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Modeling the effects of information in random utility-based stated preference methods

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Introduction

- Contingent Valuation (CV) techniques (including DCE)
  - Detailed information about public or quasi-public goods
  - Elicit preferences / willingness to pay
- Providing additional / different information matters
  - Just like for goods and services traded in markets
    - Characteristics, substitutes, complements
  - How information is presented (framing)
- This paper – theoretical and econometric framework for taking information differences into account in CV studies
  - Consistent with the notion of *Bayesian updating*
  - Additional information affects preference uncertainty
  - Information = experience, …

Behavioral context

- Decisions under uncertainty
  - Uncertainty about one's preferences
  - Learn with each consumption event (*experience goods*)
- Modelling preference uncertainty for experience goods
  - Assume consumers have a true preference parameter
  - They learn about it through Bayesian updating
- Private goods
  - Agents' repeated purchasing decisions over time
- Public or quasi-public goods

The literature

- Uncertainty about one's preferences, information effects
  - Nelson (1970, 1974) – *Journal of Political Economy*
  - Stigler and Becker (1977) – *The American Economic Review*
- Theoretical model of Bayesian updating
  - Ackerberg (2003) – *International Economic Review*
  - Israel (2005) – *The American Economic Review*
- Empirical interest in the context of experience goods
  - Erdem and Keane (1996) – *Marketing Science*
  - Crawford and Shum (2005) – *Econometrica*
  - Goeree (2008) – *Econometrica*
  - Osborne (2011) – *Quantitative Marketing and Economics*

Bayesian updating

- Utility derived by individual *i* from a good *j* at time *t*:

$$U_{ijt} = \boldsymbol{\beta}_j' \mathbf{X}_j + \delta_{ij} + \varepsilon_{ijt}$$

  - $\mathbf{X}_j$ – characteristics of a good
  - $\boldsymbol{\beta}_j$ – marginal utilities associated with these characteristics
  - $\varepsilon_{ijt} \sim N\left(0, \sigma_\varepsilon^2\right)$ – idiosyncratic error term
  - δ_{ij} – individual fixed effect, consumer 'type', time invariant
    - $\delta_{ij} \sim N\left(0, \sigma_j^2\right)$ – distribution of consumer types in the population
- Consumers are not certain what their type is
  - Observe $\left(u_{ij}^t = \delta_{ij} + \varepsilon_{ijt}\right)$
  - Learn about one's type by repeated purchasing decision

