Behavioral Economics and economic experiments, a pathway forward for Health Economics

Afternoon session

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Outline

Using behavioral biases to improve applications

Biases in health utility measurement

Ambiguity in treatment choice

Part 1

Using behavioral biases to improve applications

Biases in health utility measurement

Ambiguity in treatment choice

Question

- Patient
  - 10 y. vs (40 y., p; Death)
  - p = 0.70

- True probability of success 0.65

- Surgery?

Expected Utility

- Treatment (40y., p, 0y.)

- $EU = pU(40y.) + (1-p)U(0y.)$

Classical Elicitation Assumption

- EU used to derive utilities from people's answers to utility elicitation questions

Example

- A patient indicates indifference between living 10 years for sure and a lottery (40 y., 1/2, 0 y.)

- Then by the classical elicitation assumption

U(10 y.) = 0.50

Assumption

- People do not deviate from EU

or

- If deviations exist, they do not bias utility measurement systematically

This lecture

- Empirical evidence: people deviate systematically from EU

- Deviations may cause biases in utility elicitations

Conclusive evidence

- Hershey and Schoemaker (1985)

Example:

?y.~ (40y., 1/2, 0 y.)

? = 10 y.

CE question

Under scaling U(0 y.) = 0 and U(40 y.) = 1

EU: $U_{CE}(10\text{ y.}) = 0.50$

PE question

10 y. ~ (40 y., p?, 0 y.)

Typical answer: $p > 0.50$

EU: $U_{PE}(10 \text{ y.}) > 0.50$

Inconsistency: $U_{CE}(10 \text{ y.}) \neq U_{PE}(10 \text{ y.})$

Your data

Other inconsistency

- Llewellyn-Thomas et al. (1982)
  - direct gamble: 10 y. ~ (40 y., p?, 0 y.)
    - U(10y.) = p
  - chained gamble:
    - 10 y. ~ (40 y., q?, 5 y.)
    - 5 y. ~ (40 y., r?, 0 y.)
    - U(10y.) = q + (1 – q)r

Test

- Is direct utility = chained utility

- No, chained > direct

Reactions to the inconsistencies

1 Humean view of preference/consumer sovereignty

Preferences should be accepted as they are and should never be interpreted as inconsistent

But: EU does not work and no tools for decision analysis based on non EU

⇒ abandon medical decision making and economic evaluation

Retain medical decision making

Dilemma:

$\Rightarrow$ to solve inconsistency must deviate from the patient's responses

2nd reaction to the inconsistency

Constructive-preference approach

Elicited values = Basic values + Heuristics

Inconsistencies are solved in an interactive process with the client

Time-consuming and often not feasible

$\Rightarrow$ have to accept elicited values with their biases

3rd reaction to the inconsistency

Use “riskless” measures

Problem: risk attitude cannot be measured

4th reaction (this lecture): Correct for biases

Assumption: Deviations are biases that should be corrected

Question: which biases and how to correct for them?

Theoretical basis

Prospect Theory:

Correct utilities for probability transformation and loss aversion

Deviations from EU

- EU (40y., p, 0y.) = p U(40y.) + (1−p) U(0y.)

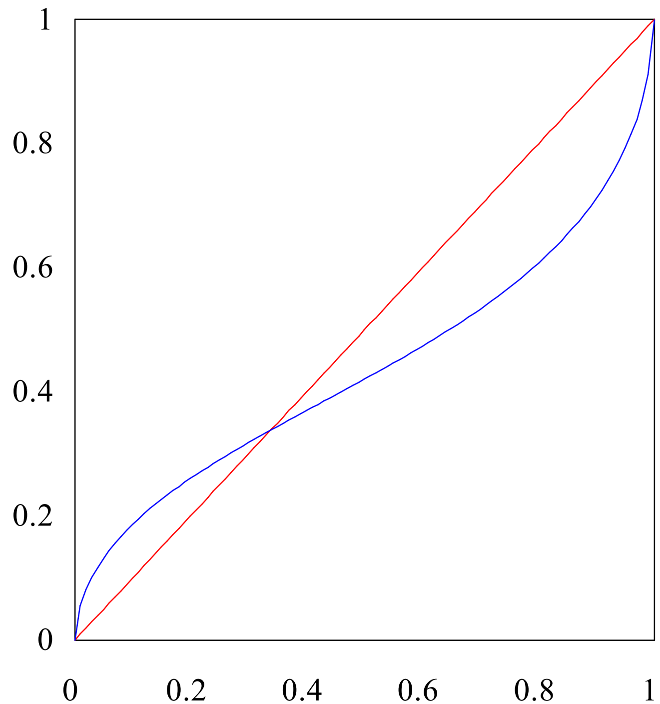
- Prospect theory:

  - probability transformation
  - loss aversion

Probability transformation

- Modeled through probability weighting function w

- Inverse S-shape



Intermezzo

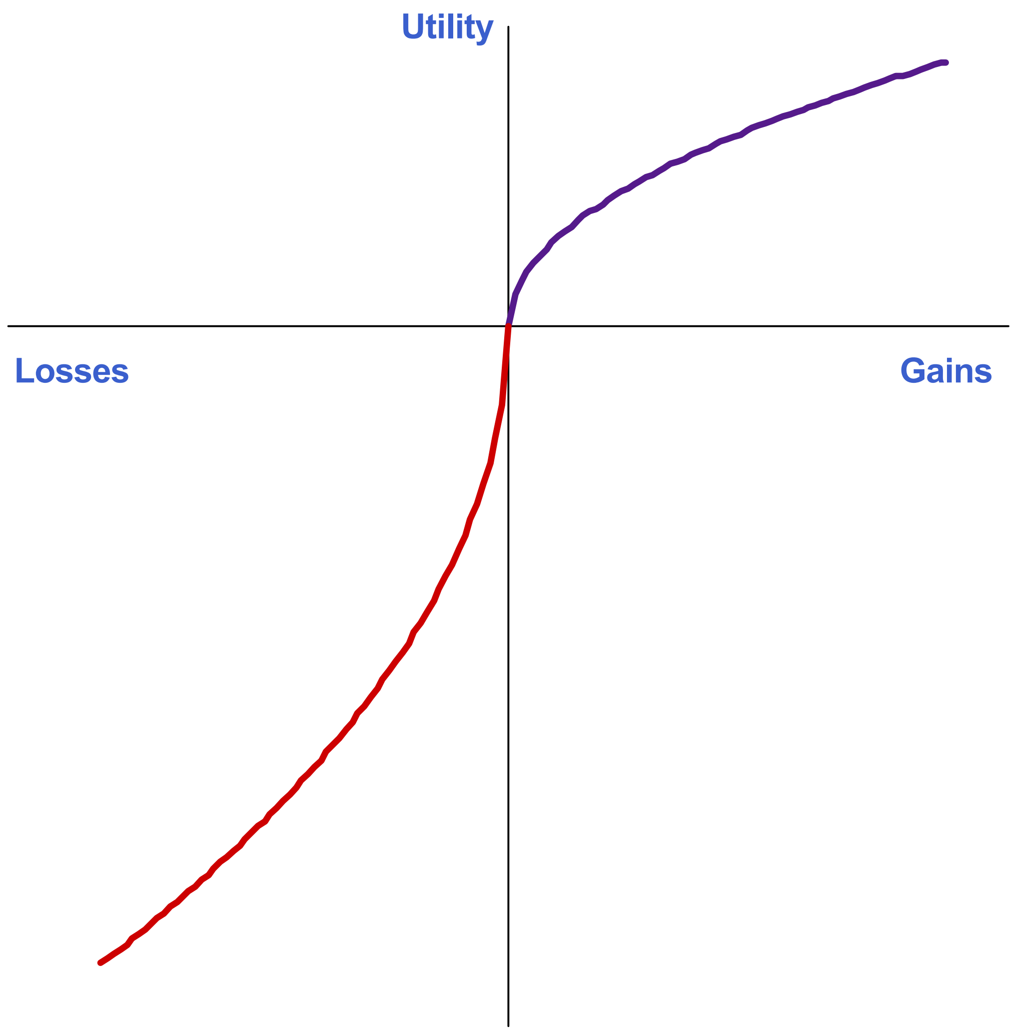
- $U\ (40y.,\ p,\ 0y.) = w(p)U(40y.) + 1 - w(p)\ U(0y.)$

Utility function

- Three key properties:

  - Reference-dependence
  - Loss aversion
  - Diminishing marginal sensitivity

Prospect theory utility function



Prospect Theory

- Suppose reference point is 30 years

- $U(40y., p, 0y.) = w^{+}(p)\,\big(U(40y.) - U(30y.)\big) - w^{-}(1-p)\,\lambda\,\big(U(30y.) - U(0y.)\big)$

Modifications in Utility Measures

- PE gambles

10y. ~ (40y., *p?*, 0y.)

