RISK COMMUNICATION IN STATED PREFERENCE CHOICE EXPERIMENTS

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Stated preference methods

- Provide estimates of economic value of non-market goods (e.g., clean air)
- Help determine the value of a good to society
  - Estimates of benefits for benefit-cost analyses
  - The value of losses from environmental damages (e.g., loss of recreation opportunities after oil spill)
  - …
- Wide range of applications: transportation, health, environment, culture, etc.
- Value estimates derived from preferences stated in surveys
  - Typically large survey studies on representative samples of respondents
  - Preferences are often elicited through discrete choice experiments

Stated preference choice experiments

Choice options: Policy scenarios

Methods and Effects of Protection	Result in 2020s with NO NEW ACTION	Result in 2020s with PROTECTION OPTION A	Result in 2020s with PROTECTION OPTION B
	**12%** 60 of 497 wetland acres expected to be lost	**7%** 25 of 497 wetland acres expected to be lost	**5%** 25 of 497 wetland acres expected to be lost
(CHOOSE ONLY ONE) I vote for	I vote for NO NEW ACTION	I vote for PROTECTION OPTION A	I vote for PROTECTION OPTION B

Outcome uncertainty – Will the effects described in scenarios indeed occur?

(1) Uncertainty in scientific models and predictions

(2) Uncertainty in the efficacy of policy interventions

(3) Inherent uncertainty in ecological systems

Inherent outcome uncertainty
(tied to ecological systems)

- Uncertainty that is invariant across policy scenarios
- Example: The effect of installing new coastal flood defenses depends on a probability of severe storms that is fixed in the study area
- Very little attention in the stated preference literature
- Most surveys provide no formal communication of outcome uncertainty
- Often (unstated) assumptions that scenario outcomes are certain, that presented attribute levels reflect expected values, etc.
- These assumptions can have important implications for the interpretation and validity of value estimates
(e.g., Veronesi et al. 2014; Reynaud and Nguyen 2016; Torres, Faccioli and Font 2017)

Communication of the uncertainty

- The effect of the uncertainty communication format is unexplored
- Typically numerical percentage probabilities are used to communicate uncertainty
- Underlying assumptions are that respondents understand, interpret and use this information when stating preferences
- However, widespread evidence suggests that individuals may not interpret or use numerical probabilities as expected to inform their decisions
(e.g., Baker et al. 2009; Cameron, DeShazo, and Johnson 2011)
- <u>Are numerical probabilities an effective approach to communicate uncertainty?</u>

Communication of the uncertainty

- Recent guidelines for stated preference research (Johnston et al. 2017, p. 329):
  - "scenarios should communicate [uncertainty] information in terms that are readily understood by respondents"
  - the literature does not recommend the use of numerical probabilities alone
- Despite this guidance and common practices, there have been
  - few external validity tests of uncertainty communication formats for stated preference studies (e.g., Loomis and duVair 1993)
  - none (to our knowledge) addressing inherent uncertainty (tied to ecological systems)

Our research question (and the paper's title):

Do numerical probabilities promote informed stated preference responses under inherent uncertainty?

Data – discrete choice experiments

- Policy scenario: coastal flood adaptation to protect homes and natural systems such as beaches and wetlands from flooding and erosion
- In Old Saybrook, Connecticut, USA
- The survey distributed via mail
- May – July 2014
- 269 complete surveys returned

PROTECTION OPTION A and **PROTECTION OPTION B** are possible protection options for Old Saybrook. **NO NEW ACTION** shows what is expected to occur with no additional protection.

