VARIABLE DISCOUNT RATES AND NON-STANDARD DISCOUNTING IN MORTALITY RISK VALUATION

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Background

- Reducing exposure to carcinogens can reduce risk of fatality after a latency period.
- How to value this in BCA?
  - WTP-based Valuation of Statistical Life (cancer)
  - Discounted for delay
- Others studies how much people discount cancer risk reductions.
  - Hammitt & Liu (2004)
  - Alberini et al (2002)
- We ask what discounting *function* is used.

What do we know?

- Cancer VSL includes offsetting of dread effects and latency (see Sue Chilton's talk tomorrow)
- Delay makes the risk 'less bad' (reduces weight)
- (Some) rates derived from survey data
  - Majority between 1.5 and 11% (Viscusi and Moore (1989), Horowitz and Carson (1990) Ganiats et al. (2000) Hammitt and Liu (2004), Alberini et al. (2006)).
  - Some 0% (Alberini and Ščasný (2011, 2013))
  - Or even 22% (Lazaro et al, (2001))
- Usual assumption is exponential discounting

What do we know?

- Discounting functional forms
  - Exponential: constant rate, consistent decision making.
  - Hyperbolic: discount rate **declines with delay**, inconsistency.
  - Sub-additive: discount rate **declines with interval**, inconsistency.
    - Looks like hyperbolic if sooner outcome is “now”.

Research overview

- Elicit discount rates from risk-risk survey data
- Investigate the elicited discount rates for sensitivity to
  - Delay (-> hyperbolic)
  - Interval (-> subadditive)
- So we need one more ingredient… how to elicit a discount rate from survey data

A relationship between road accident and cancer VSL estimates

- $R_t = R_0 * \partial_t$
  - where ∂_t is the discount factor
- $C_t = R_t * (1 + x)$
  - where $(1 + x)$ is the context premium placed on cancer, *ceteris paribus*
- In combination:

$$C_T = (R_0 * (1 + x)) * \partial_T$$

- VSL cancer at time T relative to VSL road accidents at time t = $C_T R_t = (1 + x) * \partial_T / \partial_t$

From $C_T R_t$ to a discount rate

- Take one relativity for cancer at T and road accidents at t $C_T R_t$
- Take a second relativity for cancer at T' and road accidents at t' $C_{T'} R_{t'}$
- Assume exponential discounting

$$C_T R_t = (1 + x) * \frac{1}{(1+r)^{(T-t)}}$$

$$C_{T'} R_{t'} = (1 + x) * \frac{1}{(1+r)^{(T'-t')}}$$

- Take the ratio of these relativities

$$\frac{C_T R_t}{C_{T'} R_{t'}} = \frac{(1+r)^{(T'-t')}}{(1+r)^{(T-t)}} = (1 + r)^{(T'-t'-(T-t))}$$

$$r = \sqrt[(T'-t'-(T-t))]{\frac{C_T R_t}{C_{T'} R_{t'}}} - 1$$

Research design

- Risk-Risk trade-off study
- 1h45m in our laboratory
- 10 main relativity questions varying T and t
- Follow up: Demographics.

Relativities

- Ten relativities per respondent, all compared Cancer risk at T to Road accident risk at t.
- Designed to test the exponential, hyperbolic and sub-additive discounting hypotheses.

Question number	Code	Delay until Cancer fatality	Delay until Roads fatality	Interval (years)	Average Delay (years)
1	$C_{10}R_{1}$	10	1	9	5.5
2	$C_{10}R_{2}$	10	2	8	6
3	$C_{25}R_{2}$	25	2	23	13.5
4	$C_{5}R_{2}$	5	2	3	3.5
5	$C_{7}R_{2}$	7	2	5	4.5
6	$C_{15}R_{2}$	15	2	13	8.5
7	$C_{10}R_{5}$	10	5	5	7.5
8	$C_{10}R_{7}$	10	7	3	8.5
9	$C_{25}R_{10}$	25	10	15	17.5
10	$C_{10}R_{10}$	10	10	0	10

