Statistical Innovations
Thinking outside the brackets!™

An improved latent class (LC) paradigm to obtain meaningful segments in the presence of scale confounds: Scale Adjusted Latent Class (SALC) Tree modeling

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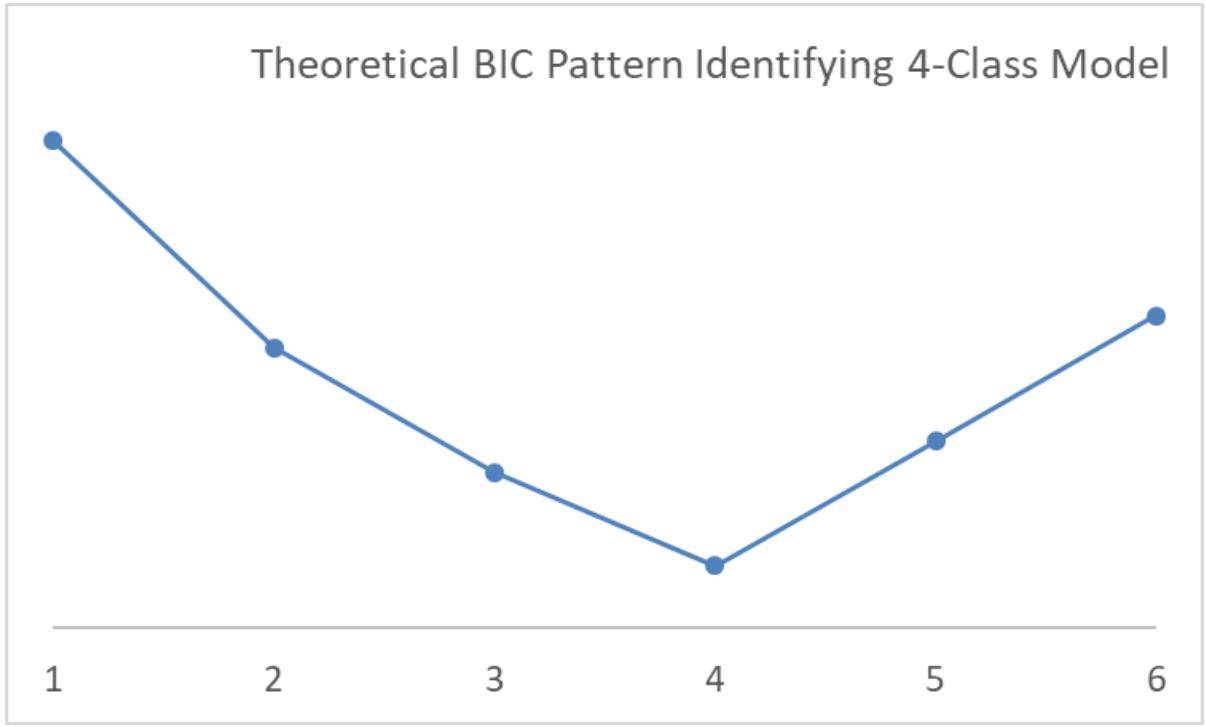
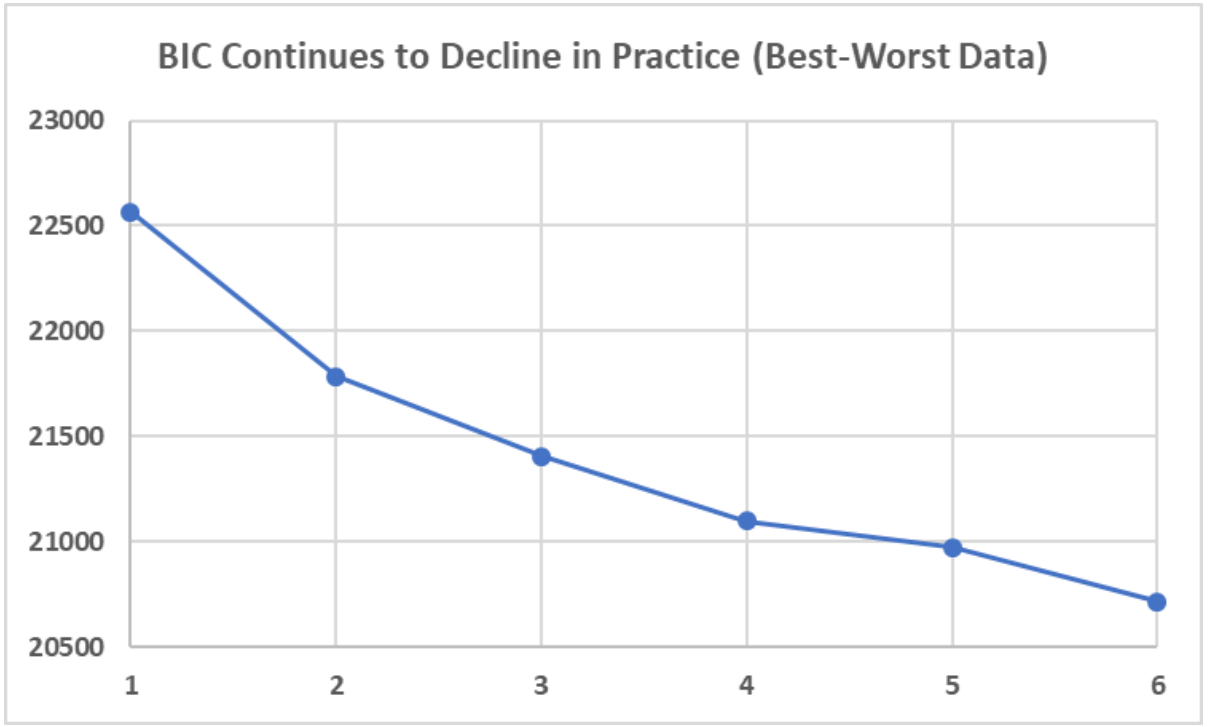
Goal: Improve Standard LC Paradigm

- Issues with standard LC paradigm when used in practice
    - Issue 1: BIC criteria often suggests too many segments to be easily interpretable
    - Issue 2: Preference vs. Scale confound may create further interpretation difficulty
      (Mean vs. Variance Heterogenity)
- Proposal: For more meaningful results, replace standard LC with SALC* tree modeling
- Example: Partial rank (Best-Worst choice) data

* Scale Adjusted Latent Class (SALC)

Issue #1: Current LC Paradigm Yields Many Segments in Practice





<u>Standard Paradigm</u>

- Estimate (say) K-class LC models with K=1,2,… classes
- Examine information criteria (i.e. BIC) for each model
- Select model K* with the lowest BIC (here, K*=4)

- Common occurrence in practice --
  BIC continues to decline since it is sensitive not only to primary but also secondary (often irrelevant) systematic differences.

Best-Worst*/Partial Ranking Questions

- Goal: Derive preferences among many (say 15) attributes (statements, items, etc.) simpler/ more efficient than asking respondents for a complete ranking
- Respondents complete a series of exercises (say 15 questions)
- In each exercise they are presented with 3 – 8 items and asked to choose which they most prefer and which they least prefer

Q Which of these benefits is most important and which is least important to you? (please tick)