Methods and Effects of Protection	Result in 2020s with NO NEW ACTION	Result in 2020s with PROTECTION OPTION A	Result in 2020s with PROTECTION OPTION B
	No Change in Existing Defenses	More Emphasis on SOFT Defenses	More Emphasis on HARD Defenses
Homes Flooded in Category 2 Storm	**24%** 1,411 of 5,840 homes expected to flood in a Category 2 storm	**24%** 1,411 of 5,840 homes expected to flood in a Category 2 storm	**12%** 701 of 5,840 homes expected to flood in a Category 2 storm
Homes Flooded Only in Category 3+ Storm	**20%** 1,174 of 5,840 homes expected to flood only in a Category 3+ storm	**20%** 1,174 of 5,840 homes expected to flood only in a Category 3+ storm	**20%** 1,174 of 5,840 homes expected to flood only in a Category 3+ storm
Wetlands Lost	**12%** 60 of 497 wetland acres expected to be lost	**5%** 25 of 497 wetland acres expected to be lost	**5%** 25 of 497 wetland acres expected to be lost
Beaches and Dunes Lost	**10%** 3 of 30 beach acres expected to be lost	**5%** 2 of 30 beach acres expected to be lost	**15%** 5 of 30 beach acres expected to be lost
Seawalls and Coastal Armoring	**24%** 12 of 50 miles of coast armored	**24%** 12 of 50 miles of coast armored	**45%** 23 of 50 miles of coast armored
$ Cost to your Household per Year	**$0** Increase in annual taxes or fees	**$35** Increase in annual taxes or fees	**$65** Increase in annual taxes or fees
HOW WOULD YOU VOTE? (CHOOSE ONLY ONE) I vote for	☐ I vote for NO NEW ACTION	☐ I vote for PROTECTION OPTION A	☐ I vote for PROTECTION OPTION B

- Three choice tasks per respondent
- We focus on the inherent uncertainty related to the protection of homes vulnerable to flooding during storms of different intensities (the Saffir-Simpson Hurricane Wind Scale) – these storms have different inherent probabilities of occurrence

Two treatments

- The effect of adaptation measures depends on inherent storm probabilities that may be characterized by:
  - historical frequencies (common in media)
  - numerical percentage probabilities (common in stated preference surveys)
- Two versions of the survey that differ only in the uncertainty communication
- **(1) Subjective treatment – without numerical probabilities**
  - describes only historical frequencies of Category 2 and 3 storms and elicits respondents' subjective risk assessments
- **(2) Objective treatment – with numerical probabilities**
  - provides identical information on historical frequencies but also translates these frequencies into numerical probabilities

Subjective treatment – without numerical probabilities

Over the last 75 years, Old Saybrook has been struck by **Category 2 storms in 1960, 1985 and 1991**, and by **Category 3 storms in 1938 and 1954**. There have been no Category 4 or 5 storms.

Please indicate how likely **you** think it is that each of the following hurricane events will strike Old Saybrook at least once by the mid 2020s (your best guess).

For example, a score of 0% would mean that you feel there is **no chance** and a score of 100% would mean that you are **absolutely certain.** Check only one box for each.

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
a. **Category 2**	☐ 1.	☐ 2.	☐ 3.	☐ 4.	☐ 5.	☐ 6.	☐ 7.	☐ 8.	☐ 9.	☐ 10.	☐ 11.
b. **Category 3 or greater**	☐ 1.	☐ 2.	☐ 3.	☐ 4.	☐ 5.	☐ 6.	☐ 7.	☐ 8.	☐ 9.	☐ 10.	☐ 11.

Objective treatment
– with numerical probabilities

Over the last 75 years, Old Saybrook has been struck by **Category 2 storms in 1960, 1985 and 1991**, and by **Category 3 storms in 1938 and 1954**. There have been no Category 4 or 5 storms.

Based on past storm events, scientists estimate that there is approximately a **55% (or about one in two) chance that a Category 2 storm will strike Old Saybrook at least once by the mid 2020s** (0% would mean there is no chance and 100% would mean it is absolutely certain).

In contrast, scientists estimate that there is approximately a **20% (or one in five) chance that a Category 3 or higher storm will strike Old Saybrook at least once by the mid-2020s** (0% would mean there is no chance and 100% would mean it is absolutely certain).

