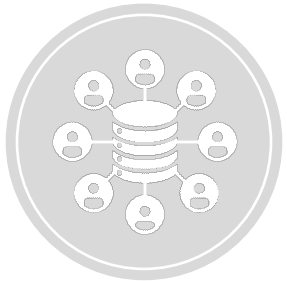
Attribute importance

Key concepts & study plan

Experimental design



Data collection & processing

Model specification & estimation

Interpretation & application

Attribute importance

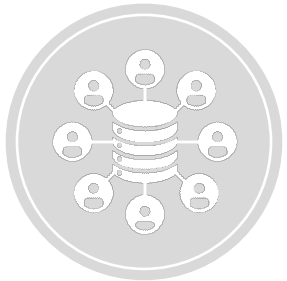
Overview

- Measuring attribute importance
- Impact on utility
- Accounting for observed heterogeneity
- Some caveats

Measuring attribute importance

Key concepts & study plan

Experimental design



Data collection & processing

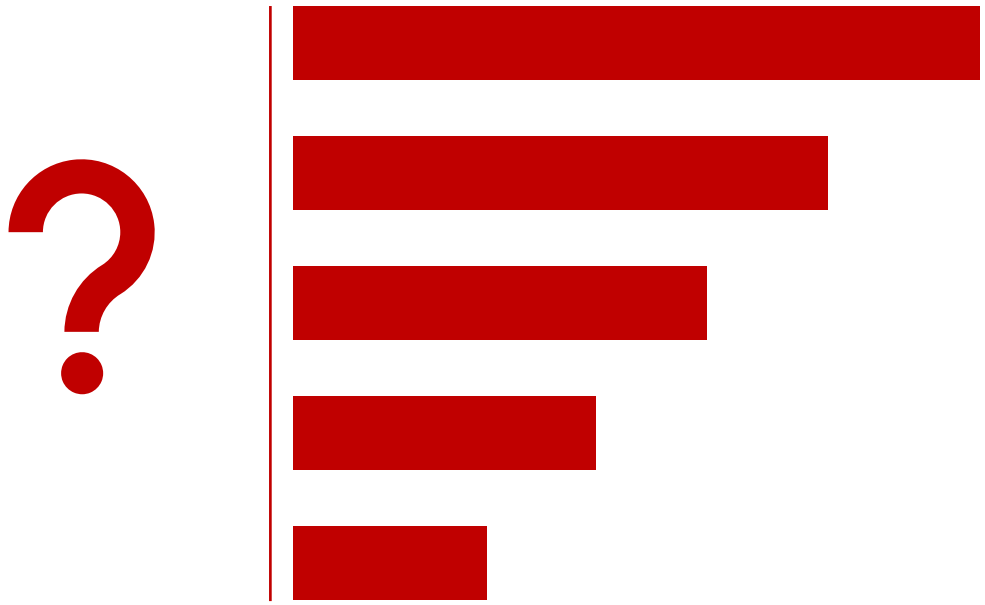
Model specification & estimation

Interpretation & application

Measuring attribute importance

Attribute importance

- Relative impact of each attribute on choice
- Importance ranking of attributes
- Based on model estimation outputs



Measuring attribute importance

Mode choice example

- Rank the attributes in this choice model from most to least important
  - Mode (labels represented by ASCs)
  - Travel time
  - Access time
  - Cost
  - Service

Estimates:

	Estimate	s.e.	t.rat.(0)	Rob.s.e.	Rob.t.rat.(0)
asc_car	0.00000	NA	NA	NA	NA
asc_bus	-2.04288	0.075132	-27.191	0.092220	-22.152
asc_air	-0.58780	0.180223	-3.262	0.197274	-2.980
asc_rail	-0.86198	0.107216	-8.040	0.117824	-7.316
b_tt	-0.01205	5.5356e-04	-21.775	5.9548e-04	-20.242
b_access	-0.01992	0.002507	-7.946	0.002489	-8.003
b_cost	-0.05870	0.001463	-40.118	0.001680	-34.951
b_no_frills	0.00000	NA	NA	NA	NA
b_wifi	0.95150	0.052893	17.989	0.055165	17.248
b_food	0.41168	0.052141	7.895	0.052807	7.796

Measuring attribute importance

How did you assess attribute importance?

- Size of the coefficient?
- Size of the *t*-ratio?
- Something else?