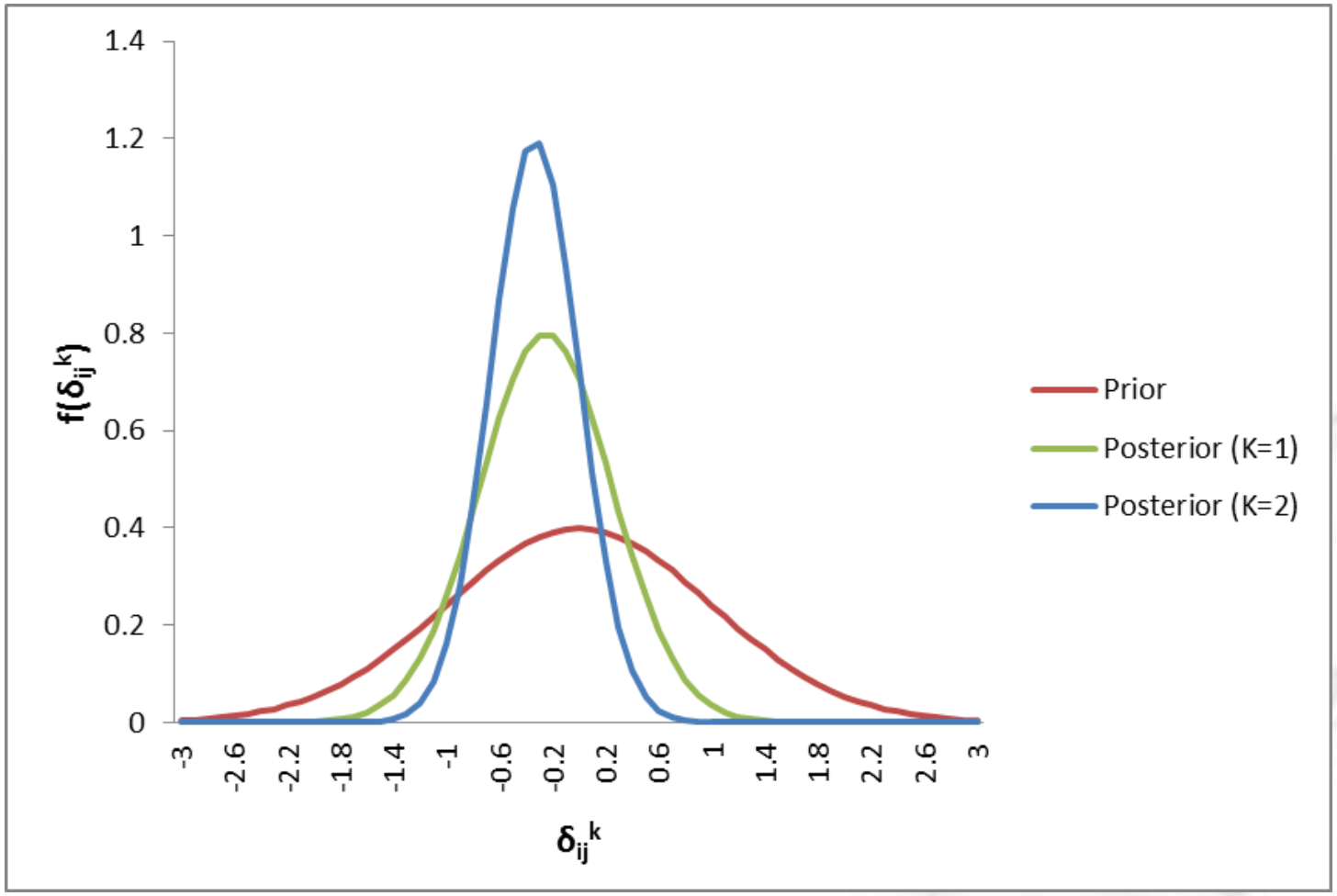
Bayesian updating

- Given the priors over one's type $\left(\delta_{ij}^{0} \sim N\left(0, \sigma_{0}^{2}\right)\right)$, posterior beliefs about type after *K* consumption experiences

$$\delta_{ij}^{K} \sim N\left(\frac{\sum_{t=1}^{K}\delta_{ij}^{t}}{\frac{\sigma_{\delta}^{2}+\sigma_{\varepsilon}^{2}}{\sigma_{o}^{2}}+K}, \frac{\sigma_{\delta}^{2}+\sigma_{\varepsilon}^{2}}{\frac{\sigma_{\delta}^{2}+\sigma_{\varepsilon}^{2}}{\sigma_{o}^{2}}+K}\right)$$

  - Additional experience has ambiguous effect for the mean
    - Relative strength of a prior vs. additional experiences
  - Additional experience reduces variance

Bayesian updating



Bayesian updating

- The effects of Bayesian updating
  - The magnitude of the deterministic relative to the idiosyncratic component of utility increases
  - The variance of that effect (between respondents) decreases

$$\operatorname{var}\left(\delta_{ij}+\varepsilon_{ijt}\middle|K\right)=\frac{\sigma_{\delta}^{2}+\sigma_{\varepsilon}^{2}}{\frac{\sigma_{\delta}^{2}+\sigma_{\varepsilon}^{2}}{\sigma_{0}^{2}}+K}+\sigma_{\varepsilon}^{2}$$

Random Utility Model Framework

- Individual *i*'s utility from choosing alternative *j* from a set of J_t alternatives available at time occasion *t*

$$U_{ijt} = \sigma_i \boldsymbol{\beta}_i' \mathbf{x}_{ijt} + \varepsilon_{ijt}$$

  - $\mathbf{x}_{ijt}$ – observed choice attributes
  - $\boldsymbol{\beta}_i \sim f(\mathbf{b}, \boldsymbol{\Sigma})$ – marginal utilities associated with these attributes (individual-specific)
  - $\sigma_i \sim LN(1, \tau)$ – individual-specific scale parameter
    - Preference and scale are not separately identifiable
    - We interpret scale heterogeneity as a parameter which collects the effect for all the parameters simultaneously
  - ε_{ijt} – iid error term