Econometric approach

- Random parameters logit – heterogeneous preferences in the population
- A model in willingness-to-pay (WTP) space – parameters can be readily interpreted as willingness-to-pay values in monetary units

$$U_{ph}(\cdot) = \lambda_h(\boldsymbol{\omega}'_h \boldsymbol{X}_{ph} - C_{ph}) + \varepsilon_{ph}$$

- A pooled model estimated over both treatment samples
- Additional variables to capture systematic variation in preferences associated with:
  - treatments (S_h = 1 for no numerical probabilities / subjective sample)
  - perceived likelihood of a Category 3 storm (p_h)

$$\boldsymbol{\omega}_h = \boldsymbol{\omega}^*_h + \boldsymbol{\rho} S_h + \boldsymbol{\varphi} S_h(p_h - 0.2)$$

Treatment samples

	Subjective Sample (without numerical probabilities) N = 146	Objective Sample (with numerical probabilities) N = 123	*p*-value
Discrete Variables			
Female	43.98%	39.22%	0.019
Academic Degree	72.34%	73.58%	0.503
Currently Employed	55.76%	66.57%	0.000
Year-Round Resident	96.97%	97.21%	0.725
Continuous Variables			
Age	62.76	59.53	0.000
Annual Household Income (USD)	119,627	127,143	0.010
Years of Residency	21.79	21.88	0.654

We assign weights to the subjective sample so that it resembles the objective sample

Random parameters logit
in willingness-to-pay space

$$\boldsymbol{\omega}_h = \boldsymbol{\omega}_h^* + \boldsymbol{\rho} S_h + \boldsymbol{\varphi} S_h (p_h - 0.2)$$

Choice attributes	Means for objective sample	Standard deviations	Mean shift for subjective sample (Vector $\boldsymbol{\rho}$)	Mean shift when diverging from 20% risk (Vector $\boldsymbol{\varphi}$)
Status quo	-5.766*** (1.863)	12.286*** (4.257)	4.611*** (1.641)	-12.761*** (4.281)
Homes 2	-1.085 (0.684)	4.620*** (1.493)	-1.018 (0.936)	4.821** (2.103)
Homes 3	-1.596* (0.853)	5.592*** (1.813)	0.128 (1.130)	4.134* (2.173)
Wetlands	-1.485 (0.956)	5.014*** (1.651)	0.380 (1.337)	-3.632 (2.789)
Beaches	-1.427** (0.621)	4.304*** (1.409)	1.294 (0.850)	-0.399 (1.418)
Seawalls	-0.136 (0.378)	1.559*** (0.488)	-0.731 (0.630)	1.293 (0.890)
Hard	-0.992 (0.672)	2.789*** (0.841)	-1.022 (1.094)	-0.784 (1.857)
Soft	-0.125 (0.611)	3.397*** (1.056)	0.494 (0.794)	-3.926** (1.943)

Random parameters logit

in willingness-to-pay space

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- No systematic effects on the value estimates associated with the numerical risk information
- The exception: a large effect for the status quo
- Subjective respondents accurately perceiving the risk of a Category 3 storm are willing to pay much less than objective respondents to avoid the status quo

Random parameters logit

in willingness-to-pay space

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- Effects related to the difference between subjective and objective probabilities—particularly for *Homes 2* and *3*
- This aligns with expectations because the elicited subjective probabilities were most closely associated with these attributes