Estimates:

	Estimate	s.e.	t.rat.(0)	Rob.s.e.	Rob.t.rat.(0)
asc_car	0.00000	NA	NA	NA	NA
asc_bus	-2.04288	0.075132	-27.191	0.092220	-22.152
asc_air	-0.58780	0.180223	-3.262	0.197274	-2.980
asc_rail	-0.86198	0.107216	-8.040	0.117824	-7.316
b_tt	-0.01205	5.5356e-04	-21.775	5.9548e-04	-20.242
b_access	-0.01992	0.002507	-7.946	0.002489	-8.003
b_cost	-0.05870	0.001463	-40.118	0.001680	-34.951
b_no_frills	0.00000	NA	NA	NA	NA
b_wifi	0.95150	0.052893	17.989	0.055165	17.248
b_food	0.41168	0.052141	7.895	0.052807	7.796

Measuring attribute importance

Looking at the size of coefficients is not valid!

- Coefficients of numerical attributes depend on chosen units
- Coefficients of categorical attributes depend on chosen reference level and type of coding

Travel time in minutes
Access time in minutes
Cost in £

Estimates:

	Estimate	s.e.	t.rat.(0)	Rob.s.e.	Rob.t.rat.(0)
asc_car	0.00000	NA	NA	NA	NA
asc_bus	-2.04288	0.075132	-27.191	0.092220	-22.152
asc_air	-0.58780	0.180223	-3.262	0.197274	-2.980
asc_rail	-0.86198	0.107216	-8.040	0.117824	-7.316
b_tt	-0.01205	5.5356e-04	-21.775	5.9548e-04	-20.242
b_access	-0.01992	0.002507	-7.946	0.002489	-8.003
b_cost	-0.05870	0.001463	-40.118	0.001680	-34.951
b_no_frills	0.00000	NA	NA	NA	NA
b_wifi	0.95150	0.052893	17.989	0.055165	17.248
b_food	0.41168	0.052141	7.895	0.052807	7.796

Travel time in hours
Access time in hours
Cost in 100£

Estimates:

	Estimate	s.e.	t.rat.(0)	Rob.s.e.	Rob.t.rat.(0)
asc_car	0.0000	NA	NA	NA	NA
asc_bus	-2.0429	0.07513	-27.191	0.09222	-22.152
asc_air	-0.5878	0.18022	-3.262	0.19727	-2.980
asc_rail	-0.8620	0.10722	-8.040	0.11782	-7.316
b_tt	-0.7232	0.03321	-21.775	0.03573	-20.242
b_access	-1.1952	0.15041	-7.946	0.14935	-8.003
b_cost	-5.8704	0.14633	-40.118	0.16796	-34.951
b_no_frills	0.0000	NA	NA	NA	NA
b_wifi	0.9515	0.05289	17.989	0.05517	17.248
b_food	0.4117	0.05214	7.895	0.05281	7.796

Measuring attribute importance

Looking at the size of *t*-ratios is not valid!

- *t*-ratios describe precision of parameter estimates, not importance
- *t*-ratios depend on the number of choice observations

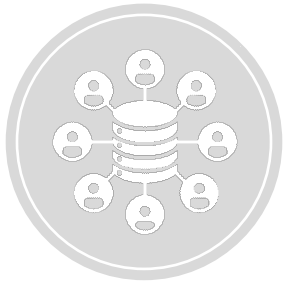
Estimates:

	Estimate	s.e.	t.rat.(0)	Rob.s.e.	Rob.t.rat.(0)
asc_car	0.00000	NA	NA	NA	NA
asc_bus	-2.04288	0.075132	-27.191	0.092220	-22.152
asc_air	-0.58780	0.180223	-3.262	0.197274	-2.980
asc_rail	-0.86198	0.107216	-8.040	0.117824	-7.316
b_tt	-0.01205	5.5356e-04	-21.775	5.9548e-04	-20.242
b_access	-0.01992	0.002507	-7.946	0.002489	-8.003
b_cost	-0.05870	0.001463	-40.118	0.001680	-34.951
b_no_frills	0.00000	NA	NA	NA	NA
b_wifi	0.95150	0.052893	17.989	0.055165	17.248
b_food	0.41168	0.052141	7.895	0.052807	7.796

Impact on utility

Key concepts & study plan

Experimental design



Data collection & processing

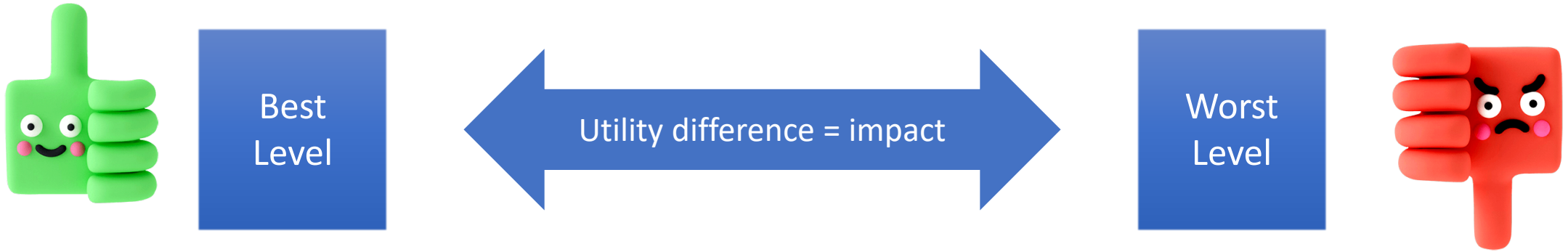
Model specification & estimation

Interpretation & application

Impact on utility

Measure of attribute importance

- Difference in utility between best and worst attribute level



Orme, B.K. (2010,2019) *Getting Started with Conjoint Analysis: Strategies for Product Design and Pricing Research*. Madison, Wis., Research Publishers LLC.