Bayesian updating in RUM framework

- Account for unobserved preference and scale heterogeneity
- Econometric framework consistent with the notion of Bayesian updating:

$$\sigma_i \sim LN\left(1+\boldsymbol{\phi}'\mathbf{z}_i, \tau+\boldsymbol{\xi}'\mathbf{z}_i\right)$$

  - Introduce observed scale heterogeneity
    - H: changes in scale (uncertainty) due to the differences in information levels
  - Introduce observed scale variance heterogeneity
    - H: changes in scale variance (how differentiated the sample is in terms of their uncertainty) due to the differences in information levels

Empirical application

- 2 DCE studies
  - Raptor conservation on heather moorland
    - 2 samples – different information packs
  - Coastal water quality in Northern Ireland
- Different information levels
  - Experience used as a proxy of information level

Case study 1
Raptor conservation on heather moorland

- Alternative protection schemes for a top-level predator birds in managed moorlands
  - Alternative protection schemes of two species of birds of prey
    - Breed on heather moorlands in the Scottish uplands
      - Areas often managed for commercial grouse shooting
      - Feed on Red Grouse – the main game bird for which the moorlands are managed

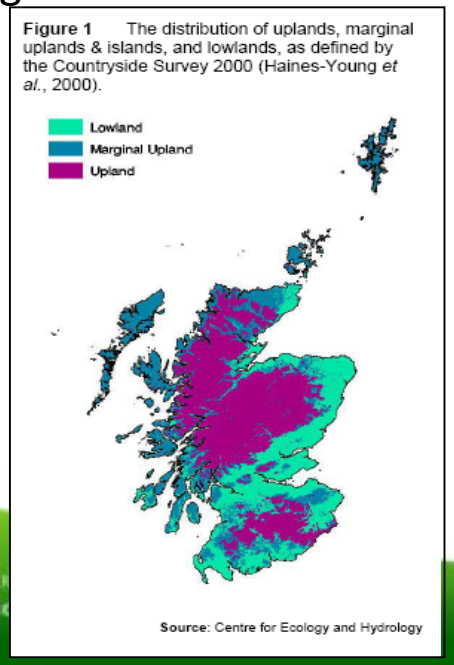


Figure 1 The distribution of uplands, marginal uplands & islands, and lowlands, as defined by the Countryside Survey 2000 (Haines-Young *et al.*, 2000).


Red grouse

Case study 1
Raptor conservation on heather moorland

- Hen Harriers
  - Medium-sized bird of prey
  - Breed on heather moorlands in the uplands
  - Roughly 633 pairs in Scotland
  - Protected by law since 1954
    - Loss of their habitat, illegal persecution – decline in their numbers
  - Can significantly reduce grouse numbers
    - Grouse shoots become uneconomical and close
    - Affect people relying on grouse shooting for jobs and income
    - Transform the moorland ecosystems

Hen harrier

Case study 1
Raptor conservation on heather moorland

- Golden eagles
  - Large bird of prey (2 m wingspan)
  - Feed on small birds and mammals
  - 442 pairs in the U.K. (440 in Scotland)
  - Often found in Hen Harrier habitat
  - Also top predators, subject to illegal persecution, particularly in managed grouse moors

Golden eagle

Case study 1
Raptor conservation on heather moorland

- The choice attributes and their levels
  - Population changes of Hen Harriers and Golden Eagles
    - Status quo management – 20% population decline
    - Introducing new management strategies – maintaining current populations, 20% increase in the new steady state
  - Monetary attribute
    - Cost of adopting a particular management strategy
    - Additional tax which respondent's household might have to pay annually if the government went ahead with selected option

Case study 1
Raptor conservation on heather moorland

- The choice attributes and their levels
  - Methods matter
    - Labeled CE – alternatives associated with e.g. management options
  - Alternative management options
    - Increasing the probability of detection of illegal persecution
      - Increasing police surveillance on grouse moors
    - Establishment of feeding stations
      - Providing alternative food sources to grouse
    - Establishing quotas for bird of prey densities on sporting estates
      - Physically moving eggs or chicks away from grouse moors to alternative locations
    - 'Status quo'
      - Maintaining current management