Hypothesis: subject takes 10y. as reference point

Modified PE formula

$$U(10y.) = \frac{w^{+}(p)}{w^{+}(p) + \lambda w^{-}(1-p)}$$

Modified CE formula

CE gamble:

x? ~ (40y., p, 0y.)

Assumption: certain outcome not status quo

Modified CE formula

- Case: All outcomes are gains

$$U(x) = w^+(p)$$

Example

- PE: 10 y. ~ (40 y., 0.70, 0)

$$U(10y.) = \frac{w^{+}(0.70)}{w^{+}(0.70) + \lambda w^{-}(0.30)}$$

Parameter values

- If no individual values are available, use Tversky and Kahneman's values

- Example:

U(10 y.) = 0.42

Graph Corrections

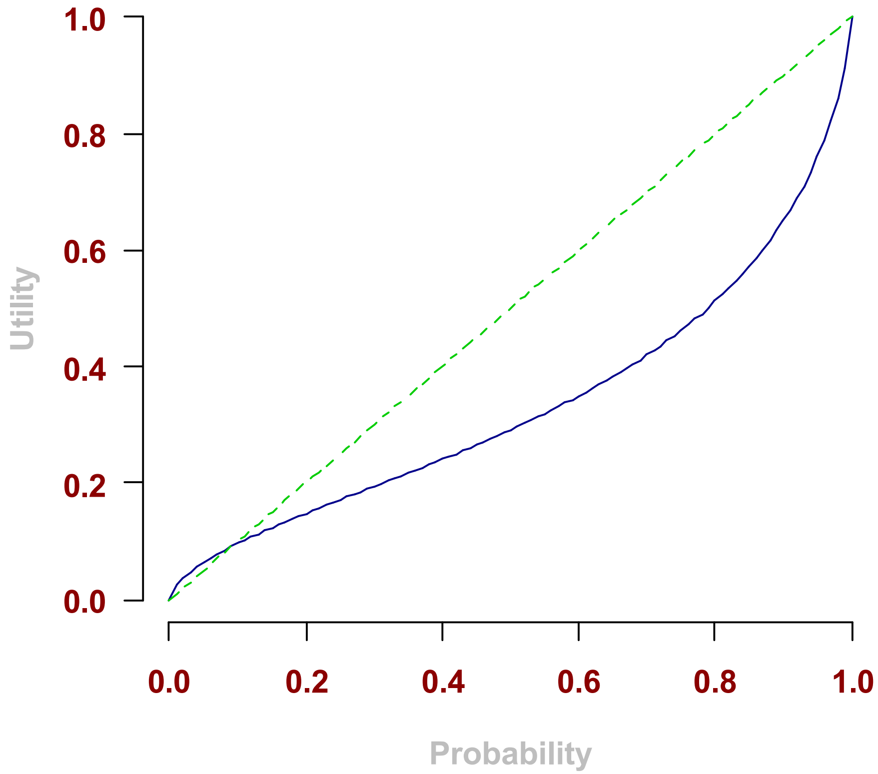


Figure 4: The Value of Health under Prospect Theory

Test

- Are the proposed quantitative corrections able to resolve the discrepancies between the methods?

CE method

- 5 questions

  CE(p) ~ (40y., p, 0y.)