	Item 1	Item 2	Item 3	Item 4
Most important	❑	❑	❑	❑
Least important	❑	❑	❑	❑

Sequential Logit Model* in Latent GOLD®

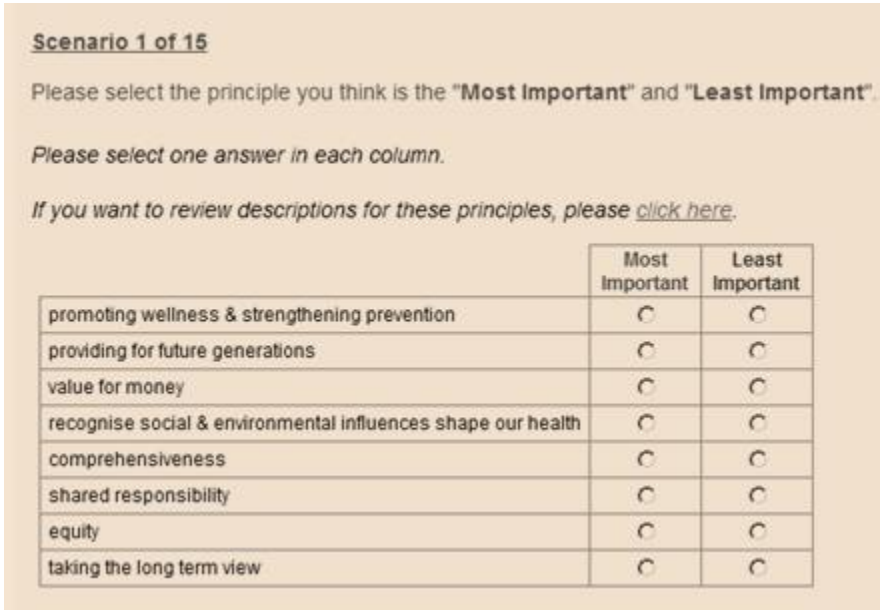
- Models the best and worst alternatives as a sequential choice process (Bockenholt, 2002; Croon, 1989; Kamakura et. al., 1994).
- That is, selection of the best option is equivalent to a first choice and selection of the worst option is a (first) choice out of the remaining alternatives, where the worst choice probabilities are negatively related to the best utilities of these alternatives

* 'Best-Worst' scale type in Latent GOLD® :
See LG tutorial 8A

https://www.statisticalinnovations.com/wp-content/uploads/LGChoice_tutorial_8A.pdf

Example: Best-Worst Experiment on Healthcare Reform Principles

Individuals respond to 15 scenarios with either 7 (version 1) or 8 options (version 2):



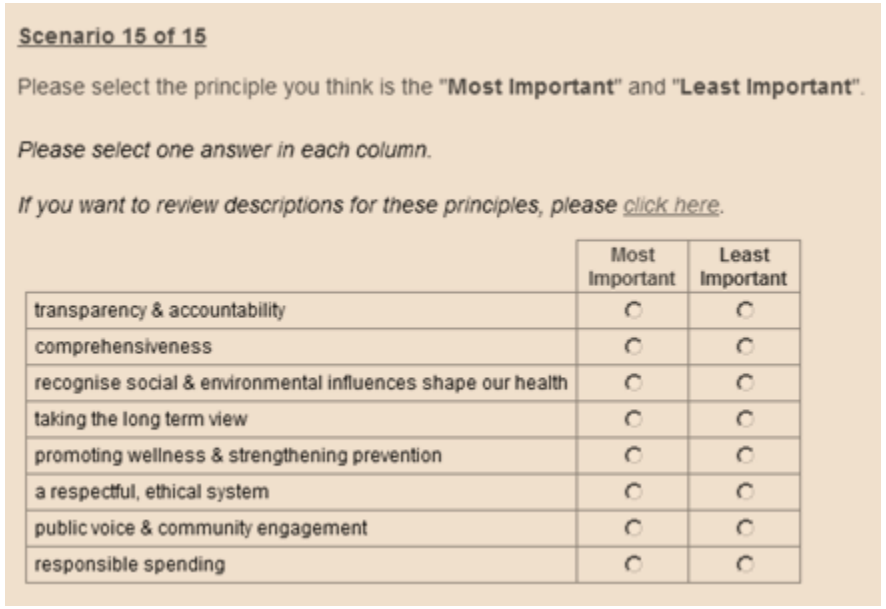
Scenario 1 of 15

Please select the principle you think is the "**Most Important**" and "**Least Important**".

Please select one answer in each column.

If you want to review descriptions for these principles, please click here.

	Most Important	Least Important
promoting wellness & strengthening prevention	○	○
providing for future generations	○	○
value for money	○	○
recognise social & environmental influences shape our health	○	○
comprehensiveness	○	○
shared responsibility	○	○
equity	○	○
taking the long term view	○	○



Scenario 15 of 15

Please select the principle you think is the "**Most Important**" and "**Least Important**".

Please select one answer in each column.

If you want to review descriptions for these principles, please click here.

	Most Important	Least Important
transparency & accountability	○	○
comprehensiveness	○	○
recognise social & environmental influences shape our health	○	○
taking the long term view	○	○
promoting wellness & strengthening prevention	○	○
a respectful, ethical system	○	○
public voice & community engagement	○	○
responsible spending	○	○

Primary goal: Determine the (primary) **policy-relevant** segments and how they differ in their preferences.
Secondary goal: Explain all of the heterogeneity in the data

Data from Louviere and Flynn (2010) Balanced Incomplete Block Designs (BIBD)

Flynn's three *policy-relevant* segments

In health economics you usually find people separate out into 3 'policy-relevant' classes (Flynn, 2010)

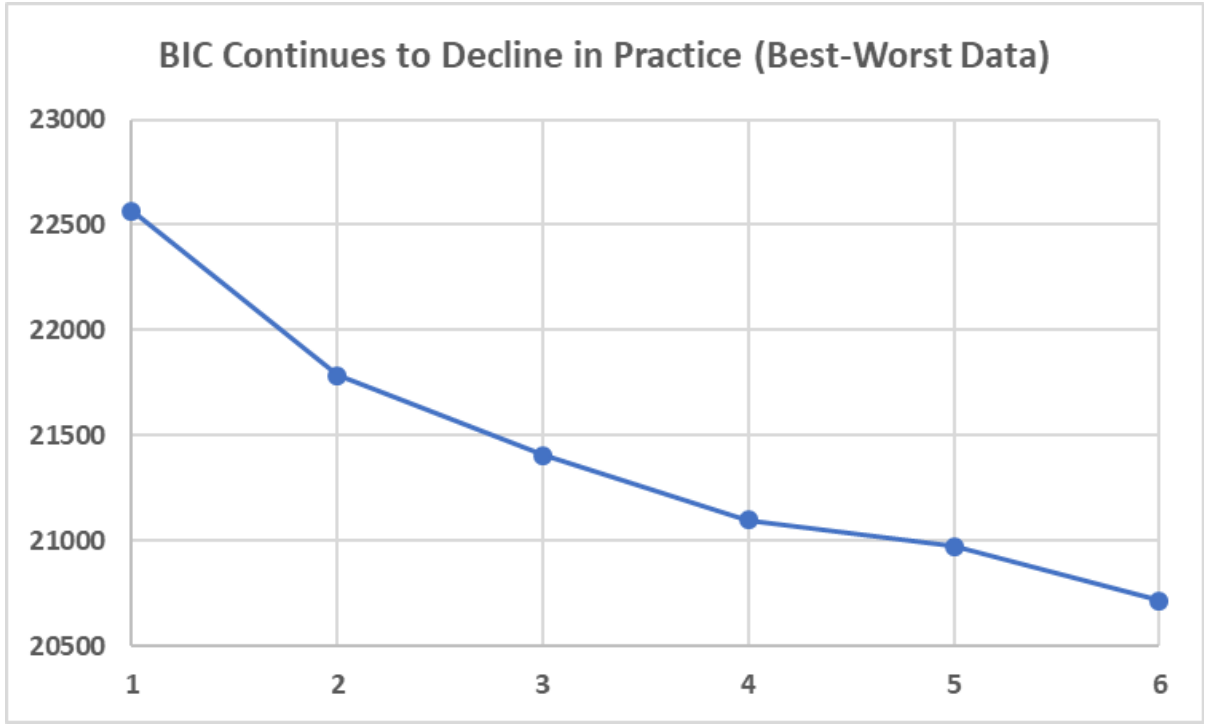
- *those who value equity*
- *those who value efficiency/value for money*
- *those who value investment in future health*

Bayesian Information Criterion (BIC), AIC, AIC3, CAIC, etc., each suggests many more classes showing detailed class differences that are not policy relevant

Three policy-relevant segments

Standard LC modeling paradigm suggests ***more*** than 3 classes (BIC continually declines).