Gonzalez, J.M. (2019) A guide to measuring and interpreting attribute importance. *The Patient*, 12, 287-295.

Impact on utility

Mode choice example

- For each attribute
  - Compute contribution to utility of each level
  - Compute difference between best and worst level

```
Estimates:
              Estimate
asc_car        0.00000
asc_bus       -2.04288
asc_air       -0.58780
asc_rail      -0.86198
b_tt          -0.01205
b_access      -0.01992
b_cost        -0.05870
b_no_frills    0.00000
b_wifi         0.95150
b_food         0.41168
```

$$V_{car,n} = \beta_{tt} \cdot \text{TravelTime}_{car,n} + \beta_{access} \cdot \text{AccessTime}_{car,n} + \beta_{cost} \cdot \text{Cost}_{car,n} + \beta_{wifi} \cdot \text{Wifi}_{car,n} + \beta_{food} \cdot \text{Food}_{car,n}$$

$$V_{bus,n} = \beta_{bus} + \beta_{tt} \cdot \text{TravelTime}_{bus,n} + \beta_{access} \cdot \text{AccessTime}_{bus,n} + \beta_{cost} \cdot \text{Cost}_{bus,n} + \beta_{wifi} \cdot \text{Wifi}_{bus,n} + \beta_{food} \cdot \text{Food}_{bus,n}$$

$$V_{air,n} = \beta_{air} + \beta_{tt} \cdot \text{TravelTime}_{air,n} + \beta_{access} \cdot \text{AccessTime}_{air,n} + \beta_{cost} \cdot \text{Cost}_{air,n} + \beta_{wifi} \cdot \text{Wifi}_{air,n} + \beta_{food} \cdot \text{Food}_{air,n}$$

$$V_{rail,n} = \beta_{rail} + \beta_{tt} \cdot \text{TravelTime}_{rail,n} + \beta_{access} \cdot \text{AccessTime}_{rail,n} + \beta_{cost} \cdot \text{Cost}_{rail,n} + \beta_{wifi} \cdot \text{Wifi}_{rail,n} + \beta_{food} \cdot \text{Food}_{rail,n}$$

Impact on utility

Mode choice example

- Attribute: Travel time
- Levels in the data: 50, 90, 120, 170, 250, 330, 420 mins
- Parameter estimate(s): -0.01205
- Utility range: 4.4585

```
Estimates:
              Estimate
asc_car        0.00000
asc_bus       -2.04288
asc_air       -0.58780
asc_rail      -0.86198
b_tt          -0.01205
b_access      -0.01992
b_cost        -0.05870
b_no_frills    0.00000
b_wifi         0.95150
b_food         0.41168
```

$$V_{jn} = \ldots + \beta_{\text{tt}} \cdot \text{TravelTime}_{jn} + \ldots$$

Attribute	Level	Contribution to utility		Utility range (best minus worst)	
Travel time (minutes)	50	50 x (-0.01205)=	-0.6025	Best	(Highest utility)
	90	90 x (-0.01205)=	-1.0845		
	120	120 x (-0.01205)=	-1.4460		
	170	170 x (-0.01205)=	-2.0485		-0.6025 – (-5.0610) = **4.4585**
	250	250 x (-0.01205)=	-3.0125		
	330	330 x (-0.01205)=	-3.9765		
	420	420 x (-0.01205)=	-5.0610	Worst	(Lowest utility)

Impact on utility

Mode choice example

- Attribute: Access time
- Levels in the data: 5, 15, 25, 35, 45, 55 mins
- Parameter estimate(s): -0.01992
- Utility range: 0.9960

```
Estimates:
             Estimate
asc_car       0.00000
asc_bus      -2.04288
asc_air      -0.58780
asc_rail     -0.86198
b_tt         -0.01205
b_access     -0.01992
b_cost       -0.05870
b_no_frills   0.00000
b_wifi        0.95150
b_food        0.41168
```

$$V_{jn} = \ldots + \beta_{\text{access}} \cdot \text{AccessTime}_{jn} + \ldots$$