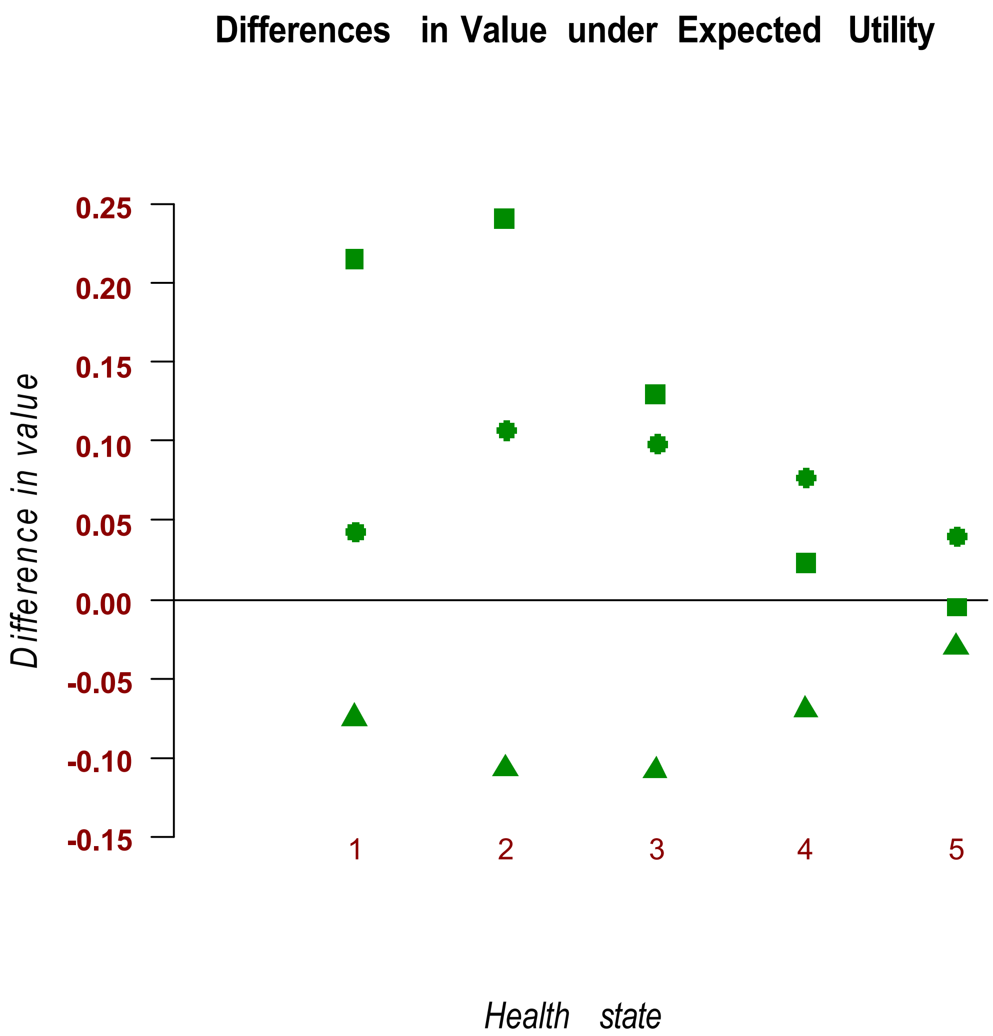
- p = 0.10, 0.25, 0.50, 0.75, 0.90

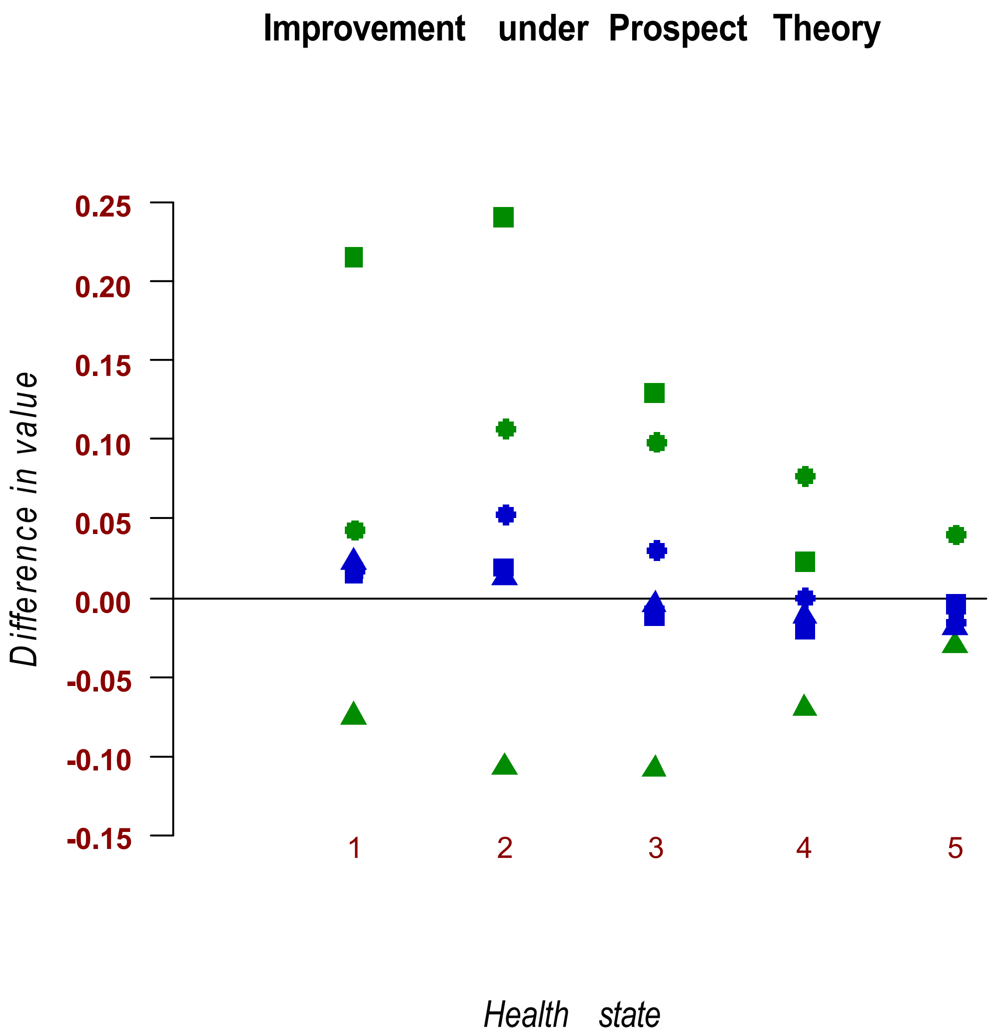
PE method

- 5 questions

  Y ~ (40y., p, 0y.)

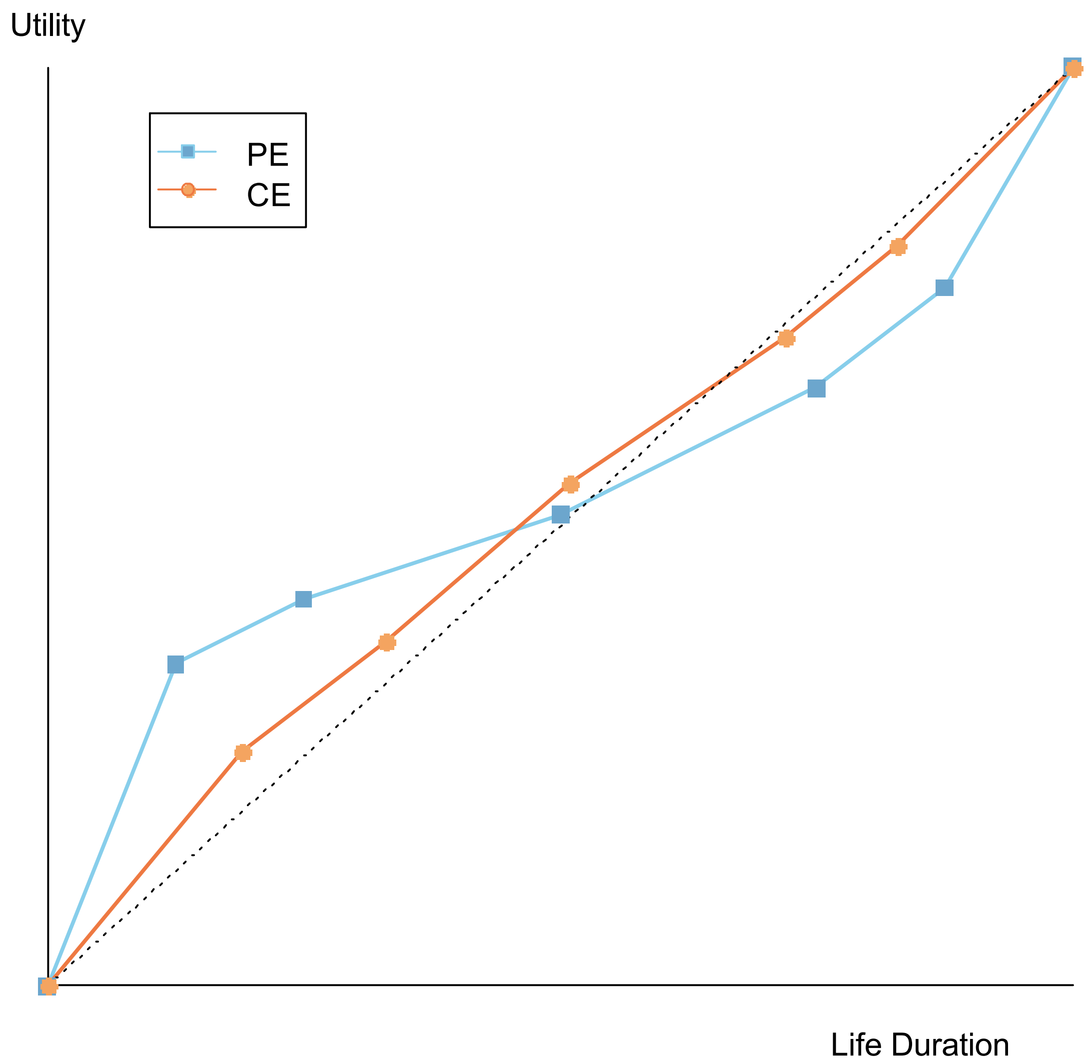
- Y= 5y., 10y., 15y., 25y., 35y.


Differences in Value under Expected Utility
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
Difference in value
1
2
3
4
5
Health state


Improvement under Prospect Theory
Difference in value
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
1
2
3
4
5
Health state

Your data

Your data



Conclusions

- Corrections for probability transformation and loss aversion improve consistency methods

- At least some biases are avoided

- In absence of individual data, TK parameters are a good choice.

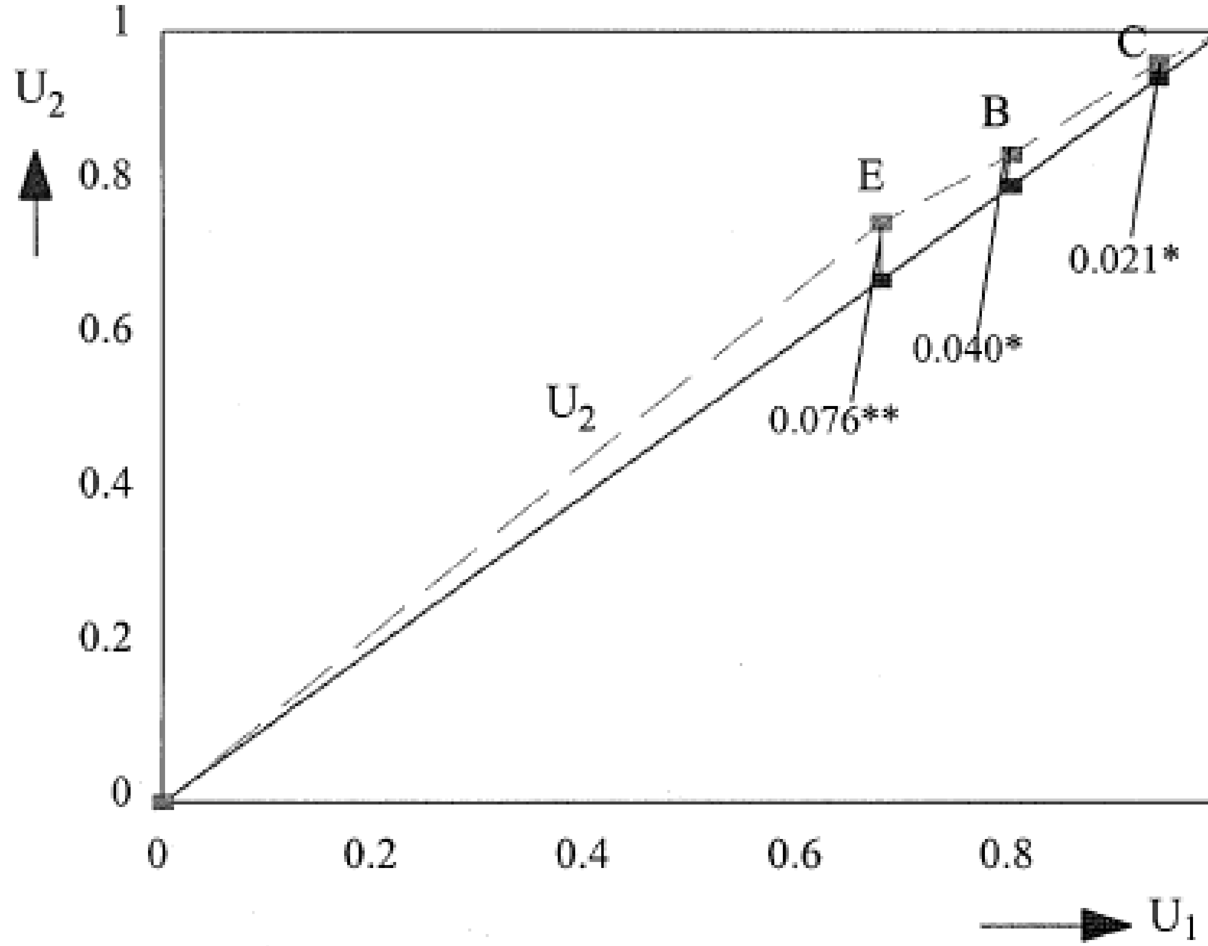
Conclusions II

- PE insensitive for “high utility outcomes”

- Caution against use of PE utility elicitation.