Willingness-to-pay (WTP) estimates

Choice Attributes	Mean WTP for Objective Respondents	Mean WTP for Subjective Respondents with Stated Perceived Risk p_h										
		$p_h = 0$	$p_h = 0.1$	$p_h = 0.2$	$p_h = 0.3$	$p_h = 0.4$	$p_h = 0.5$	$p_h = 0.6$	$p_h = 0.7$	$p_h = 0.8$	$p_h = 0.9$	$p_h = 1$
Status quo	-576.62***	139.74	12.13	-115.49	-243.10	-370.71	-498.33	-625.94	-753.56	-881.17	-1008.79	-1136.40
Homes 2	-10.85	-30.67	-25.85	-21.03	-16.21	-11.39	-6.57	-1.75	3.07	7.90	12.72	17.54
Homes 3	-15.96*	-22.96	-18.82	-14.69	-10.55	-6.42	-2.29	1.85	5.98	10.11	14.25	18.38
Wetlands	-14.85	-3.79	-7.42	-11.05	-14.68	-18.32	-21.95	-25.58	-29.21	-32.84	-36.48	-40.11
Beaches	-14.27**	-0.53	-0.93	-1.33	-1.73	-2.12	-2.52	-2.92	-3.32	-3.72	-4.12	-4.52
Seawalls	-1.36	-11.25	-9.96	-8.67	-7.37	-6.08	-4.79	-3.49	-2.20	-0.91	0.39	1.68
Hard	-99.17	-185.65	-193.49	-201.32	-209.16	-216.99	-224.83	-232.66	-240.50	-248.33	-256.17	-264.00
Soft	-12.50	115.40	76.14	36.88	-2.39	-41.65	-80.91	-120.18	-159.44	-198.71	-237.97	-277.23

Marked in blue when there are significant differences from the objective respondents (with numerical probabilities)

Willingness-to-pay (WTP) estimates

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		$p_h = 0$	$p_h = 0.1$	$p_h = 0.2$	$p_h = 0.3$	$p_h = 0.4$	$p_h = 0.5$	$p_h = 0.6$	$p_h = 0.7$	$p_h = 0.8$	$p_h = 0.9$	$p_h = 1$
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- Extremely large anti-status-quo WTP estimates—arguably biased—are for (i) objective respondents and (ii) subjective respondents heavily overestimating the storm probability
- Mean values of objective respondents are statistically indistinguishable from those of subjective respondents with perceived risk of 50%
- The average subjective perceived risk is 42% $\rightarrow$ Subjective respondents with mean risk perceptions and objective respondents have statistically equivalent WTP values $\rightarrow$ Objective respondents might have not used the presented probability (20%) to update their prior beliefs

Discussion

- Findings contradict a common (perhaps naïve) expectation that objective respondents—provided with the actual numerical probability (20%)—will reveal mean WTP values comparable to those of subjective respondents with similar beliefs about the storm risk
- Model results show little evidence that objective respondents adjusted their beliefs to match the given probabilities
- <u>The results do not appear to support a key assumption underlying stated preference studies that quantify inherent outcome uncertainty using numerical probabilities</u>

Discussion – possible explanations

1) Objective respondents may have overlooked the provided numerical probabilities in the questionnaire
   – Rather unlikely – if so, no significant differences should be observed between objective and subjective respondents' WTP values

2) Respondents lack understanding of numerical probabilities
   – But we see at least some working knowledge of these probabilities—at a minimum, respondents correctly associated larger probabilities with higher risk and made choices accordingly

3) Objective respondents were aware of the presented probabilities, but at least some of these respondents did not update their prior beliefs

<u>Regardless of the interpretation, our results provide no evidence that the provision of numerical probabilities helped respondents update their prior beliefs about this inherent risk and thus make more informed choices</u>

Conclusions

Do numerical probabilities promote informed stated preference responses under inherent uncertainty?

- Not necessarily
- Welfare estimates are sensitive to subjective perceptions of the uncertainty
- But the use of percentage probabilities to communicate risk increases symptoms of scenario rejection such as (anti-)status quo bias
- Respondents also seem not to update their ex ante beliefs in response to the provided information on percentage probabilities
- Percentage probabilities may not be an effective way to communicate inherent uncertainty in environmental stated preference questionnaires

THANK YOU!

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