Attribute	Level	Contribution to utility		Utility range (best minus worst)	
Access time (minutes)	5	5 x (-0.01992)=	-0.0996	Best	(Highest utility)
	15	15 x (-0.01992)=	-0.2988		
	25	25 x (-0.01992)=	-0.4980	-0.0996 – (-1.0956) = **0.9960**	
	35	35 x (-0.01992)=	-0.6972		
	45	45 x (-0.01992)=	-0.8964		
	55	55 x (-0.01992)=	-1.0956	Worst	(Lowest utility)

Impact on utility

Mode choice example

- Attribute: Cost
- Levels in the data: 15, 40, 65, 85, 110 GBP
- Parameter estimate(s): -0.05870
- Utility range: 5.5765

```
Estimates:
             Estimate
asc_car       0.00000
asc_bus      -2.04288
asc_air      -0.58780
asc_rail     -0.86198
b_tt         -0.01205
b_access     -0.01992
b_cost       -0.05870
b_no_frills   0.00000
b_wifi        0.95150
b_food        0.41168
```

$$V_{jn} = \ldots + \beta_{\text{cost}} \cdot \text{Cost}_{jn} + \ldots$$

Attribute	Level	Contribution to utility		Utility range (best minus worst)	
Access time (minutes)	15	15 x (-0.05870)=	-0.8805	Best	(Highest utility)
	40	40 x (-0.05870)=	-2.3480		
	65	65 x (-0.05870)=	-3.8155		-0.8805 – (-6.4570) = **5.5765**
	85	85 x (-0.05870)=	-4.9895		
	110	110 x (-0.05870)=	-6.4570	Worst	(Lowest utility)

Impact on utility

Mode choice example

- Attribute: Service
- Levels in the data: no frills, wifi, food
- Parameter estimate(s): 0.00000, 0.95150, 0.41168 (dummy coded)
- Utility range: 0.9515

```
Estimates:
             Estimate
asc_car       0.00000
asc_bus      -2.04288
asc_air      -0.58780
asc_rail     -0.86198
b_tt         -0.01205
b_access     -0.01992
b_cost       -0.05870
b_no_frills   0.00000
b_wifi        0.95150
b_food        0.41168
```

$$V_{jn} = \ldots + \beta_{\text{wifi}} \cdot \text{Wifi}_{jn} + \beta_{\text{food}} \cdot \text{Food}_{jn} + \ldots$$

Attribute	Level	Contribution to utility		Utility range (best minus worst)	
Service	No frills	(dummy base)	0.00000	Worst	(Lowest utility)
	Wifi	(dummy)	0.95150	Best	(Highest utility)
	Food	(dummy)	0.41168		0.95150 – 0.00000 = **0.9515**

Impact on utility

Mode choice example

- Attribute: Mode of transport [label]
- Levels in the data: car, bus, air, rail
- Parameter estimate(s): 0.00000, -2.04288, -0.58780, -0.86198 (ASCs)
- Utility range: 2.0429

```
Estimates:
             Estimate
asc_car       0.00000
asc_bus      -2.04288
asc_air      -0.58780
asc_rail     -0.86198
b_tt         -0.01205
b_access     -0.01992
b_cost       -0.05870
b_no_frills   0.00000
b_wifi        0.95150
b_food        0.41168
```

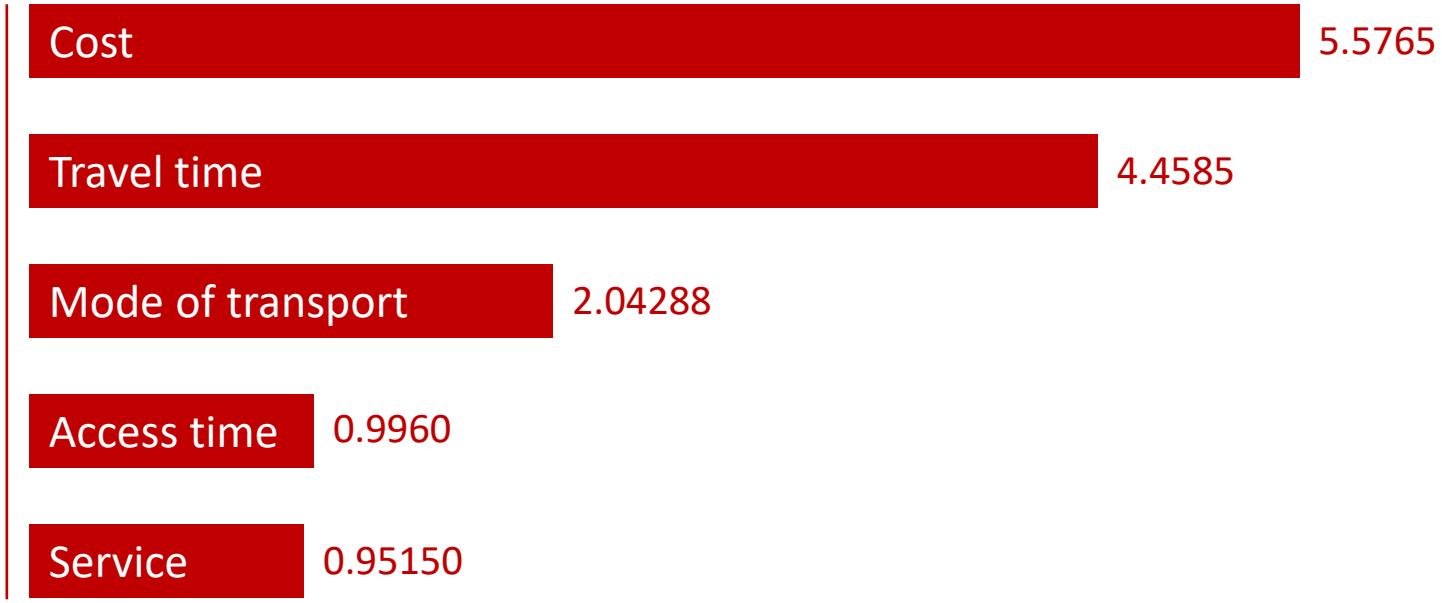
$$V_{jn} = \ldots + \beta_{\text{bus}} \cdot \text{Bus}_{jn} + \beta_{\text{air}} \cdot \text{Air}_{jn} + \beta_{\text{rail}} \cdot \text{Rail}_{jn} + \ldots$$