LC Models	LL	BIC(LL)	Npar
1-Class LC	-11245.6	22565.7	14
2-Class LC	-10815.0	21784.2	29
3-Class LC	-10585.4	21404.8	44
4-Class LC	-10392.8	21099.5	59
5-Class LC	-10235.2	20864.0	74
6-class LC	-10121.3	20715.9	89



Related issue with model with many classes: As number of classes increases, more local solutions are encountered

Interpretation Difficulty with Many Classes

	Option	Class1	Class2	Class3	Class4	Class5	Class6	Class7	Class8
1	a culture of reflective improvement & innovation	-0.39	-1.77	-1.18	-0.40	-1.03	-2.51	-0.48	-0.15
2	a respectful, ethical system	-0.07	-0.35	1.06	1.29	-0.56	0.19	1.08	0.40
3	comprehensiveness	-0.55	-0.59	0.74	-1.40	0.57	-0.12	-1.46	0.45
4	equity	-0.64	-0.61	0.12	-2.05	-0.95	2.18	-1.89	2.65
5	people & family centred	0.90	0.94	-0.17	2.59	-1.47	1.90	-0.58	-0.91
6	promoting wellness & strengthening prevention	0.25	-0.68	0.52	1.55	2.15	-0.47	3.31	0.24
7	providing for future generations	0.82	0.07	-0.36	1.24	-0.26	0.17	0.16	0.32
8	public voice & community engagement	-0.46	-1.53	-0.38	-0.70	-2.74	-1.31	-0.15	-1.04
9	quality & safety	0.06	2.12	0.86	2.01	2.47	3.26	0.72	0.46
10	recognise social & environmental influences shape our health	0.14	-1.27	-1.08	0.87	-1.01	-1.90	2.46	1.14
11	responsible spending	0.27	1.44	0.65	-1.24	1.38	-0.27	-0.70	-1.42
12	shared responsibility	-0.50	-0.95	-0.82	-0.62	-0.03	-0.73	-1.26	-0.62
13	taking the long term view	0.43	0.03	-0.92	-0.63	0.24	-0.60	-0.02	0.45
14	transparency & accountability	-0.41	0.08	1.12	-0.03	-0.23	0.28	-0.99	-1.20
15	value for money	0.15	3.06	-0.15	-2.48	1.47	-0.08	-0.20	-0.76

Implied Rankings for Each Latent Class

1st Choice

Last Choice

Class1	Class2	Class3	Class4	Class5	Class6	Class7	Class8
5	15	14	5	9	9	6	4
7	9	2	9	6	4	10	10
13	11	9	6	15	5	2	9
11	5	3	2	11	14	9	3
6	14	11	7	3	2	7	13
15	7	6	10	13	7	13	2
10	13	4	14	12	15	8	7
~~9~~	~~2~~	~~15~~	~~1~~	~~14~~	~~3~~	~~15~~	~~6~~
2	3	5	12	7	11	1	1
1	4	7	13	2	6	5	12
14	6	8	8	4	13	11	15
8	12	12	11	10	12	14	5
12	10	13	3	1	8	12	8
3	8	10	4	5	10	3	14
4	1	1	15	8	1	4	11

Even with rank order simplification patterns difficult to explain (decipher!)

High information (high contrast) options

4: classes 6, 8 (high/rest low)
10: classes 7, 8 (high/rest low)
15: classes 2, 5 (high/rest low)

Low information (low contrast) options

2, 6, 7, 9: generally high rank
1, 8, 10, 12: generally high rank

Moderate information (moderate contrast) options

3: classes 3, 8
5: classes 1, 2, 4, 6 (high/rest lower)
11: class 8 (low rank)
14: class 3, class 6 (higher/rest lower)
13: most classes are ambivalent

Statistical versus Substantive (Policy-Relevant) Differences

Why standard LC paradigm yields so many classes

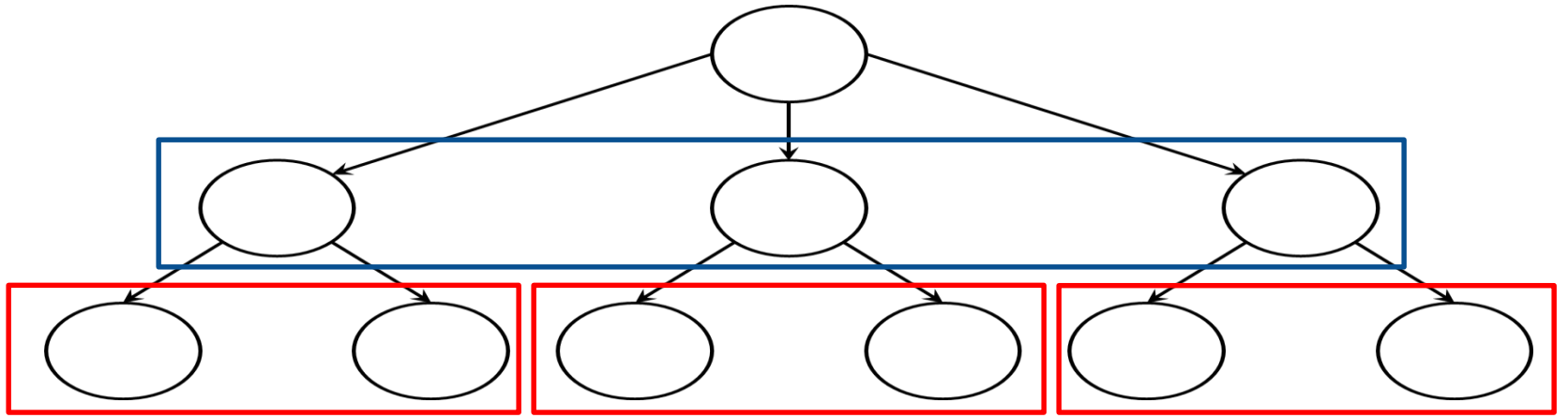
BIC sensitive to any preference – not only **primary differences**, but also any secondary, tertiary, …, differences.

Even with only 5 Best-Worst options, there are 5! = 120 possible preference rankings, and with 15 options, there are 3.8 million possible orderings!

LC probability structure may suggest 10 underlying classes, each with different ranking, but unlikely that all 10 are meaningful from policy perspective.

Idea is to develop new paradigm based on LCT modeling that yields a smaller number of meaningful classes, by focusing on **primary** differences.

LC *Tree* Modeling Assumes Underlying Hierarchical Tree Structure



- First split reveals meaningful "theme classes" (trichotomous latent variable)
- Next splits reveal secondary differences (3 dichotomous latent variables)

LC tree models to be automated in Latent GOLD® 6.0.

Relative Log-Likelihood (RLL)

Useful to determine # theme classes (for 1st split of tree)
Recognizes largest improvement in LL occurs from 1 to 2 classes ($logL_2 - LogL_1$):