Case study 1
Raptor conservation on heather moorland

CHOICE A	DO NOTHING Maintain current management	LAW Stricter law enforcement	FEED Feeding stations away from grouse	MOVE Move eggs and chicks to new sites
HEN HARRIER	20% population decline	Maintain current population	Maintain current population	Maintain current population
GOLDEN EAGLE	20% population decline	20% population increase	20% population decline	20% population decline
COST	£0	£50	£25	£25
YOUR CHOICE (please tick one only)	☐	☐	☐	☐

Case study 1
Raptor conservation on heather moorland

- Two samples of the general public
  - Differ only in the nature of information provided
- Info pack 2 relative to pack 1
  - Moorland management depicted as more beneficial
  - Hen harriers depicted as less threatene
  - Golden eagles depicted in less detail and in a less “sympathetic” way
- Expected result:
  - Lower levels of willingness to pay for both hen harriers and golden eagles
  - Greater willingness to choose a management option rather than the status quo in study 2 as compared to study 1

Case study 2
Coastal water quality in Northern Ireland

- Changes to the EU Bathing Water Directive in 2015
  - Environmental monitoring data collected
  - Set targets and standards
    - Current good standard to become the future mandatory standard
    - Current excellent becomes the good standard
    - Future excellent twice as strict
- DCE used to investigate preferences for these kind of water quality / beach quality improvements
- Three parallel surveys in four countries
  - “Active” beach users surveyed in Ireland only

Case study 2
Coastal water quality in Northern Ireland

- Attributes
  - Human Health risk
    - Following the directive, current good standard identified to have a 10% risk of stomach upsets
  - Beach Debris management
    - Seen as important in earlier studies
  - Benthic health
    - Nutrient cycle will be affected, and therefore the ecological condition of sea bed
    - Impacts upon other species – mammals, birds etc.
  - Costs
    - For recreational users – an additional travel cost per trip to beach with higher standards
    - For off-site surveys – council taxes

Case study 2
Coastal water quality in Northern Ireland

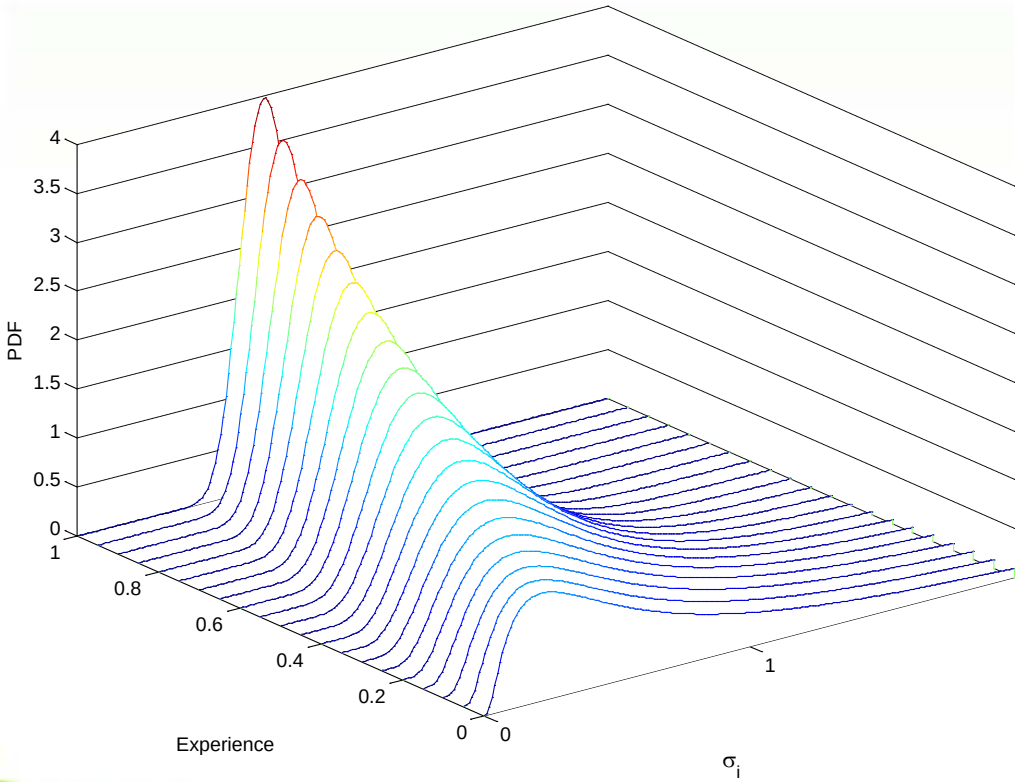
	Beach A	Beach B	Beach C
Benthic Health and population	**Small increase** More fish, mammals and birds. Limited potential to notice the change in species numbers	**Large increase** More fish, mammals and birds and an increased potential of seeing these species	**No Improvement**
Health Risk (of stomach upsets and ear infections)	**Very Little Risk** Excellent water quality	**5% Risk** Good water quality	**10% Risk** No improvement
Debris Management	**Prevention** More filtration of storm water, more regular cleaning of filters and better policing of fly tipping	**Collection and Prevention** Debris collected from beaches more regularly in addition to filtration and policing	**No Improvement**
Additional travel cost	£ 18	£ 67	£ 0
Please tick the **ONE** option you prefer	☐	☐	☐