Same interval, different average delay

Same interval, different average delay

Same average delay, different interval

Question Layouts

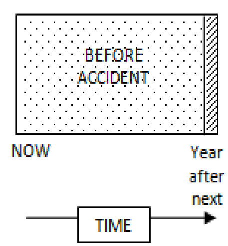
INITIALS ________
DATE ________

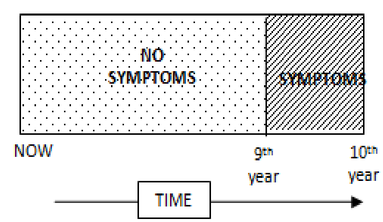
RR AS

QUESTION 2

Your current risk of dying by each cause is **1000 in 60 million**.
Which would you choose, if you had to:

C	D
An increase in my risk of dying in a **car accident** during the **year after next (2014)** of 50 in 60 million	An increase in my risk of dying from **cancer 10 years** from now of 50 in 60 million





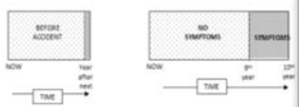
CIRCLE THE ONE YOU WOULD CHOOSE

Question Layouts

QUESTION 2

Your current risk of dying by each cause is **1000 in 60 million**.
Which would you choose, if you had to:

C	D
An increase in my risk of dying in a **car accident** during the **year after next** (2014) of 50 in 60 million	An increase in my risk of dying from **cancer** **10 years** from now of 50 in 60 million



DATE

RR AS

ANSWER SHEET 2A

C		D	
Dying in a car accident during the year after next *1000 in 60 million* RISK INCREASE :		*Dying from cancer 10 years from now* *1000 in 60 million* RISK INCREASE :	CHOICE:
50 in 60 million	OR	50 in 60 million	C
100 in 60 million	OR	50 in 60 million	C
140 in 60 million	OR	50 in 60 million	C
180 in 60 million	OR	50 in 60 million	C
220 in 60 million	OR	50 in 60 million	C
260 in 60 million	OR	50 in 60 million	C
300 in 60 million	OR	50 in 60 million	D
340 in 60 million	OR	50 in 60 million	D
380 in 60 million	OR	50 in 60 million	D
420 in 60 million	OR	50 in 60 million	D
	OR	50 in 60 million	D

This respondent switched ‘at 280’, giving a relativity of $C_{10}R_2 = 280/50 = 5.6$

Sample

Variable	Average
Gender (% female)	44.5%
Age (mean (std dev.))	20.72 (1.82)
Household size (mean (s. dev.))	4.41 (1.74)
Rental (% rent)	75.2%
Personal income (monthly mean (s. dev.))	£616.76 (495.96)
Household income (monthly mean (s. dev.))	£3234.31 (2844.58)
Cancer personal experience* (%)	69.4%
Road accident experience* (%)	48.2%

*personal experience was defined as the respondent or a close friend or family member having experienced cancer or a serious road accident.

Relativities

Question	Code	Latency interval (years)	Average Delay (years)	Geometric mean	95% confidence interval
1	$C_{10}R_{1}$	9	5.5	**0.97**	[0.59, 1.60]
2	$C_{10}R_{2}$	8	6	**0.72**	[0.42, 1.23]
3	$C_{25}R_{2}$	23	13.5	**0.35**	[0.21, 0.59]
4	$C_{5}R_{2}$	3	3.5	**1.67**	[1.08, 2.58]
5	$C_{7}R_{2}$	5	4.5	**1.16**	[0.71, 1.89]
6	$C_{15}R_{2}$	13	8.5	**0.61**	[0.37, 1.01]
7	$C_{10}R_{5}$	5	7.5	**1.02**	[0.59, 1.77]
8	$C_{10}R_{7}$	3	8.5	**1.67**	[1.00, 2.80]
9	$C_{25}R_{10}$	15	17.5	**0.49**	[0.29, 0.83]
10	$C_{10}R_{10}$	0	10	**3.58**	[2.37, 5.41]