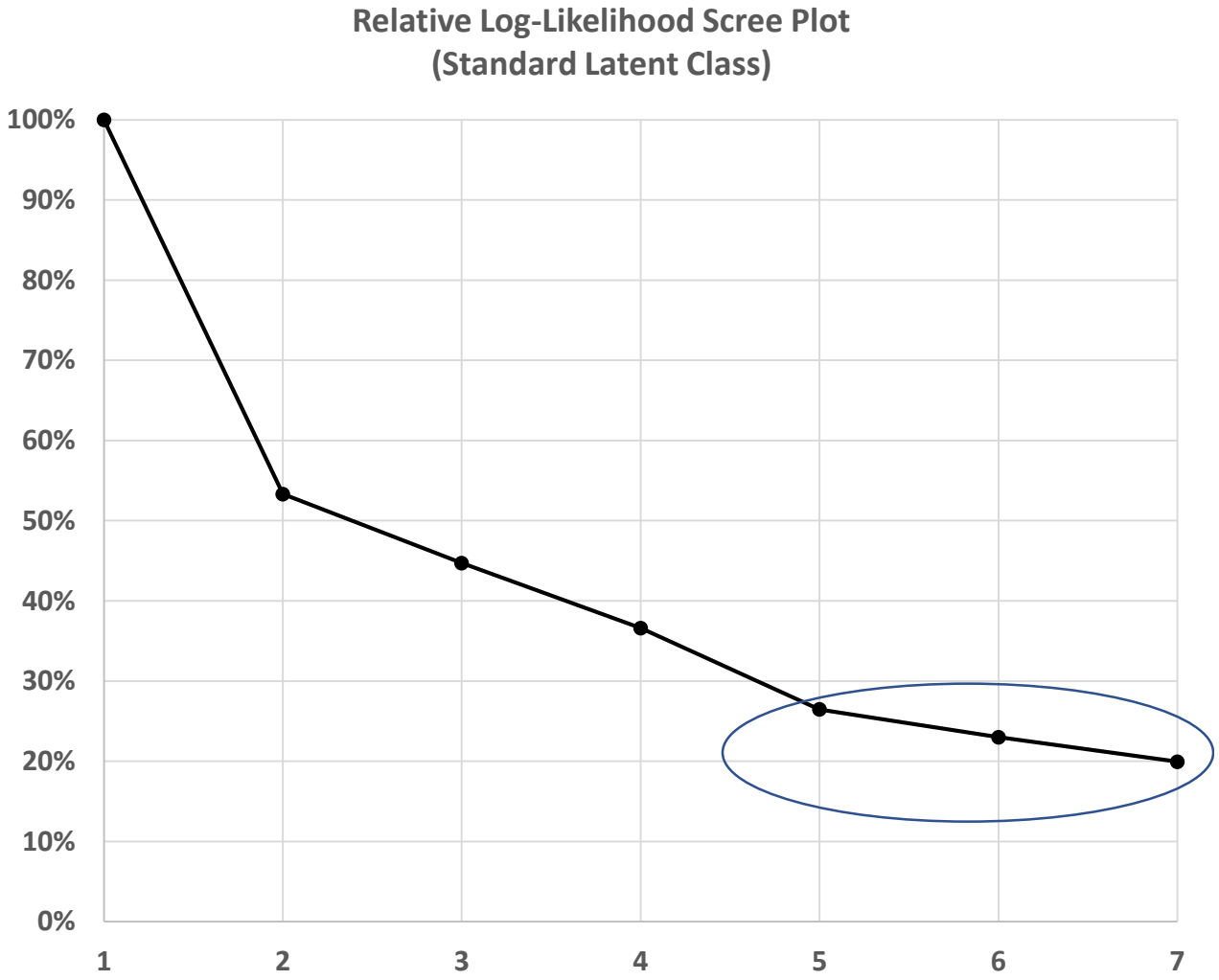
Further improvements ($logL_{K+1} - LogL_K$) compared to ($logL_2 - LogL_1$):

$$RLL_{K,K+1} = \frac{logL_{K+1} - logL_K}{logL_2 - logL_1}$$

Select K* theme classes that suggest *primary* improvement in log-likelihood.

RLL proposed to determine the number of *core* (1st level) LCT model classes in van den Bergh et. al. (2018)

RLL Scree Plot for LC Model Suggests 2, 3, 4 or 5 Theme Classes



Similar to scree plot used to determine # factors in factor analysis

Select at most K* theme classes after which RLL levels off (K* = 3,4,5 ?)

<u>Y-axis key</u>

RLL measures relative gain as # classes increase from K (X-axis key) to K+1

Results Provide some Support for Flynn's 3 Segments

But results suggest confound between preference and scale

Attribute (Item No.)	Estimated Utility Parameters						
	3-Class Model			4-Class Model			
	Class 1	Class 2	Class 3	Class 1	Class 2	Class 3	Class 4
A culture of reflective improvement & innovation (1)	-1.64	-0.48	-0.49	-0.37	-1.42	-1.83	-0.40
A respectful, ethical system (2)	-0.23	0.34	0.51	0.07	-0.48	0.85	1.25
Comprehensiveness (3)	-0.24	0.27	-1.08	-0.29	-0.25	0.54	-1.39
Equity (4)	-0.11	0.52	-1.55	-0.33	-0.66	1.67	-2.12
People & family centred (5)	0.49	-0.16	1.60	0.35	0.00	0.72	2.11
Promoting wellness & strengthening prevention (6)	0.28	0.22	1.32	0.52	0.55	-0.24	1.84
Providing for future generations (7)	0.02	0.10	0.99	0.56	-0.01	-0.23	1.00
Public voice & community engagement (8)	-1.72	-0.33	-0.54	-0.30	-1.89	-1.03	-0.78
Quality & safety (9)	2.14	0.35	0.92	0.12	2.09	2.01	1.64
Recognise social & environment influences shape our health (10)	-1.14	-0.13	0.55	0.09	-0.98	-1.18	0.86
Responsible spending (11)	0.92	0.08	-0.32	0.22	1.26	-0.17	-1.02
Shared responsibility (12)	-0.47	-0.49	-0.81	-0.60	-0.48	-0.76	-0.64
Taking the long term view (13)	-0.11	-0.21	0.22	0.24	0.13	-0.93	-0.22
Transparency & accountability (14)	0.02	-0.04	-0.24	-0.36	-0.09	0.84	-0.23
Value for money (15)	1.80	-0.04	-1.08	0.07	2.24	-0.25	-1.91
Class Size	0.35	0.34	0.31	0.39	0.26	0.18	0.17
Standard deviation σ	1.08	0.31	0.96	0.35	1.16	1.09	1.37

Note: In both solutions, there is one class indicative of '*uncertainty*' -- parameter magnitudes very low (low standard deviation = large *error* variance)

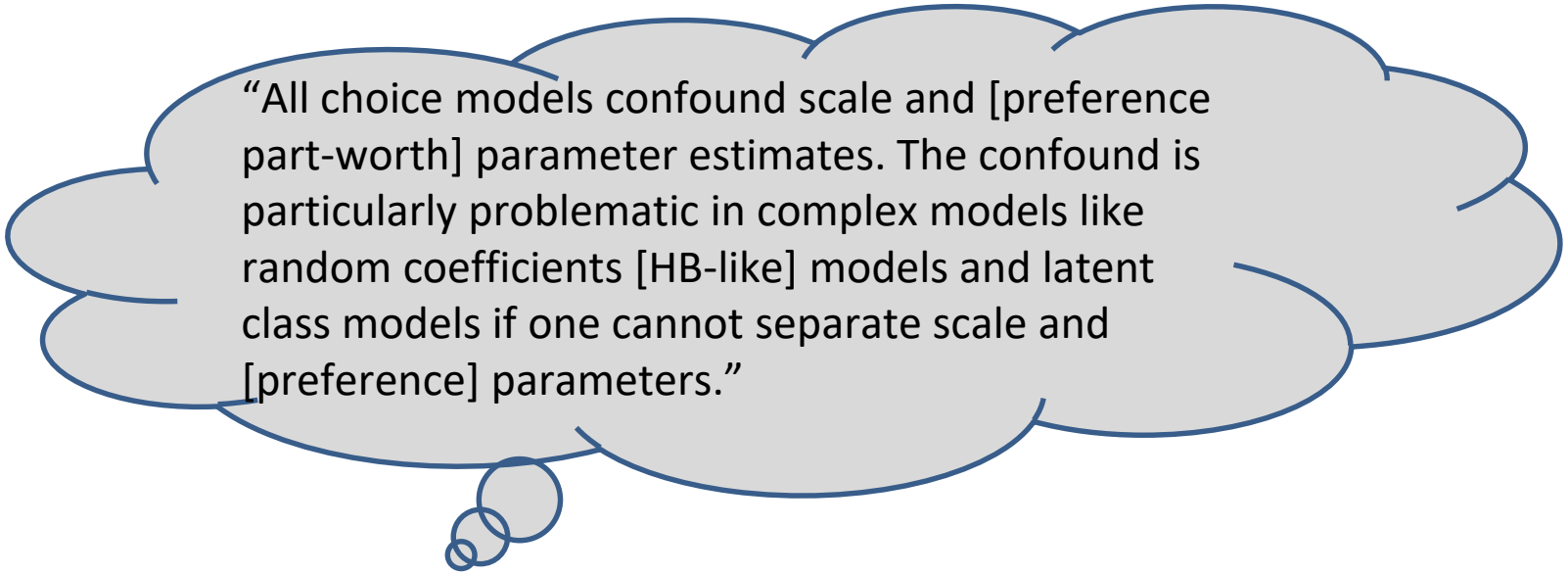
Restricted Model Supports Interpretation as Uncertain Class (Scale Factor = 0)