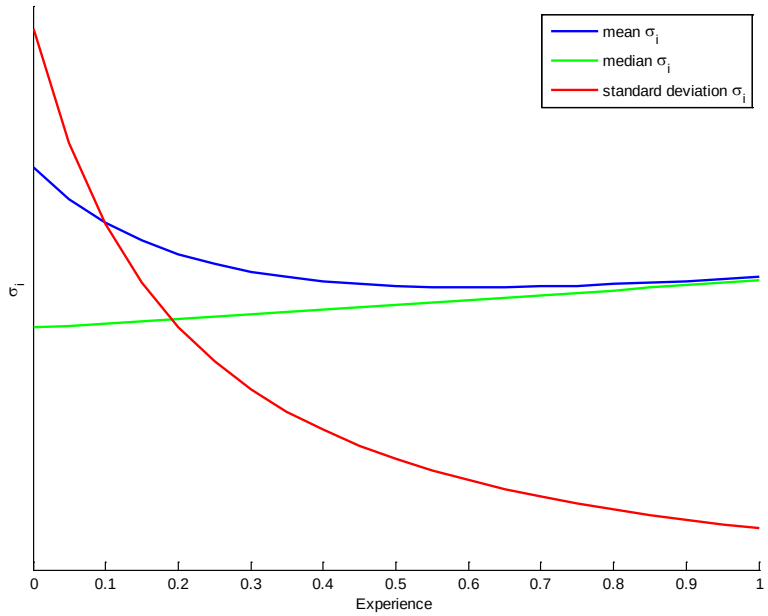
Experience measures

- Raptor conservation study
  - *visit* – log of the number of trips to the UK uplands in the last 12 months
  - (still control for 2 information treatments)
- Coastal water quality study
  - *bdays* – log of the number of days spent on a beach in the last 12 months

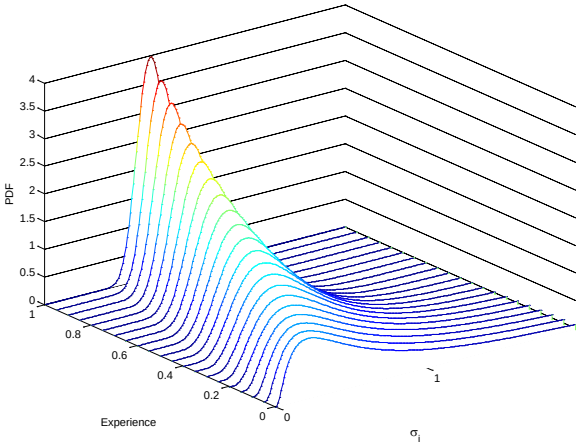
	Raptor conservation study – experience accounted for	Raptor conservation study – experience not accounted for	Coastal water quality – experience accounted for	Coastal water quality – experience not accounted for
Covariates of scale (φ)				
log(*visit*) or log(*bday*)	0.2796*** (0.0671)	–	0.0778** (0.0353)	–
study	0.5991** (0.2753)	0.7208*** (0.2616)	–	–
Scale variance parameter (τ)				
τ	7.3734*** (0.8755)	7.2005*** (0.9822)	1.1164*** (0.3896)	2.0094*** (0.4208)
Covariates of scale variance (ξ)				
log(*visit*) or log(*bday*)	-0.0641*** (0.0122)	–	-0.4807* (0.2535)	–
study	-0.2931*** (0.0565)	-0.2628*** (0.0496)	–	–
Model characteristics				
Log-likelihood	-2732.4803	-2736.2703	-3112.6638	-3116.2321
McFadden's pseudo R^2	0.4287	0.4279	0.3365	0.3358
AIC/n	1.6368	1.6378	1.4492	1.4499
n (observations)	3450	3450	4366	4366
k (parameters)	91	89	51	49