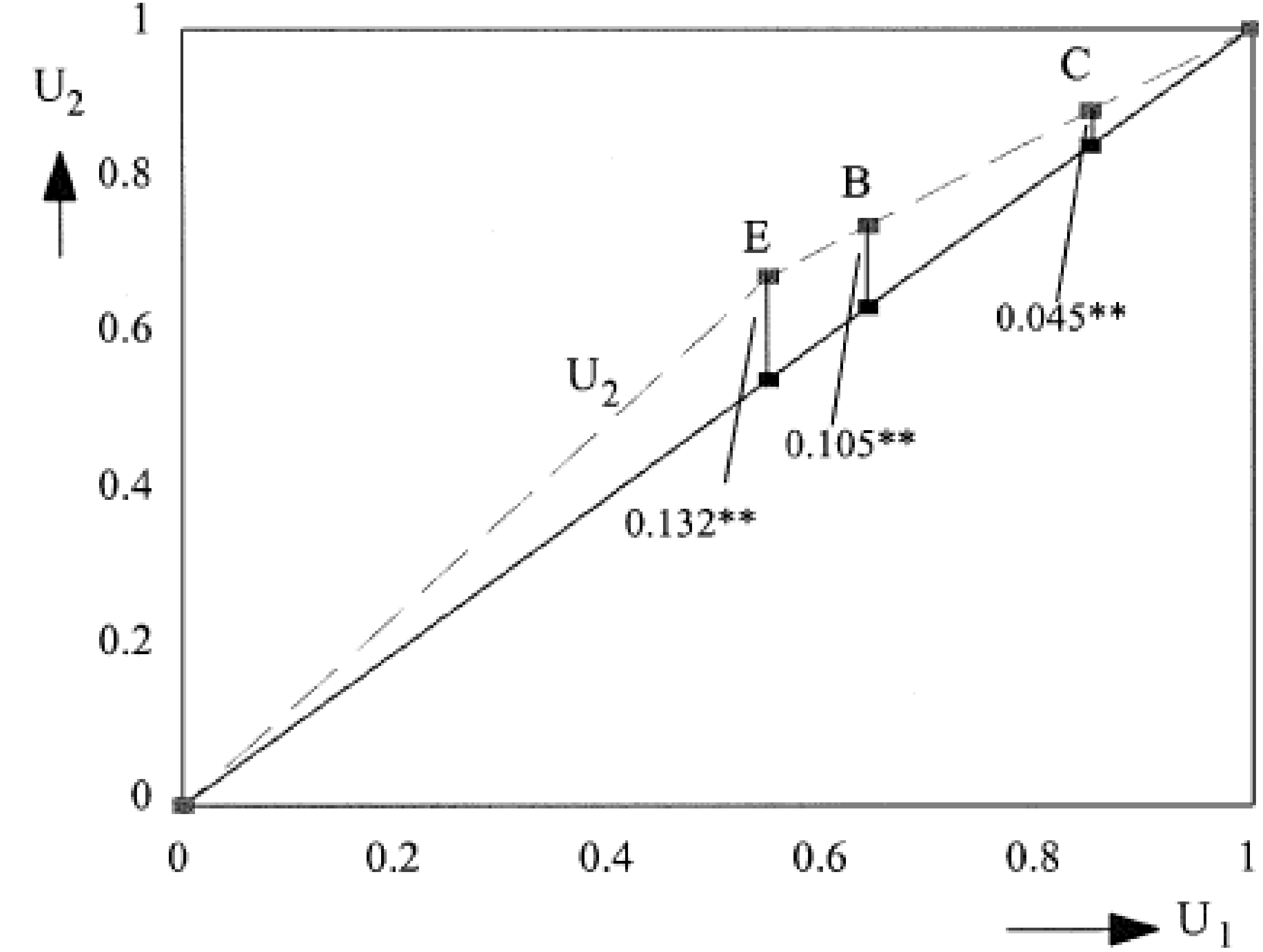
Futher caution

- Discrepancy direct and chained utility
  - direct gamble: 10 y. ~ (40 y., p?, 0 y.)
  - chained gamble:
    - 10 y. ~ (40 y., q?, 5 y.)
    - 5 y. ~ (40 y., r?, 0 y.)



* Significantly different from zero at $\alpha = 0.05$

** Significantly different from zero at $\alpha = 0.01$



** Significantly different from zero at α = 0.01

But

- Discrepancy may be due to “more elementary” violations of EU

- Anchoring and insufficient adjustment

Question

- Patient
  - 10 y. vs (40 y., p; Death)
  - p = 0.70

- True probability of success 0.65

- Modified utility: 0.420

- Surgery!

Part 2

Using behavioral biases to improve applications

Biases in health utility measurement

Ambiguity in treatment choice

Health state utilities

- Three Methods
  - Rating Scale
  - Time Trade-Off
  - Standard Gamble

Question

- Methods give systematically different results
  - SG > TTO > RS
  - Your data:
    - RS =
    - TTO =
    - SG =

- Which one is best?

Old Belief

- SG is best
- Based on EU
- EU is normative theory of decision under risk
- risk important in medical decision making

Problem

- People violate EU
- Inconsistencies in SG utilities

Llewellyn-Thomas et al. (1982)

- Two ways of determining U(X)
  - Direct: X ~ (FH, p; Death)
    - U(X) = p
  - Chained:
    - X ~ (FH, q; Y)
    - Y ~ (FH, r; Death)
    - U(X) = q + (1– q) r

Result

- Chained method gives systematically higher utilities than direct method

Dilemma

- Methods give different results
- Do not know which method is best

Attempt to Solve Dilemma

- Bleichrodt and Johannesson (1997)

- Idea: Utility model should explain choices

- Examine which method produces QALY weights that are most consistent with choices over health profiles.

Approach

- Valued Back Pain by SG, TTO, and RS.

- Defined 7 health profiles
  - 20 y. BP
  - 18 y. FH
  - 16 y. FH
  - 14 y. FH
  - 12 y. FH
  - 8 y. FH + 8 y. BP
  - 6 y. FH + 11 y. BP

- Computed QALYs for each of 7 profiles based on SG, TTO, RS
- Led to ranking of profiles according to SG-QALYs, TTO-QALYs, and RS-QALYs
- Also asked subjects to rank profiles directly
- Compared rankings through Spearman rank-correlation coefficients

Results

Method	Utility
SG	0.67
TTO	0.58
RS	0.40

Rank correlations

Method	Utility
SG	0.73
TTO	0.84
RS	0.75

Conclusions

- TTO most consistent with individual preferences
- But why?