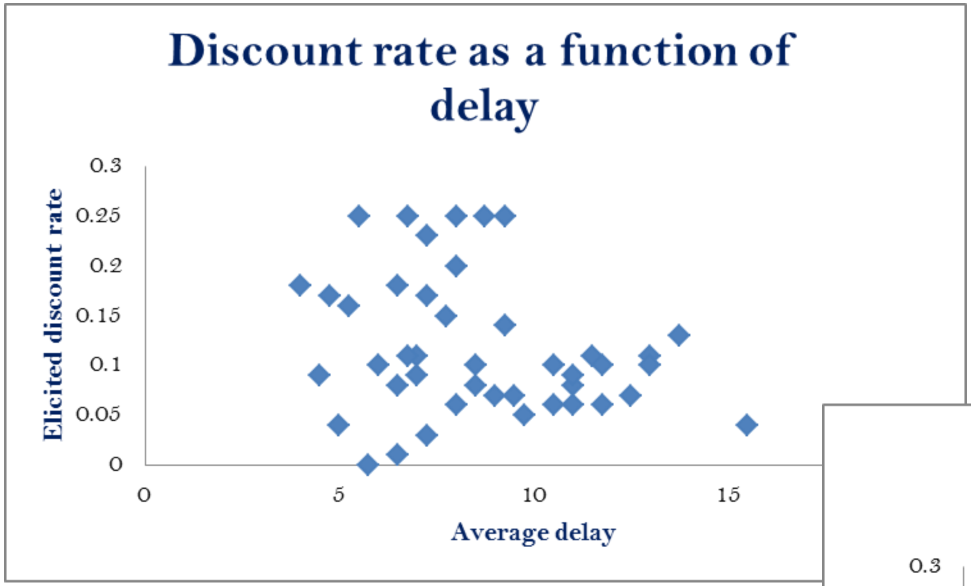
Elicited discount rates: sample average

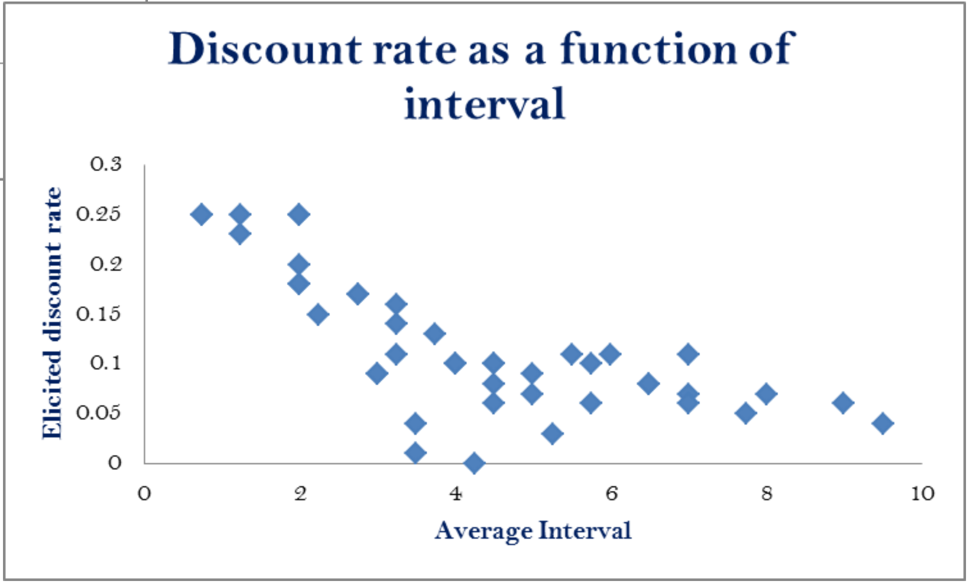
		$C_{10}R_1$	$C_{10}R_2$	$C_{25}R_2$	C_5R_2	C_7R_2	$C_{15}R_2$	$C_{10}R_5$	$C_{10}R_7$	$C_{25}R_{10}$	$C_{10}R_{10}$
	Sample Relativities	**0.97**	**0.72**	**0.35**	**1.67**	**1.16**	**0.61**	**1.02**	**1.67**	**0.49**	**3.58**
$C_{10}R_1$	**0.97**	.	.	.	.	.	.	.	.	.	.
$C_{10}R_2$	**0.72**	-0.29	.	.	.	.	.	.	.	.	.
$C_{25}R_2$	**0.35**	0.07	0.05	.	.	.	.	.	.	.	.
C_5R_2	**1.67**	0.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.	.	.	.
C_7R_2	**1.16**	0.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.	.	.	.
$C_{15}R_2$	**0.61**	0.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.	.	.	.
$C_{10}R_5$	**1.02**	0.01	0.11	0.06	0.25	.	0.06	.	.	.	.
$C_{10}R_7$	**1.67**	0.09	0.17	0.08	.	0.18	0.10	0.25	.	.	.
$C_{25}R_{10}$	**0.49**	0.11	0.06	0.04	0.10	0.09	0.11	0.07	0.10	.	.
$C_{10}R_{10}$	**3.58**	0.15	0.20	0.10	0.25	0.23	0.14	0.25	0.25	0.13	.