Attribute (Item No.)	Estimated Utilities							
	4-Class Model (restricted)				4-Class Model (unrestricted)			
	Class 1	Class 2	Class 3	Class 4	Class 1	Class 2	Class 3	Class 4
A culture of reflective improvement & innovation (1)	0.00	-1.40	-1.96	-0.40	-0.37	-1.42	-1.83	-0.40
A respectful, ethical system (2)	0.00	-0.34	0.82	0.77	0.07	-0.48	0.85	1.25
Comprehensiveness (3)	0.00	-0.16	0.02	-1.20	-0.29	-0.25	0.54	-1.39
Equity (4)	0.00	-0.66	1.59	-1.68	-0.33	-0.66	1.67	-2.12
People & family centred (5)	0.00	0.03	1.07	1.90	0.35	0.00	0.72	2.11
Promoting wellness & strengthening prevention (6)	0.00	0.54	-0.07	1.66	0.52	0.55	-0.24	1.84
Providing for future generations (7)	0.00	0.08	-0.18	1.25	0.56	-0.01	-0.23	1.00
Public voice & community engagement (8)	0.00	-1.91	-0.96	-0.73	-0.30	-1.89	-1.03	-0.78
Quality & safety (9)	0.00	1.91	2.50	0.90	0.12	2.09	2.01	1.64
Recognise social & environ influences shape our health (10)	0.00	-0.92	-1.36	0.77	0.09	-0.98	-1.18	0.86
Responsible spending (11)	0.00	1.22	-0.07	-0.65	0.22	1.26	-0.17	-1.02
Shared responsibility (12)	0.00	-0.55	-0.95	-0.88	-0.60	-0.48	-0.76	-0.64
Taking the long term view (13)	0.00	0.19	-0.62	0.04	0.24	0.13	-0.93	-0.22
Transparency & accountability (14)	0.00	-0.15	0.76	-0.55	-0.36	-0.09	0.84	-0.23
Value for money (15)	0.00	2.11	-0.62	-1.19	0.07	2.24	-0.25	-1.91
Class Size	0.31	0.29	0.17	0.24	0.39	0.26	0.18	0.17
Standard deviation σ	0.00	1.11	1.18	1.13	0.35	1.16	1.09	1.37

Best-Worst Model	LL	BIC(LL)	Npar
4-Class (unrestricted)	-10392.8	21099.5	59
4-class (restricted)	-10425.8	21091.0	45

Restricted model fits better. Despite their uncertainty, we would like to classify them into the *Preference* class most consistent with their responses.

Problem #2: Preference is Confounded with Scale in Utility Parameters

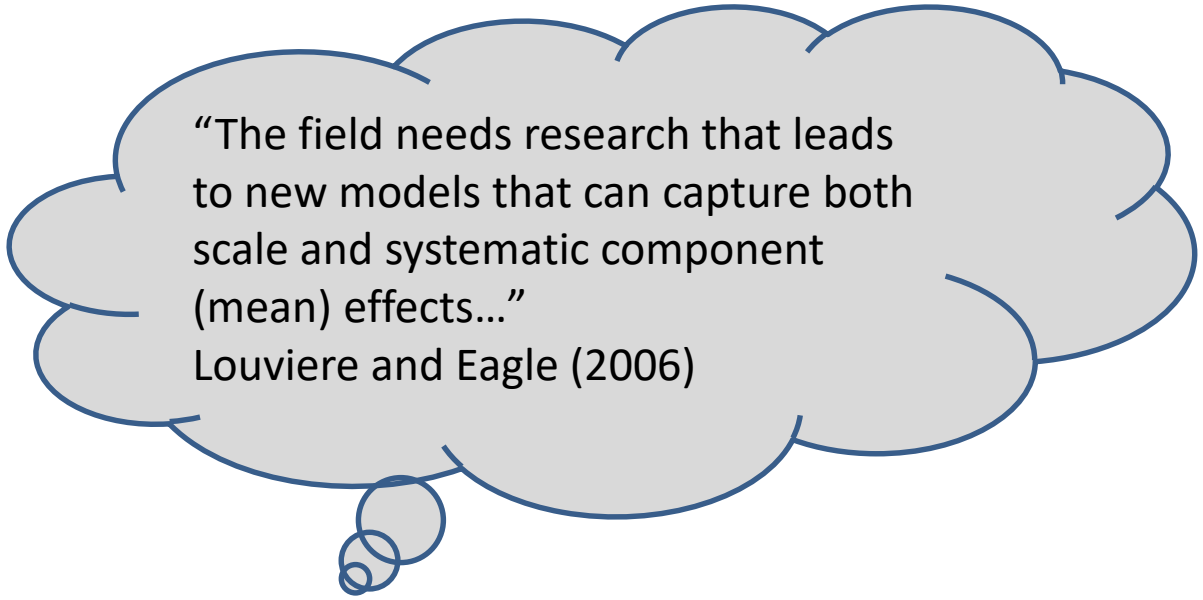


Louviere and Eagle (2006)

Louviere, Jordan J., Thomas C. Eagle, 2006. "Confound it! That Pesky Little Scale Constant Messes Up," 2006 Sawtooth Software Conference Proceedings.

SALC Models Introduced in 2007

Development of SALC model by Magidson and Vermunt (2007) was motivated by the Louviere and Eagle call to action at the 2006 Sawtooth Software Conference



*Magidson, J. and J.K. Vermunt, 2007. "Removing the Scale Factor Confound in Multinomial Logit Choice Models to Obtain Better Estimates of Preference", 2007 Sawtooth Software Conference Proceedings.

History of SALC Model in Latent GOLD® Choice Module

SALC model proposed originally by Magidson and Vermunt (2007) and estimated using the syntax module in Latent GOLD 4.5.

- SALC model updated in LG 5.0 based on log-scale model suggested by Vermunt (2013)
- Improves over earlier SALC approach by Magidson and Vermunt (2007), and allows for covariates to affect scale.
- SALC Tree approach added to LG 6.0 (see Groothuis-Oudshoorn et al., 2018)

Several publications on SALC modeling over past few years (see References).

Groothuis-Oudshoorn, C.G.M., T. Flynn, H.I. Yoo, J. Magidson, M. Oppe (2018). Key Issues and Potential Solutions for Understanding Health Care Preference Heterogeneity Free from Patient Level Scale Confounds. The Patient: Patient-Centered Outcomes Research. https://rdcu.be/Mx8e

How Utilities for Attribute Level j Differ within a Latent Class

$$\beta_{j.s} = \exp(\lambda_s - \lambda_0)\beta_{j.1}$$

- Log-scale factors λ_s estimated simultaneously with preference parameters $\beta_{j.1}$
- For purposes of identification, λ_s is determined relative to a fixed reference point λ_0, and can be modeled using individual-level or group-level latent variables (Vermunt, 2013):
  - Latent categorical scale classes (sClasses): For identification we use the first sClass, s=1, as the reference and set $\lambda_1 = \lambda_0 = 0$.