Attribute	Level	Contribution to utility		Utility range (best minus worst)	
Mode of transport	Car	(dummy base)	0.00000	Best	(Lowest utility)
	Bus	(dummy)	-2.04288	Worst	(Highest utility)
	Air	(dummy)	-0.58780		0.0000 – (-2.04288) = **2.0429**
	Rail	(dummy)	-0.86198		

Impact on utility

Mode choice example

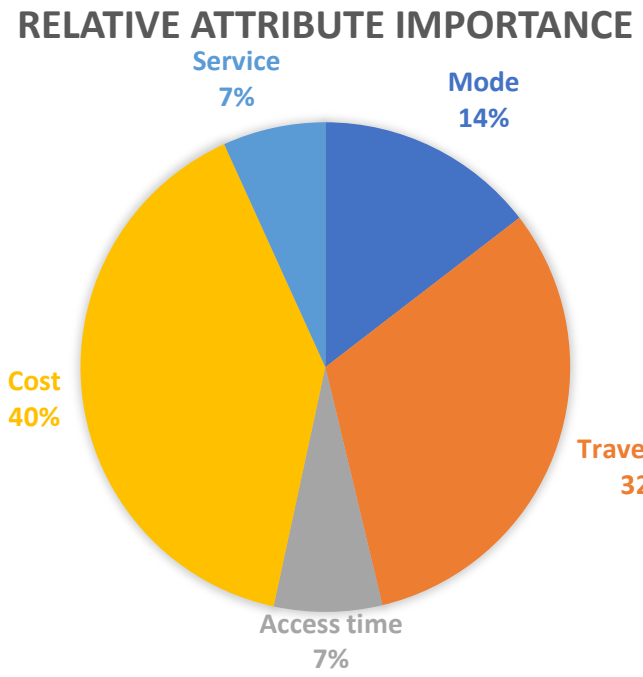
- Attribute impact on utility



Impact on utility

Mode choice example

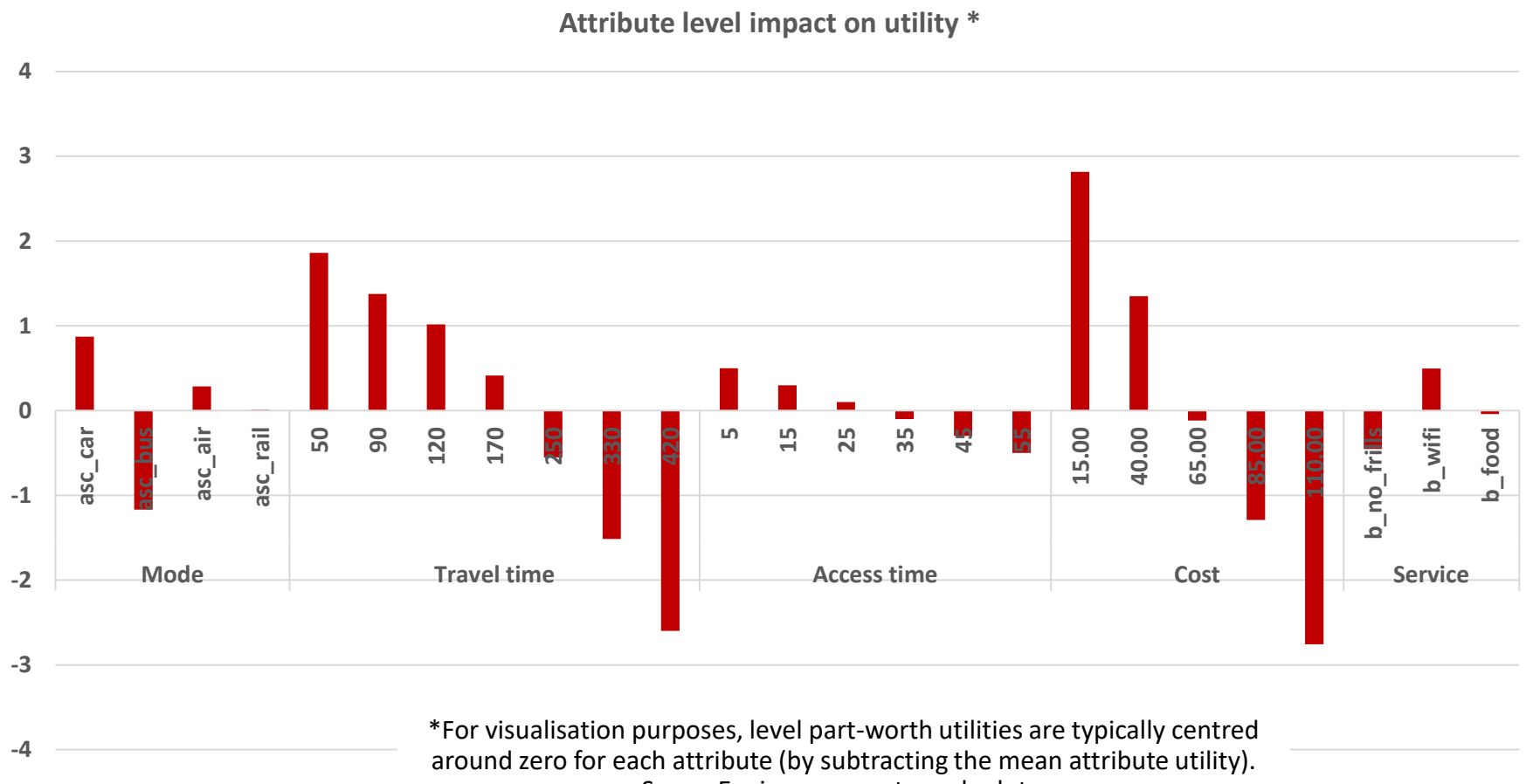
- Relative attribute impact on utility



$$\frac{4.4585}{5.5765 + 4.4585 + 2.04288 + 0.9960 + 0.95150} \times 100\%$$

Impact on utility

Visualising attribute-level contributions to utility



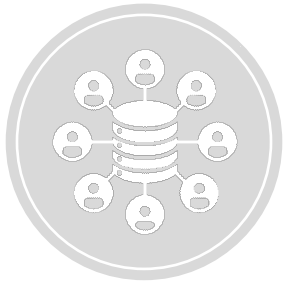
*For visualisation purposes, level part-worth utilities are typically centred around zero for each attribute (by subtracting the mean attribute utility). SurveyEngine can create such plots.

Range per attribute reflects attribute importance

Accounting for observed heterogeneity

Key concepts & study plan

Experimental design



Data collection & processing

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Interpretation & application

Accounting for observed heterogeneity

Attribute importance may vary

- Population segments
  - Defined by socio-demographic/economic variables in the utility function
- Choice contexts