$$\sqrt[15]{2.06} - 1 = r$$

- Assumes exponential discount function
- Elicit sample level discount rates for each combination of relativity pairs
- None possible for $C_{10}R_7$ and C_5R_2 or $C_{10}R_5$ and C_7R_2 because they have the same intervals so the calculation cannot work.

Elicited discount rates: sample average





- Not a clear relationship between elicited discount rate and average delay
- But a clear negative relationship between the discount rate and the interval

Individual discount rate analysis

- 43 discount rates elicited per individual (some fewer, if failed to provide all relativities).
- Pooled for the sample, 4336 individual discount rates
- Regression on the features of the underlying relativities can inform us about the likely discount function for the sample

Discount rate	Model (1) N=4336 R^2=0.0157
Latency interval	-0.012*** (0.002)
Average delay	-
Constant	0.229*** (0.023)

Individual level analysis

- 43 discount rates elicited per individual (some fewer, if failed to provide all relativities).
- For each individual, OLS regression is run.
- Sign and significance of the coefficient on latency and average delay categorise each individual according to likely discounting function.

Classification	Coefficient on Delay	Coefficient on Interval	N (% of usable sample of 104)
Exponential	insignificant	insignificant	36 (34.6%)
Hyperbolic	negative significant	unspecified	16 (15.4%)
Subadditive	unspecified	negative significant	43 (41.4%)
Both	negative significant	negative significant	2 (1.9%)
Other	unspecified	unspecified	7 (8.6%)