Standard LC choice model assumes no scale heterogeneity – i.e.,

$$\lambda_s = \lambda_0 \text{ for all s}$$

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Syntax for Scale-Adjusted Latent Class (SALC) Choice Models

```
latent
    sclass nominal 3 coding=first,     // S=3 scale classes
    Class nominal 3;                   // K=3 theme classes
equations
Class <- 1;                            // class sizes
  sClass <- 1 ;                        // scale class sizes
  choice <- object | Class;            // sequential logit model
    choice <<- (-) sClass ;            //log-scale model
```

Model can be setup using GUI interface. **See Latent GOLD Choice tutorial 8A:**
http://www.statisticalinnovations.com/wp-content/uploads/LGChoice_tutorial_8A.pdf

BIC Continues to Decline as Number of Classes Increase (Similar to LC)

Latent Class Models

Model	LL	BIC	Npar
1-class	-11245.6	22565.7	14
2-class	-10815.0	21784.2	29
3-class	-10585.4	21404.8	44
4-class	-10392.8	21099.5	59
5-class	-10237.2	20974.2	74
6-class	-10121.3	20715.9	89

SALC Models*

Model	LL	BIC	Npar
1-class SALC	-11035.0	22165.8	18
2-class SALC	-10572.7	21320.9	33
3-class SALC	-10359.5	20974.2	48
4-class SALC	-10197.9	20730.7	63
5-class SALC	-10094.7	20604.2	78
6-class SALC	-9994.6	20485.0	93

SALC allows scale differences within each latent class

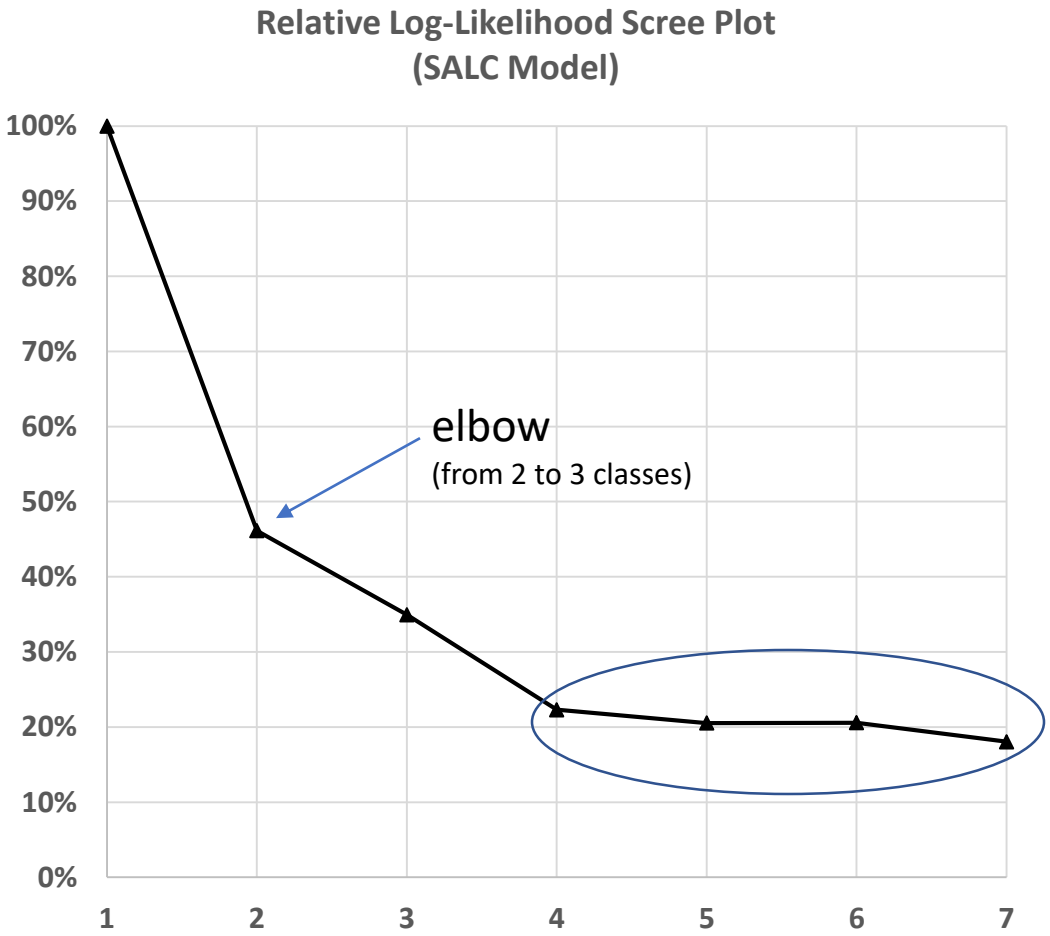
BIC identifies 3 scale classes (sClass) = (high, medium, low) preference clarity:

*SALC models contain 3 scale classes

SALC/ 3 Pref. classes	LL	BIC(LL)	Npar
1 scale class (sClass)	-10585.4	21404.8	44
2 sClasses	-10394.1	21032.9	46
3 sClasses	-10359.5	20974.2	48
4+ sClasses	-10359.5	N/A *	N/A *
Continuous scale	-10376.2	20996.9	46

Note: BIC for 3-sClasses consistently better than 2 or 4 sClasses regardless of number of classes

RLL Scree Plot Suggests 3 or 4 Theme Classes with SALC Model



Elbow occurs for K=3 class SALC

RLL **clearly** levels off after K=4; Thus, no gain in RLL after K=4

Comparison of 3 vs. 4-class SALC Models

By default, Latent GOLD® displays parameters for scale class 1

Class 4 in 4-class model redundant with other classes; Thus, better to choose K*=3 theme classes

LatentGOLD

File Edit View Model Window Help

	Class		
	1	2	3
object			
a culture of reflective improvement & innovation	-2.1678	-0.6081	-3.0636
a respectful, ethical system	-0.6011	1.3657	1.2077
comprehensiveness	-0.2421	-1.9083	0.4766
equity	-1.0337	-2.8577	2.5582
people & family centred	-0.2671	2.9193	1.7748
promoting wellness & strengthening prevention	0.8980	2.6435	-0.0771
providing for future generations	0.0750	2.0424	-0.2094
public voice & community engagement	-2.7916	-1.3029	-1.7138
quality & safety	2.9465	1.6397	3.7791
recognise social & environmental influences shape our health	-1.3490	1.3476	-2.1296
responsible spending	2.1243	-1.1548	-0.1660
shared responsibility	-1.0473	-1.2974	-1.4917
taking the long term view	0.3424	0.0450	-1.1764
transparency & accountability	-0.2726	-0.8508	1.0486
value for money	3.3862	-2.0230	-0.8173

LatentGOLD

File Edit View Model Window Help

	Class			
	1	2	3	4
object				
a culture of reflective improvement & innovation	-0.6250	-2.2839	-2.8719	-1.2632
a respectful, ethical system	1.3666	-0.3444	0.9186	-0.1466
comprehensiveness	-1.8583	-0.9175	0.0458	0.8289
equity	-2.7481	-1.0710	2.6269	-0.8843
people & family centred	2.7772	1.4929	1.8117	-1.7410
promoting wellness & strengthening prevention	2.5841	-0.8802	-0.2678	2.5865
providing for future generations	1.9634	0.5044	0.2480	-0.0281
public voice & community engagement	-1.0348	-2.0799	-1.4670	-3.1403
quality & safety	1.6099	2.5312	3.8606	2.4471
recognise social & environmental influences shape our health	1.4994	-1.5566	-2.0562	-1.1391
responsible spending	1.2382	1.8381	-0.1896	1.6206
shared responsibility	-1.2307	-1.3134	-1.4157	-0.4958
taking the long term view	-0.0582	0.2986	-1.0262	0.1699
transparency & accountability	-0.8661	-0.0896	1.0489	-0.3021
value for money	-2.1412	3.8713	-0.7702	1.4875

Preference Parameters for all 3 Scale Classes

Item No.	Class 1 by scale class			Class 2 by scale class			Class 3 by scale class		
	sClass 1	sClass 2	sClass 3	sClass 1	sClass 2	sClass 3	sClass 1	sClass 2	sClass 3
1	-2.17	-1.15	-0.30	-0.61	-0.32	-0.09	-3.06	-1.62	-0.43
2	-0.60	-0.32	-0.08	1.37	0.73	0.19	1.21	0.64	0.17
3	-0.24	-0.13	-0.03	-1.91	-1.01	-0.27	0.48	0.25	0.07
Equity	-1.03	-0.55	-0.14	-2.86	-1.52	-0.40	2.56	1.36	0.36
Family	-0.27	-0.14	-0.04	2.92	1.55	0.41	1.77	0.94	0.25
Prevent	0.90	0.48	0.13	2.64	1.40	0.37	-0.08	-0.04	-0.01
Future	0.08	0.04	0.01	2.04	1.08	0.29	-0.21	-0.11	-0.03
8	-2.79	-1.48	-0.39	-1.30	-0.69	-0.18	-1.71	-0.91	-0.24
Quality	2.95	1.56	0.41	1.64	0.87	0.23	3.78	2.00	0.53
10	-1.35	-0.72	-0.19	1.35	0.72	0.19	-2.13	-1.13	-0.30
11	2.12	1.12	0.30	-1.15	-0.61	-0.16	-0.17	-0.09	-0.02
12	-1.05	-0.56	-0.15	-1.30	-0.69	-0.18	-1.49	-0.79	-0.21
13	0.34	0.18	0.05	0.05	0.03	0.01	-1.18	-0.63	-0.17
14	-0.27	-0.14	-0.04	-0.85	-0.45	-0.12	1.05	0.56	0.15
Money	3.39	1.80	0.47	-2.02	-1.07	-0.28	-0.82	-0.43	-0.11

The least certain class (sClass 3) contains 31.4% of respondents. Despite their uncertainty, the SALC model is able to classify them into the *Preference* class most consistent with their responses.