  - Defined by scenario variables in the utility function

- Can compute attribute impact on utility for each population segment and/or choice context

Accounting for observed heterogeneity

Mode choice example

- Add interactions with scenario variable
  - Non-business trip (0)
  - Business trip (1)

$$
\begin{aligned}
V_{jn} = {} & \beta_j + \beta_{\text{tt}} \cdot \text{TravelTime}_{jn} + \beta_{\text{tt\_business}} \cdot \text{TravelTime}_{jn} \cdot \text{Business}_n \\
& + \beta_{\text{access}} \cdot \text{AccessTime}_{jn} + \beta_{\text{access\_business}} \cdot \text{AccessTime}_{jn} \cdot \text{Business}_n \\
& + \beta_{\text{cost}} \cdot \text{Cost}_{jn} + \beta_{\text{cost\_business}} \cdot \text{Cost}_{jn} \cdot \text{Business}_n \\
& + \beta_{\text{wifi}} \cdot \text{Wifi}_{jn} + \beta_{\text{food}} \cdot \text{Food}_{jn} \\
= {} & \beta_j + \left(\beta_{\text{tt}} + \beta_{\text{tt\_business}} \text{Business}_n\right) \cdot \text{TravelTime}_{jn} \\
& + \left(\beta_{\text{access}} + \beta_{\text{access\_business}} \cdot \text{Business}_n\right) \cdot \text{AccessTime}_{jn} \\
& + \left(\beta_{\text{cost}} + \beta_{\text{cost\_business}} \cdot \text{Business}_n\right) \cdot \text{Cost}_{jn} \\
& + \beta_{\text{wifi}} \cdot \text{Wifi}_{jn} + \beta_{\text{food}} \cdot \text{Food}_{jn}
\end{aligned}
$$