Rating Scale

- Easiest to use
- But,
  - No economic foundation (not choice based)
  - Response spreading/Context Effects
  - Endpoint bias
  - Duration neglect
  - Always put death at bottom

Context Effects

- Value depends on other health states that are included

- Robinson et al. (2001)

	I	II
X	0.60	0.80
S	0.375	0.60
R	0.20	0.30

Today

- Focus on SG and TTO
- Will explain why they differ and why TTO is "best"

Empirical Research

- SG > TTO
- Explanation based on EU:
- Difference due to utility curvature
- Concave utility for duration
  - risk aversion

Puzzling for EU

- SG consistent with EU
- TTO imposes restrictions
- But TTO more consistent with preferences

Will argue

- Common explanation is not complete because it is based on EU

- People violate EU

- Violations bias SG and TTO utilities

Reasons for violations

- Probability weighting
- Loss aversion
- Scale compatibility

Assumptions

- $U(Q,T) = H(Q)L(T)$
  - Common assumption in health utility measurement
  - Empirical support
- People prefer more years in full health to less

Standard Gamble

- $(Q_1,T) \sim ((FH,T), \boldsymbol{p}, Death)$
- $H(FH) = 1, U(Death) = 0$
- $H(Q_1)L(T) = pH(FH)L(T) + (1-p)U(Death)$
- $H(Q_1) = p$

Time Trade-Off

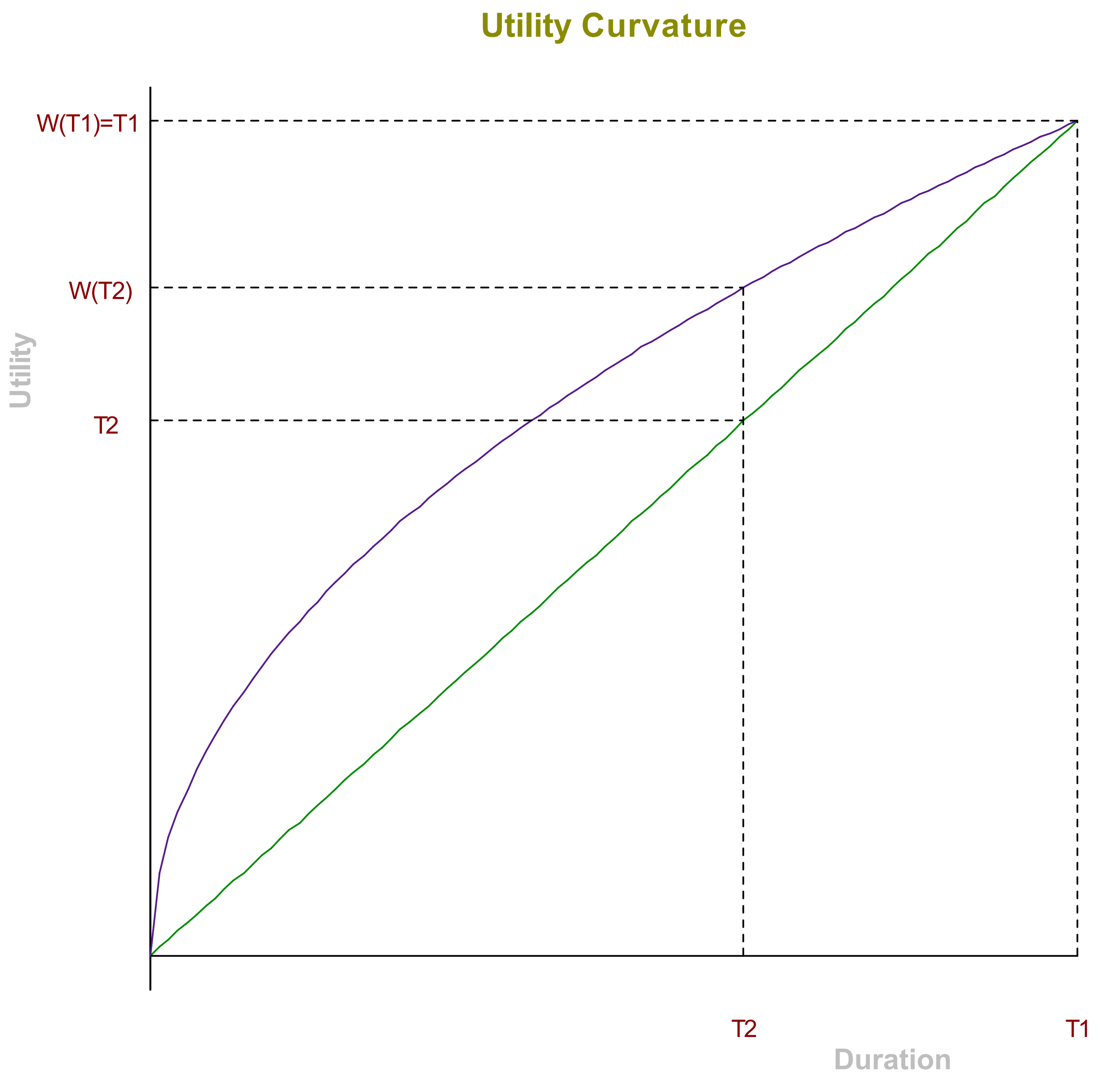
- $(Q_1,T_1) \sim (FH, \boldsymbol{T_2})$
- $L(T) = T$
- $H(Q_1)T_1 = H(FH)T_2$
- $H(Q_1) = T_2 / T_1$

Utility Curvature

- If L is concave/convex then the TTO weights are biased downwards/upwards

- Empirical Research:
  - L is concave both under EU (and under PT)

- TTO biased downwards, SG unbiased


Utility Curvature
W(T1)=T1
W(T2)
T2
Utility
T2
T1
Duration

Probability weighting

- Empirical research: people do not evaluate probabilities linearly but weight probabilities

- Formal theory: Prospect Theory
  - $PT((Q_1,T_1), p, (Q_2,T_2)) = w(p)\ U(Q_1,T_1) + (1-w(p))\ U(Q_2,T_2)$
  - U unique up to unit and location

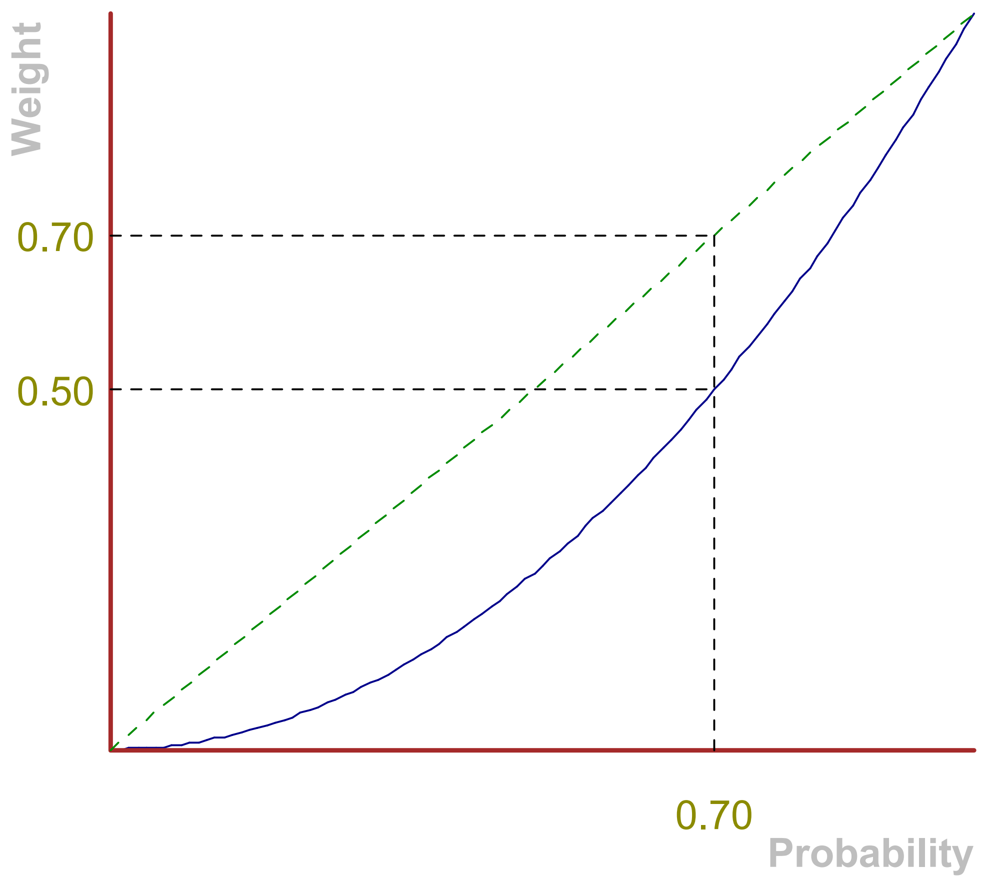
Impact

- TTO riskless, hence no impact probability distortion
- SG: $(Q_1,T) \sim ((FH,T), \boldsymbol{p}, \text{Death})$
- $H(FH) = 1$, $U(\text{Death}) = 0$
- $H(Q_1)L(T) = w(p)H(FH)L(T) + (1-w(p))U(\text{Death})$
- $H(Q_1) = w(p)$

