forest
    - Typical commercial forest
  - Restricting the number of visits
  - Cost (coercive, income tax)



National Park, and the nature reserves

- About 35% of the Białowieża Forest
- Remains practically unaffected by human activity
- ~100 m^3 of dead wood / ha

Typical commercial forest

- About 50% of the Białowieża Forest
- Have been subjected to human activity and commercial use
- Management focused on sustainable timber production

Second-growth forest

- 15% of the Białowieża Forest clear-cut after the WW-1 and never reforested
- Area of natural regeneration – natural dynamics and adaptation to local conditions

The sample, design and models

- The sample
  - Representative sample of adult Polish population
  - 1000 CAWI
  - 24 choice-tasks per respondent
- Design
  - 500 – optimal-in-difference
  - 500 – efficient design (optimized for the MNL model)
- Models estimated using 18 choice tasks (6 used as a hold-out sample)
  - Separate MNL model for each individual
  - Sample level MNL
  - Sample level MXL (all parameters normally distributed, correlated)

Results – data patterns in the sample

Type		Attribute	No. of respondents
Complete or quasi-complete separation	Lexicographic	SQ	126
		Commercial	10
		Second-growth	8
	Other deterministic	2	128
		3	131
		4	68
		5	13
Overlap	Quasi-overlap		200
	Full overlap		316
Total			**1000**

Who is deterministic? (binary logit)

	Lexicographic behavior	Deterministic behavior
Constant	-1.480***	-1.316***
Female	0.013	-0.179*
Age	0.188**	0.010*
Education	-0.189*	0.171*
Income	-0.186	0.312
Visitor	0.051	-0.090
O-i-D	-0.241*	0.589***

Performance of modelling approaches

	Estimation sample 18 CT			Hold-out sample 6 CT		
	LL	correct predict.	correct choice prob.	LL	correct predict.	correct choice prob.
MNL-ILM	-6150.5	0.84	0.81		0.75	0.71
MNL-sample	-18614.5	0.45	0.37	-6124.1	0.45	0.37
MXL-sample	-8818.9	0.79	0.70	-3443.5	0.75	0.66

- Not possible to calculate LL of MNL-ILM for hold-out sample
- Use likelihood function (not log-likelihood) for comparisons?

Summary and conclusions

- We investigated the possibility of using ML estimator for RUM-based individual-level models
  - Convergence problems (2/3 of the sample)
    - 48% of the sample – deterministic decision rules
    - 20% of the sample – do not trade on one or more attributes
  - 32% of the sample – finite ML estimator exist
    - These are respondents who make errors!
  - Evidence of the influence of design type
- Using RUM-based IL models problematic
  - Provide a way to identify decision rules
  - Perform very well in predictions
    - Although only marginally better than the MXL model