	Estimate
asc_car	0.000000
asc_bus	-2.270801
asc_air	-0.941147
asc_rail	-1.064552
b_tt	-0.012651
b_tt_business	-0.005223
b_access	-0.022685
b_access_business	0.007991
b_cost	-0.076550
b_cost_business	0.030152
b_no_frills	0.000000
b_wifi	1.016387
b_food	0.422237

Accounting for observed heterogeneity

Mode choice example

- Attribute: Travel time
- Levels in the data: 50, 90, 120, 170, 250, 330, 420 mins
- Parameter estimate(s): non-business: -0.01265
  business: -0.01265 + (-0.00522) = -0.01787
- Utility range: 4.6809 (non-business) 6.6134 (business)

	Estimate
asc_car	0.000000
asc_bus	-2.270801
asc_air	-0.941147
asc_rail	-1.064552
b_tt	-0.012651
b_tt_business	-0.005223
b_access	-0.022685
b_access_business	0.007991
b_cost	-0.076550
b_cost_business	0.030152
b_no_frills	0.000000
b_wifi	1.016387
b_food	0.422237

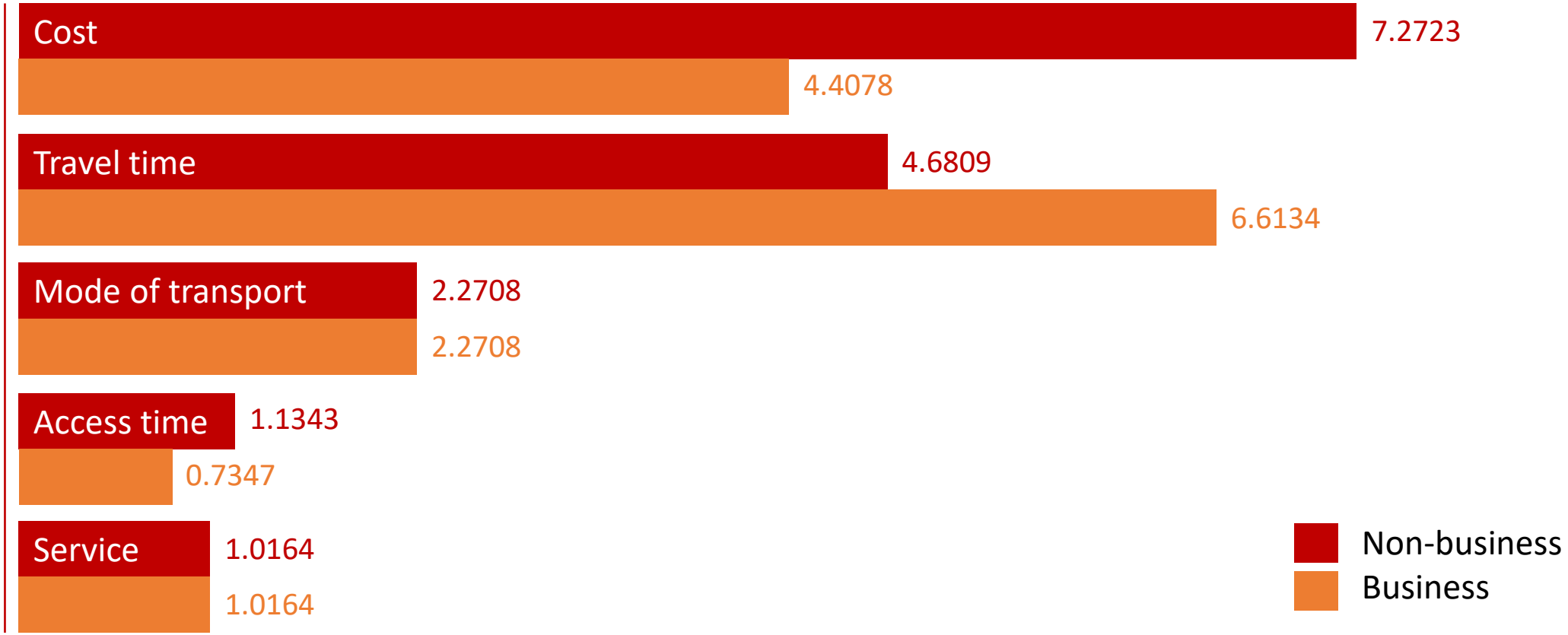
$$V_{jn} = \ldots + \left(\beta_{\text{tt}} + \beta_{\text{tt\_business}}\text{Business}_n\right) \cdot \text{TravelTime}_{jn} + \ldots$$