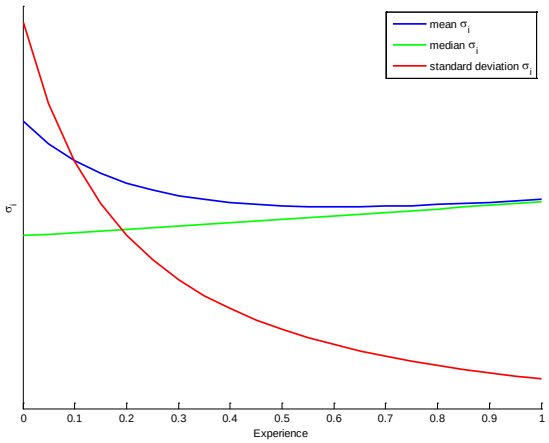
Experience-related distribution of individual scale parameters (log-normal distribution)



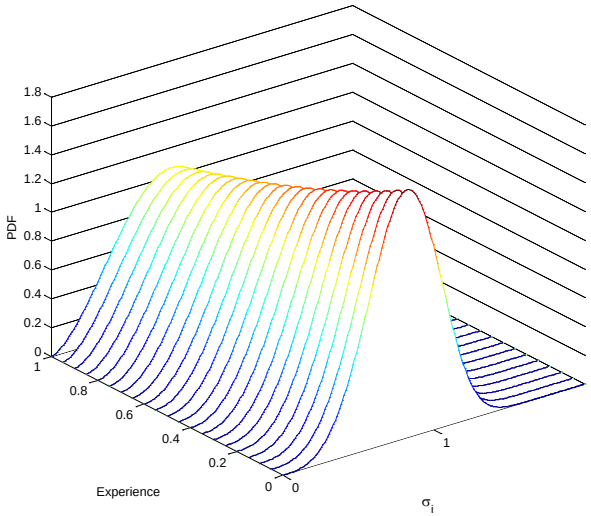


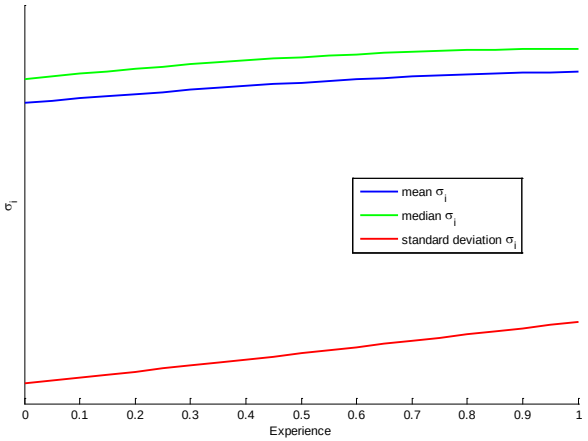
Log-normal



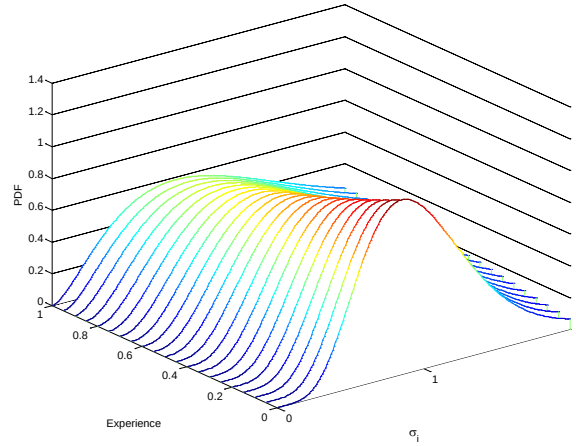


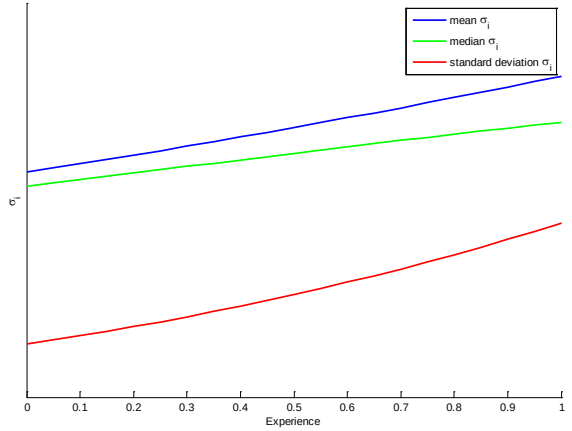
Weibull





Gamma





Raptor conservation study – implicit prices (GBP)						
	Model with experience related covariates			Model without experience related covariates		
	median	95% c.i.		median	95% c.i.	
LAW_1	21.83 (10.5519)	2.52 –	44.06	26.40 (12.3651)	5.25 –	53.27
FEED_1	17.00 (10.3418)	-1.65 –	38.97	25.29 (12.2705)	4.22 –	51.88
MOVE_1	14.99 (10.4744)	-4.08 –	37.01	23.47 (12.1938)	2.33 –	49.90
HH1_1	13.27 (5.4750)	2.59 –	24.22	16.59 (4.7052)	7.13 –	25.78
HH2_1	13.10 (4.9696)	3.08 –	22.59	16.26 (4.6003)	6.81 –	25.14
GE1_1	21.11 (5.8122)	9.64 –	32.35	24.72 (4.8489)	14.88 –	33.87
GE2_1	21.34 (5.7622)	9.74 –	32.27	25.71 (4.9880)	15.27 –	35.05
LAW_2	50.06 (12.8543)	28.58 –	79.02	46.21 (14.1695)	23.49 –	79.00
FEED_2	58.85 (13.2612)	37.17 –	88.98	53.54 (14.6885)	30.25 –	88.40
MOVE_2	58.65 (12.6048)	37.97 –	87.41	52.75 (14.6233)	29.37 –	87.24
HH1_2	20.86 (5.1928)	9.64 –	29.93	22.03 (5.5040)	10.59 –	32.17
HH2_2	20.03 (5.2451)	8.73 –	29.22	21.17 (5.1209)	10.55 –	30.66
GE1_2	30.58 (5.7398)	17.64 –	40.54	31.80 (5.7249)	19.61 –	42.24
GE2_2	33.21 (5.8140)	20.15 –	43.00	34.15 (5.8234)	21.70 –	44.73

Coastal water quality – implicit prices (GBP)						