Implication

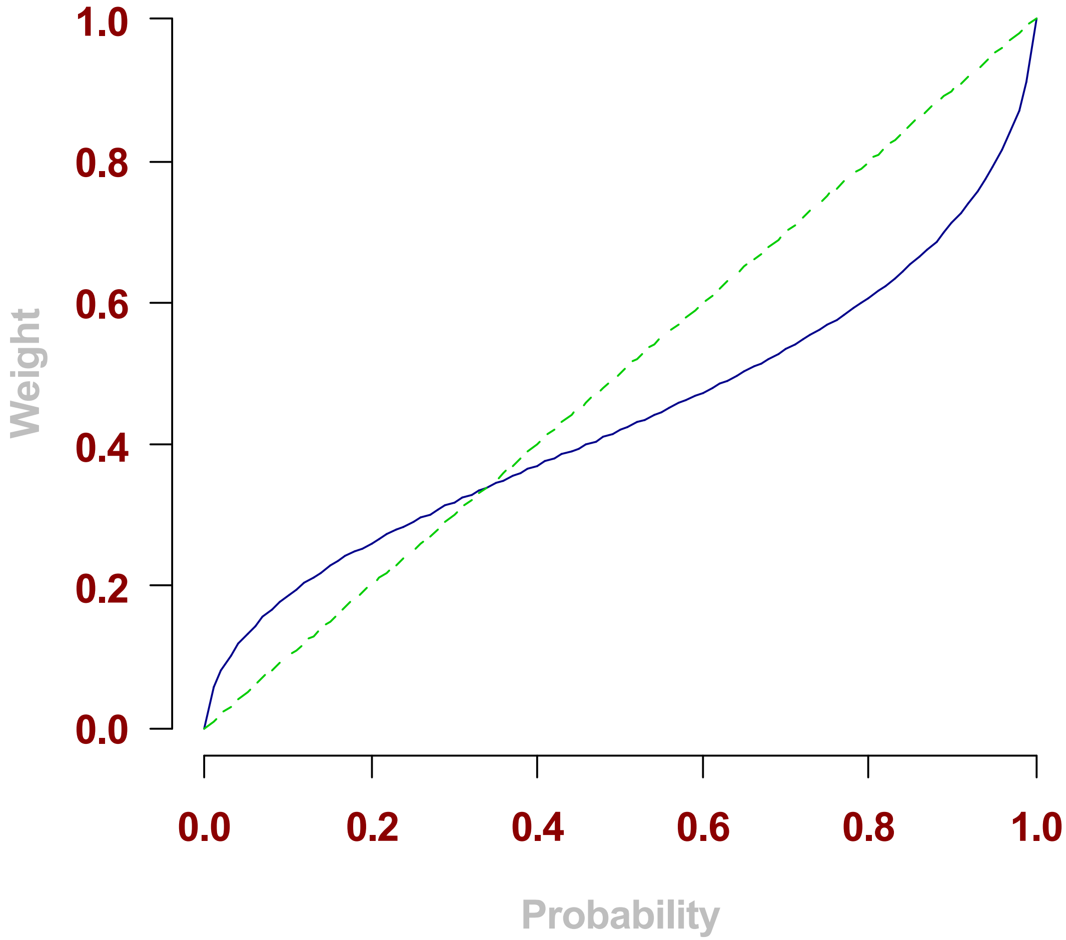
- Suppose $w(p) < p$ for all p
- Suppose $(Q_1,T) \sim ((FH,T),$ ***0.70***, Death)
- Then $H(Q_1) = w(0.70) < 0.70$
- But SG: $H(Q_1) = 0.70$

Probability Weighting



Empirical research

- w has inverse S-shape
- $w(p) > p$ for $p < 0.35$, $w(p) < p$ on $[0.35, 1]$
- p in SG generally exceeds 0.35
- Hence, SG generally biased upwards


1.0
0.8
0.6
0.4
0.2
0.0
Weight
0.0
0.2
0.4
0.6
0.8
1.0
Probability

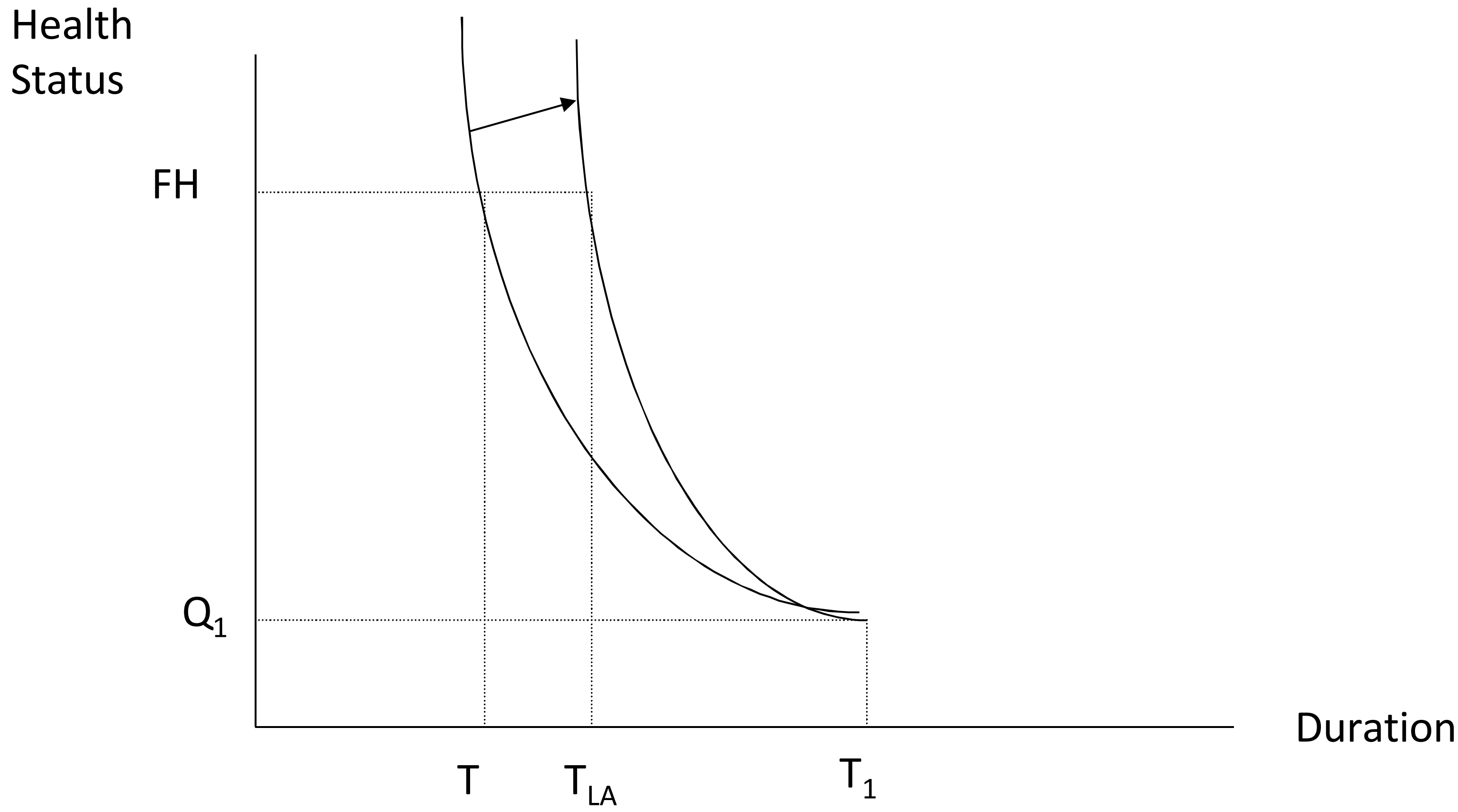
Loss Aversion

- Prospect Theory: people evaluate outcomes as gains and losses relative to a *reference point*

- People are loss averse: they are more sensitive to losses than to gains

- Much empirical evidence for loss aversion.