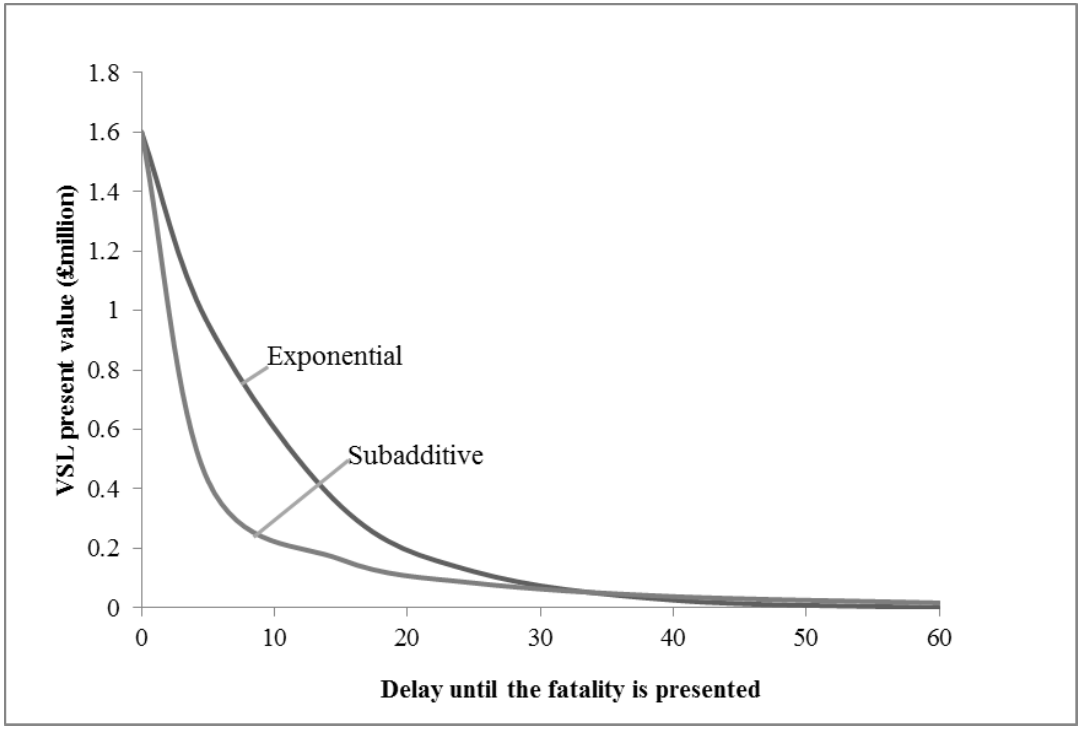
Implications for policy

- If exponential assumption is used and discount rate elicited here is respected, policy makers would generate a discounted VSL for a fatality after T years as $VSL_T = \frac{VSL_0}{e^{\delta T}} = \frac{VSL_0}{e^{0.122 * T}}$
- However, reanalysis using the subadditive discount factor generates very different estimates of the VSL for medium term fatalities

Time from the present (years)	Discount factor with Exponential assumption (geometric mean rate = 10.9%)	(median rate = 6.2%)	Discount factor with Subadditive assumption (geometric mean rate = 55.8%)	(median rate = 71.9%)
0	1	1	1	1
5	0.58	0.73	0.27	0.48
15	0.19	0.39	0.10	0.28
25	0.07	0.21	0.05	0.19
40	0.01	0.08	0.02	0.12
60	0.00	0.02	0.01	0.08

Implications for policy (2)

- If exponential assumption is used and discount rate elicited here is respected, policy makers would generate a discounted VSL for a fatality after T years as $VSL_T = \frac{VSL_0}{e^{\delta T}} = \frac{VSL_0}{e^{0.122*T}}$
- However, reanalysis using the subadditive discount factor generates very different estimates of the VSL for medium term fatalities.