SALC Model *More Fully* Supports Flynn's 3 Policy-Relevant Segments

Principles	***Preference Parameters**** 3-Class SALC Model		
	Class 1	Class 2	Class 3
A culture of reflective improvement & innovation	-1.38	-0.31	-1.28
A respectful, ethical system	-0.38	0.69	0.51
Comprehensiveness	-0.15	-0.96	0.20
Equity	-0.65	-1.43	1.07
People & family centered	-0.17	1.46	0.74
Promoting wellness & strengthening prevention	0.57	1.32	-0.03
Providing for future generations	0.05	1.02	-0.09
Public voice & community engagement	-1.77	-0.65	-0.72
Quality & safety	1.87	0.82	1.58
Recognize social/environ influences shape health	-0.86	0.68	-0.89
Responsible spending	1.35	-0.58	-0.07
Shared responsibility	-0.67	-0.65	-0.62
Taking the long term view	0.22	0.03	-0.49
Transparency & accountability	-0.17	-0.43	0.44
Value for money	2.15	-1.01	-0.34
Class Size	0.39	0.35	0.26
Standard deviation	1.07	0.89	0.75

Point #1: Individuals belonging to the same ***class*** have the same ***preferences***. Scale is adjusted out.

Point #2: Individuals *within* a given preference class exhibit different levels of ***clarity*** *(high, medium, low), as* assessed by 1 of 3 *scale* factors.

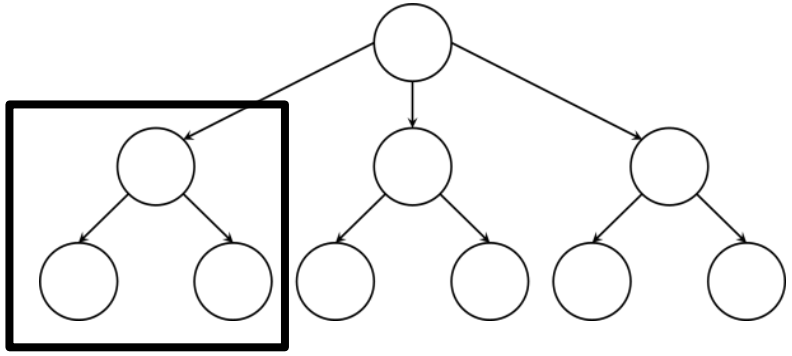
****Preference*** parameters are aggregated over the 3 scale classes (weighted average coding)

SALC Tree Model Splits the 3 Theme Classes Revealing Secondary Differences

Theme Class #1 =

Theme Class #2 =

Theme Class #3 =



	SALC Tree					
	0.21	0.17	0.20	0.16	0.16	0.10
a culture of reflective improvement & innovation	-1.38	-0.78	-0.61	0.02	-1.61	-1.64
a respectful, ethical system	-0.24	-0.36	0.60	0.87	0.85	-0.18
comprehensiveness	-0.52	0.51	-1.16	-0.87	0.57	-0.24
equity	-0.57	-0.60	-1.76	-1.29	0.20	3.81
people & family centred	0.76	-1.20	1.41	1.55	1.07	0.52
promoting wellness & strengthening prevention	-0.51	1.64	1.60	1.09	0.26	-0.35
providing for future generations	0.18	-0.04	1.16	0.97	0.09	-0.59
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quality & safety	1.60	1.61	0.23	1.27	1.71	3.08
recognise social & environmental influences shape our health	-0.93	-0.70	0.65	0.87	-0.97	-1.52
responsible spending	1.14	1.15	-0.08	-1.12	0.10	-0.65
shared responsibility	-0.80	-0.23	-0.73	-0.71	-0.68	-0.91
taking the long term view	0.14	0.20	0.33	-0.35	-0.56	-0.56
transparency & accountability	-0.02	-0.31	-0.56	-0.35	0.52	0.59
value for money	2.39	1.11	-0.03	-1.80	-0.62	-0.36

Point #1: Individuals in same **theme *class*** (1-2,3-4,5-6) have the same ***1st order preferences***. Scale is adjusted out.

Point #2: Individuals *within* a theme class show secondary differences (preference class 1 vs. 2, 3 vs. 4, 5 vs. 6)

SALC Tree Model Splits the 3 Theme Classes Revealing Secondary Differences

Theme Class #1 =

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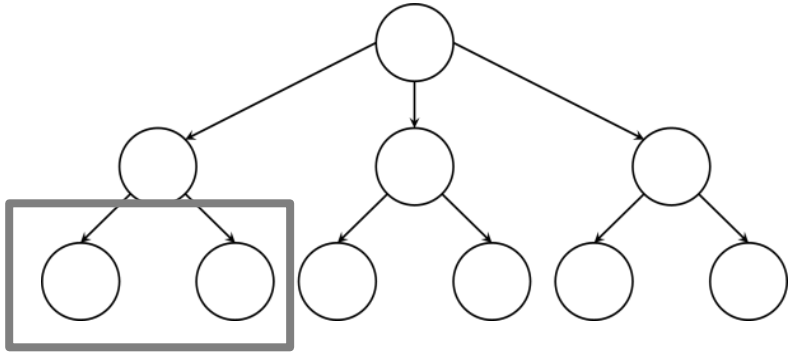

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taking the long term view	0.14	0.20	0.33	-0.35	-0.56	-0.56
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value for money	2.39	1.11	-0.03	-1.80	-0.62	-0.36

Point #1: Individuals belonging to the same **theme *class*** (1-2,3-4,5-6) have the same ***preferences***. Scale is adjusted out.

Point #2: Individuals *within* a theme class show secondary differences (preference class 1 vs. 2, 3 vs. 4, 5 vs. 6)

SALC Tree Model Splits the 3 Theme Classes Revealing Secondary Differences

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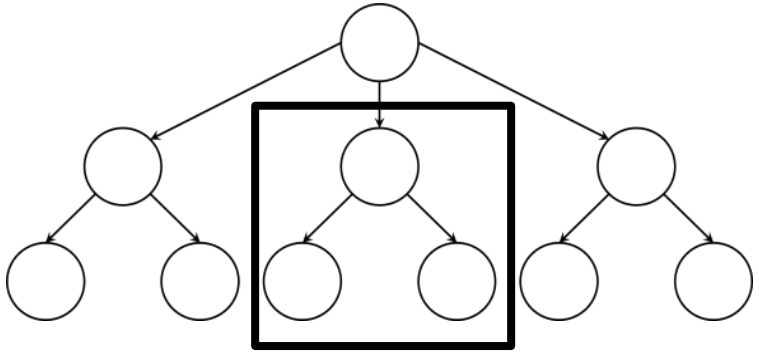

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Structure is consistent across branches connected to the same "root" or "theme" class

Point #1: Individuals belonging to the same **theme *class*** (1-2,3-4,5-6) have the same ***preferences***. Scale is adjusted out.