Loss Aversion



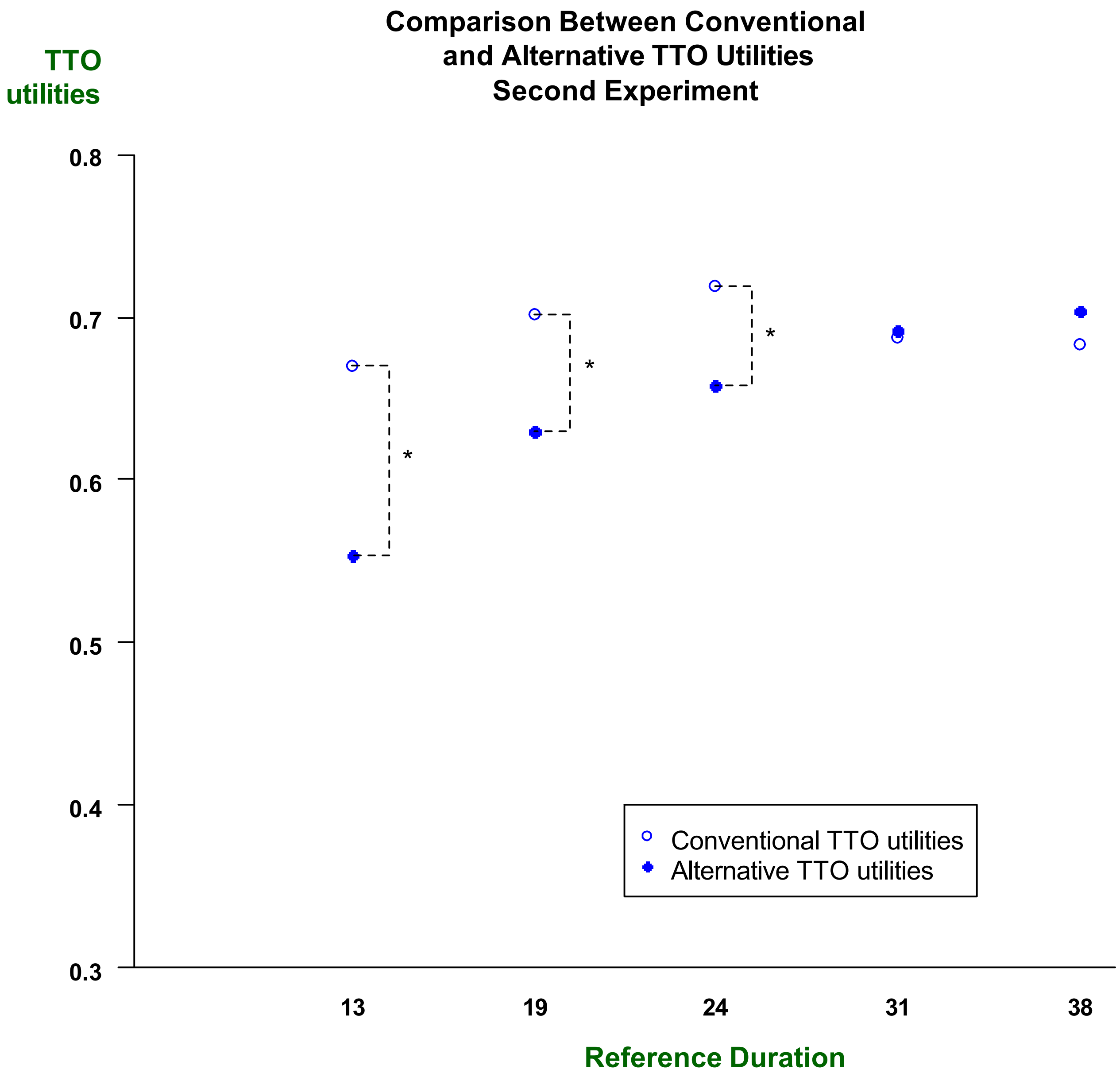
TTO

- $(Q_1, T_1) \sim (FH, \boldsymbol{T})$
- Gain in health status from Q_1 to FH weighted against loss in duration from T_1 to T.
- T will rise by loss aversion
- Hence $T_{LA}/T_1 > T/T_1$
- And thus TTO biased upwards by loss aversion

Evidence

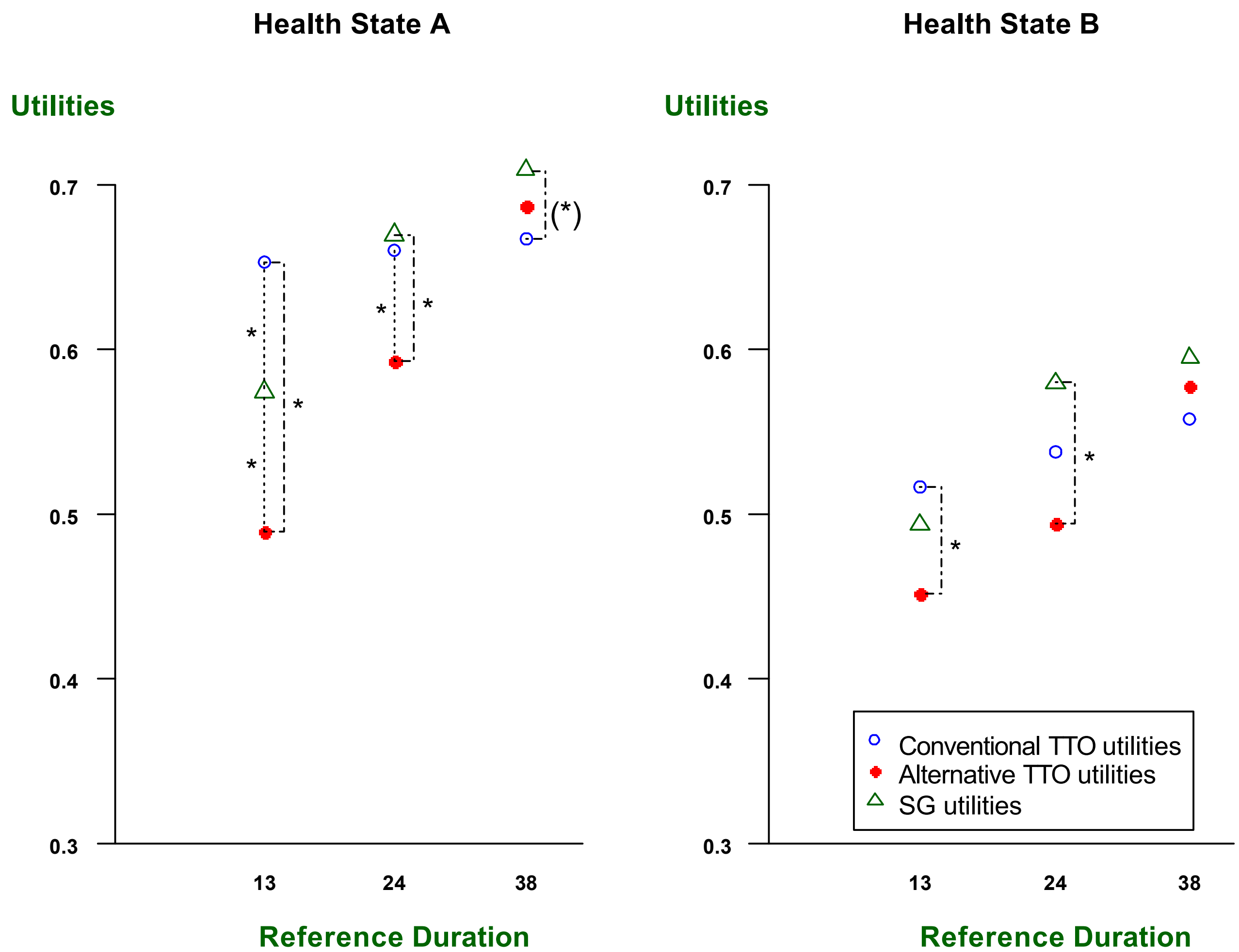
- Bleichrodt, Abellan & Pinto (2003)

- Two ways of asking TTO
  - Conventional
    - (30y., A) ~ (?y., FH)
    - ? = 20y.
  - Alternative
    - (?y., A) ~ (20y.,FH)



* denotes significantly different at alpha = 0.01

Comparison Between
Conventional TTO, Alternative TTO, and SG
Second Experiment



* denotes significantly different at alpha = 0.01 both by the paired t-test and by Wilcoxon's test
(*) denotes significantly different at alpha = 0.01 by Wilcoxon's test only