	Model with experience related covariates			Model without experience related covariates		
	median	95% c.i.		median	95% c.i.	
SQ	-2.59 (0.6543)	-3.88 –	-1.35	-2.78 (0.6884)	-4.10 –	-1.52
BH1	1.27 (0.2649)	0.77 –	1.83	1.26 (0.2675)	0.76 –	1.80
BH2	1.92 (0.3954)	1.19 –	2.75	1.84 (0.3842)	1.14 –	2.59
HR1	1.14 (0.3701)	0.41 –	1.87	0.94 (0.3719)	0.21 –	1.68
HR2	1.38 (0.4416)	0.49 –	2.24	1.19 (0.4589)	0.31 –	2.07
DM1	1.60 (0.3945)	0.81 –	2.39	1.49 (0.4322)	0.64 –	2.34
DM2	2.23 (0.3610)	1.43 –	2.91	2.25 (0.4434)	1.26 –	2.99

Summary

- Econometric framework consistent with Byesian udating
  - Framework for taking information differences into account
- Theoretical predictions observed
  - Additional information (experience) vs. scale
  - Additional information (experience) vs. scale variance
- Marginal changes in WTP
  - However, ranking of the most preferred options can change
- Convenient way of accounting for scale differences when combining datasets
  - Controlling for scale variances significant

Conclusions

- Datasets can vary in not only scale but also scale heterogeneity
- Measures of information differences (experience) impact the randomness of choice, and how it varies across people
  - Excluding these effects (mis-specification of the choice model) results in marginal bias only
- Future work
  - Combine (i) variation in ex ante and (ii) new information
    - Unfamiliar good (cold water corals in Norway)
    - Familiar (flood management in the UK)