Attribute	Level	Contribution to utility *non-business*		Contribution to utility *business*		Utility range (best minus worst)	
Travel time (minutes)	50	50 x (-0.01265)=	-0.6326	50 x (-0.01787)=	-0.8937	Best	*Non-business*
	90	90 x (-0.01265)=	-1.1386	90 x (-0.01787)=	-1.6087		-0.6326 – (-5.3134) =
	120	120 x (-0.01265)=	-1.5181	120 x (-0.01787)=	-2.1449		**4.6809**
	170	170 x (-0.01265)=	-2.1507	170 x (-0.01787)=	-3.0386		
	250	250 x (-0.01265)=	-3.1628	250 x (-0.01787)=	-4.4685		*Business*
	330	330 x (-0.01265)=	-4.1748	330 x (-0.01787)=	-5.8984		-0.8937 – (-7.5071) =
	420	420 x (-0.01265)=	-5.3134	420 x (-0.01787)=	-7.5071	Worst	**6.6134**

Accounting for observed heterogeneity

Mode choice example

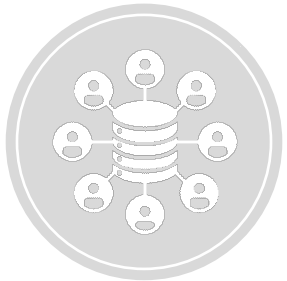
- Attribute impact on utility



Some caveats

Key concepts & study plan

Experimental design



Data collection & processing

Model specification & estimation

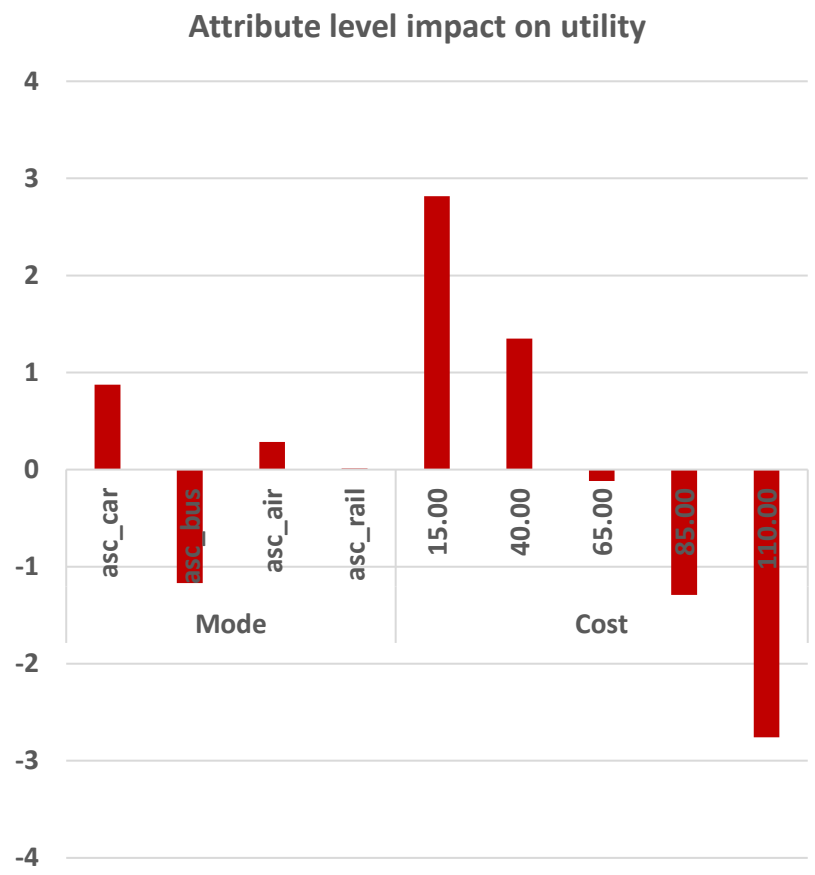
Interpretation & application

Some caveats

Important to note

- Impact on utility depends on attribute levels
  - In a choice experiment, levels are chosen by the analyst!
- Would mode be as important if bus had been excluded?
- Would cost be as important if level £ 15 had been excluded or level £ 150 had been included?

➢ Study objectives should lead the research design!



Some caveats

Impact on choice?

- Impact on utility is not the same as impact on choice
  - In a choice experiment, levels are chosen by the analyst!
- Elasticities can be used to assess how sensitive choice probabilities are to changes in attributes