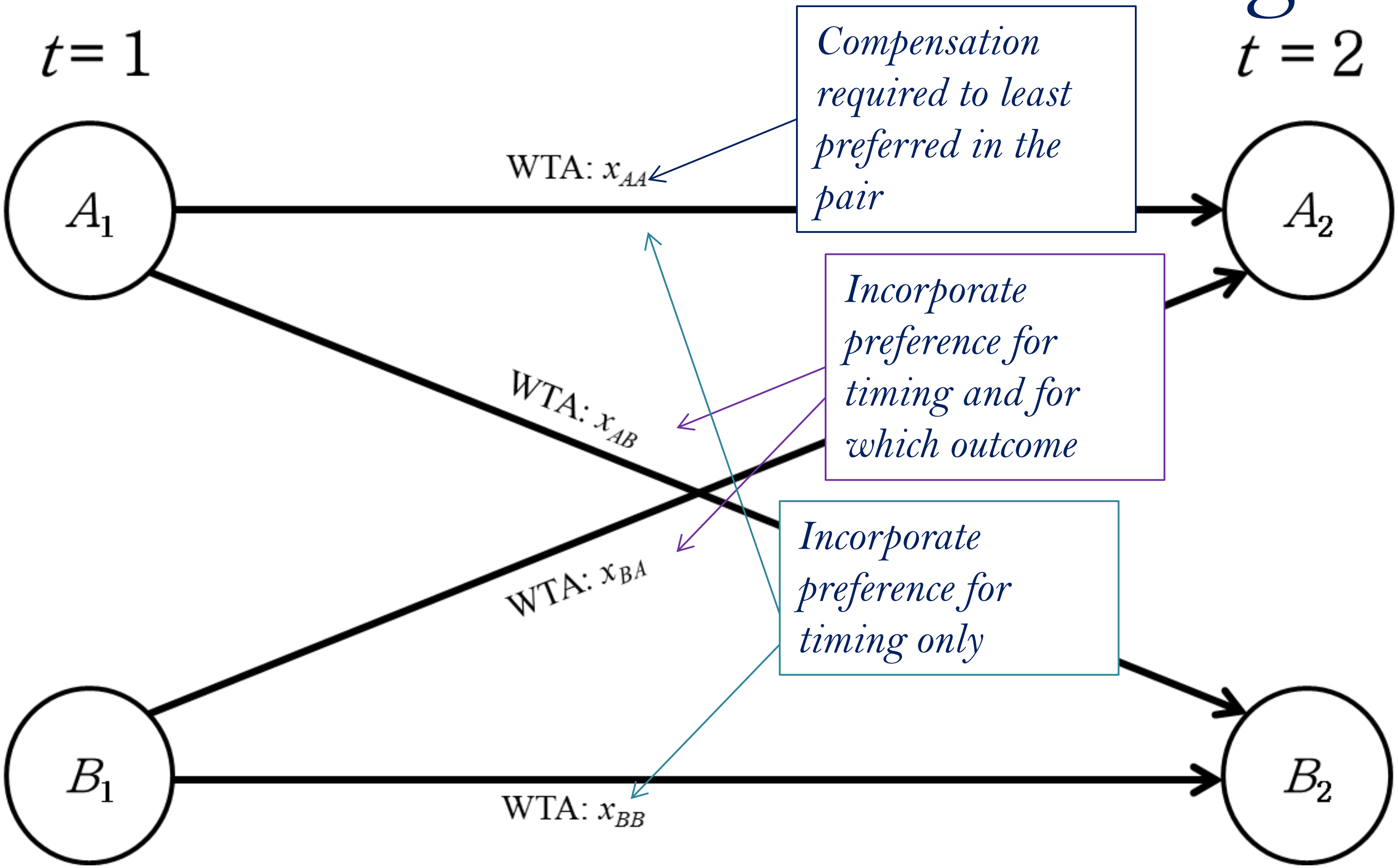
Main Study Summary

- We elicited discount rates from relative risk tradeoffs for cancer and road accident fatalities.
- Analysis suggests that
  - Discounting of mortality risks depends on the interval between the fatality times
  - Sub-additive discounting characterises the majority of the sample
  - A unique discount rate for use in policy may not exist.
- Heterogeneity between individuals characterises both the discount rate and the discount function in mortality risk valuation.

Cross-Modal Discounting

- We elicited discount rates from options differing in cause (cancer and roads) and time (T and t).
- We could have elicited within-cause relativities.
- According to economic theory this should not make a difference.

Cross-Modal Discounting



Econ theory: $x_{AA}+x_{BB} = x_{AB}+x_{BA}$ (with utility for money linear)

Cross-Modal Discounting

- We (with D. Read & R Cubitt) found that summed 'cost of delay' (i.e. impatience) is LOWER for cross-modal than uni-modal comparisons. (consumer goods)
- More (excess?) weight placed on delay when it is the only attribute that differs.
- Tricky implications for the appropriate way to elicit discount rates for policy.
- Could explain some of the heterogeneity between existing studies.

Thank you.

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