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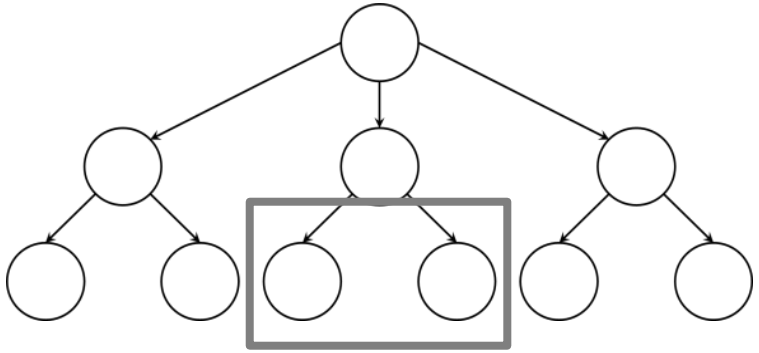

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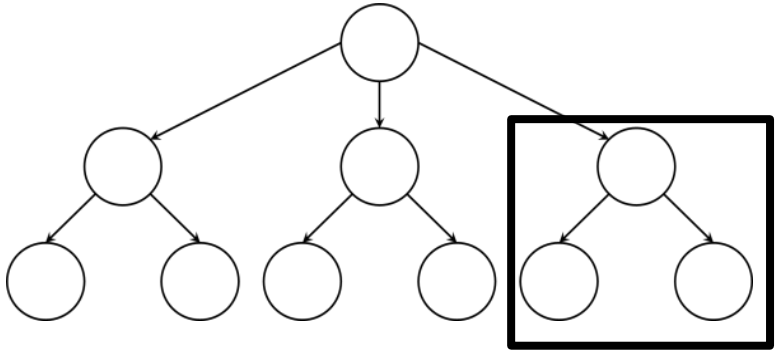

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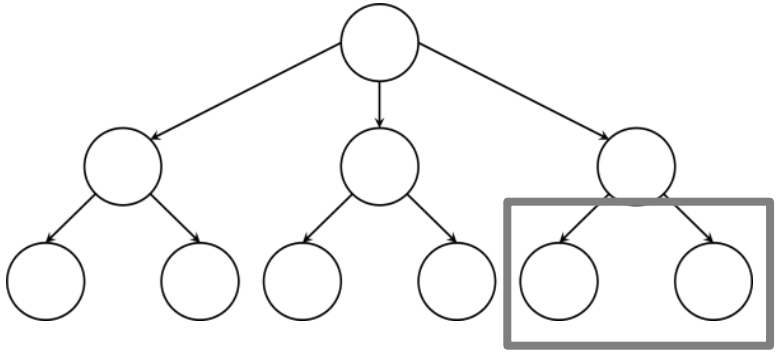

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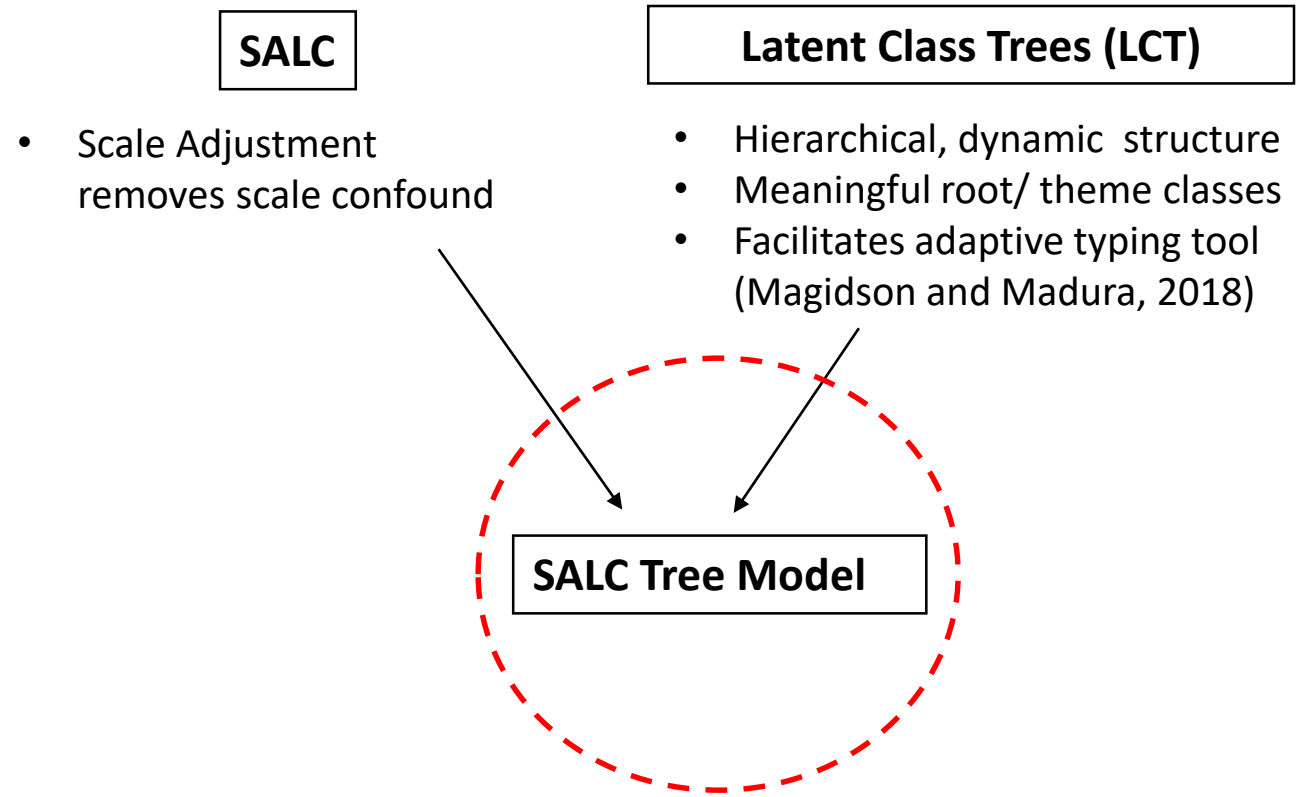
Summary: What Model Fitting Paradigm Should be Used?



Standard LC Replaced by SALC tree Models to Improve Interpretation/ Policy Relevance

Our Research is Ongoing

Current/Future Research Topics include:

- Improving the classification/typing performance by making **optimal use of the tree structure for MaxDiff and other choice formats** (e.g., optimal classification into theme and terminal segments) – See Magidson and Madura (2018)

- How to best deal with the **scale classes at the different segmentation levels**

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Appendix

Three Different Models for Analyzing BestWorst Response Data

- Sequential Logit (Best-Worst) — Vermunt and Magidson (2003)
- MaxDiff model (Joint Best-Worst) – Marley and Louviere (2005)
- MaxDiff Independence* – Louviere (1993)
  - implemented in Sawtooth Software

Best-Worst responses are a type of partial ranking data.
All three of these models are implemented in Latent GOLD®
(further slides available for Panel session)
* Theoretically inconsistent (assumes same alternative can be both best and worst)

Sequential Best-Worst Model

- Models the best and worst alternatives as a sequential choice process (Bockenholt, 2002; Croon, 1989; Kamakura et. al., 1994).
- That is, selection of the best option is equivalent to a first choice and selection of the worst option is a (first) choice out of the remaining alternatives, where the worst choice probabilities are negatively related to the best utilities of these alternatives.
- Using the ‘Ranking’ or the newer ‘BestWorst’ scale types causes Latent GOLD to automatically eliminate the option selected as ‘best’ from set of options available for choice of ‘worst’.
- This model was first implemented in Latent GOLD® Choice 3.0 -- See Magidson (2003).
- ‘Best-Worst’ scale type – implemented with GUI interface added in version 5.0 (Vermunt and Magidson, 2013)

Syntax for Scale-Adjusted Latent Class (SALC) Choice Models (Continuous Scale Option)

- latent
- sCfactor continuous,
- Class nominal 3;
- equations
- Class <- 1 + income;
- (1)sCfactor ; //variance of continuous factor set to 1 for identification
- choice <- brand | Class + (-) price | Class + nobuy | Class;
- choice <<- sCFactor ;