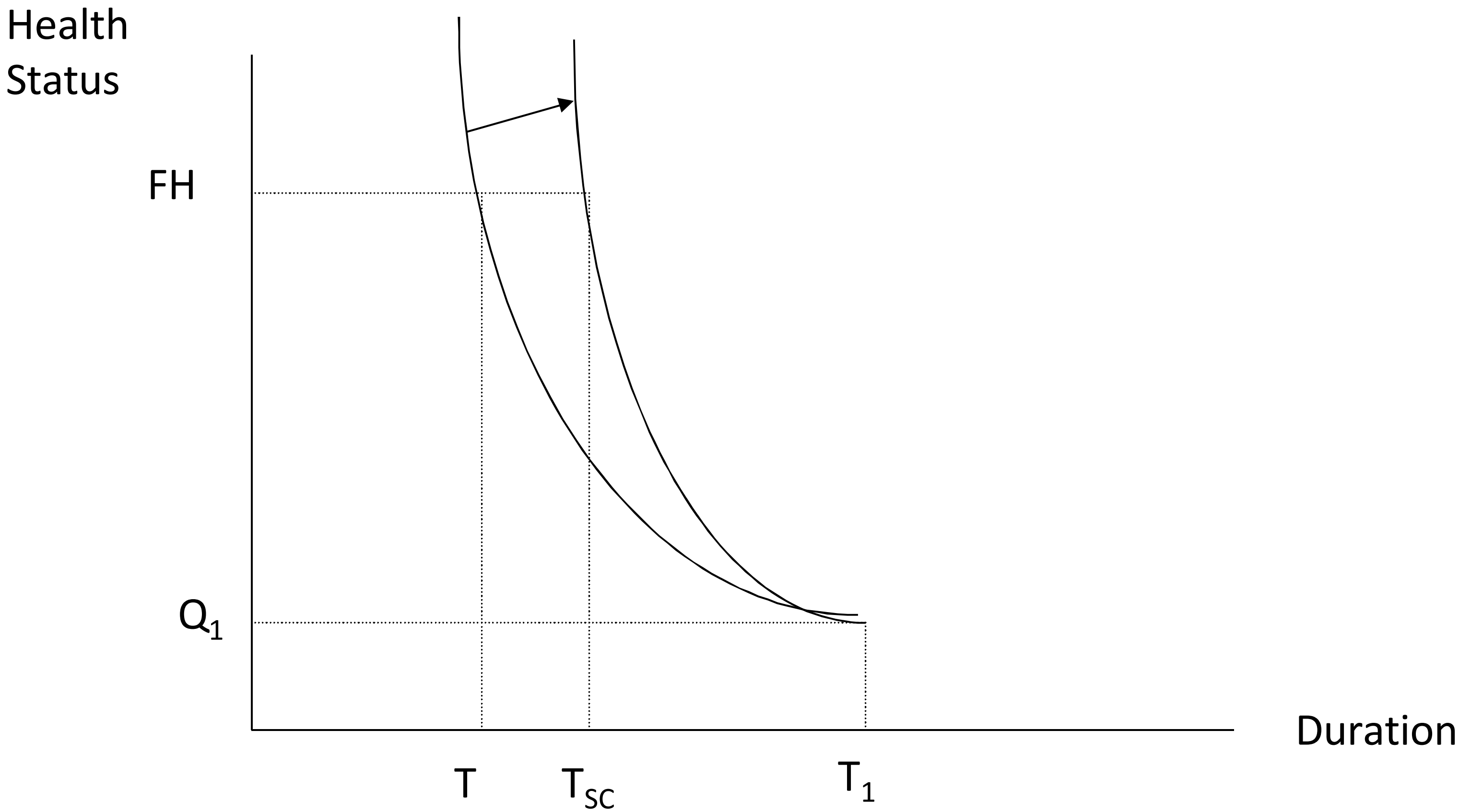
Standard Gamble

- $(Q_1,T) \sim ((FH,T), \boldsymbol{p}, Death)$
- Individual trades-off possible gain from (Q_1,T) to (FH,T) against possible loss from (Q_1,T) to death
- $p' > p$
- Loss Aversion induces upward bias in SG utilities

Scale Compatibility

- Attribute gets more weight if it is used as a response scale

Scale Compatibility



TTO

- $(Q_1,T_1) \sim (FH,\boldsymbol{T})$
- Response scale is duration
- $T_{SC} > T$
- Hence $T_{SC}/T_1 > T/T_1$
- And thus TTO biased upwards by scale compatibility

Standard Gamble

- $(Q_1,T) \sim ((FH,T), \boldsymbol{p}, \text{Death})$
- Scale compatibility predicts: overweighting of probability
- There are three probabilities in the SG
  - Probability p of good outcome (FH,T)
  - Probability $1-p$ of bad outcome Death
  - Probability 1 of (Q_1,T)
- Effect scale compatibility on SG utility ambiguous

Conclusion

- SG generally upward biased
- In TTO both upward and downward biases
- Hence, TTO utility lower and more consistent with individual preferences
  - Do not correct TTO for utility curvature
  - B&J: TTO most consistent when no discounting

What about corrected SG?

Van Osch et al. (2004)

- TTO, SG, CE
- CE used to estimate utility for life duration
- Correct TTO for utility curvature
- Correct SG by prospect theory formulas

Main findings

- Limited evidence of utility curvature
  - Median power 0.80
  - Mean power: 1.16
- TTO corrected and TTO uncorrected nearly equal
- Hence, TTO biased upwards.
- SG with corrections lower
- Recommend using SG with corrections

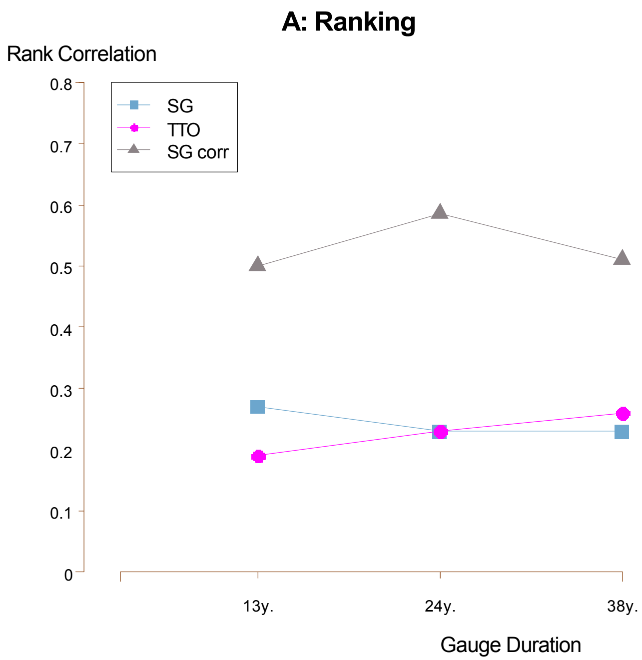
Abellan-Perpiñan, Bleichrodt & Pinto-Prades (2009)

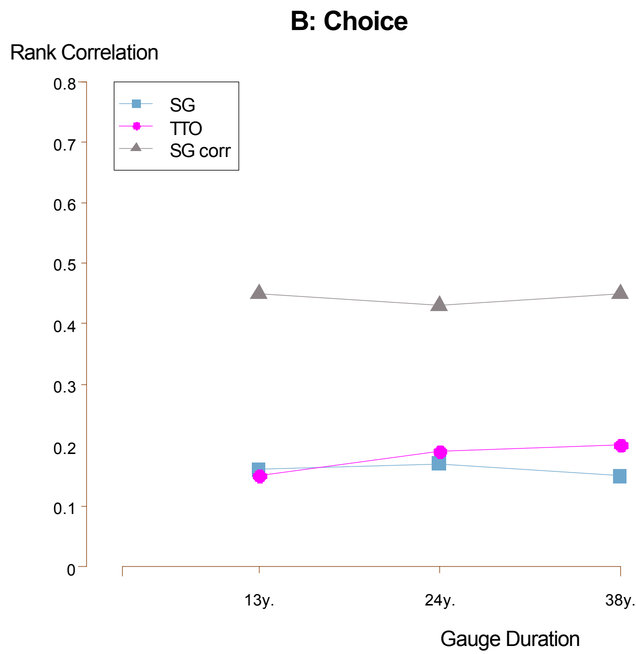
Health state A	Health state B
• Some problems walking about • Some problems performing self-care activities (e.g. eating, washing, dressing) • No problems performing usual activities (e.g. work, study, family or leisure activities) • Moderate pain or discomfort • Moderately anxious or depressed	• Some problems walking about • Some problems performing self-care activities (e.g. eating, washing, dressing) • Unable to perform usual activities (e.g. work, study, family or leisure activities) • Moderate pain or discomfort • Moderately anxious or depressed

Profiles

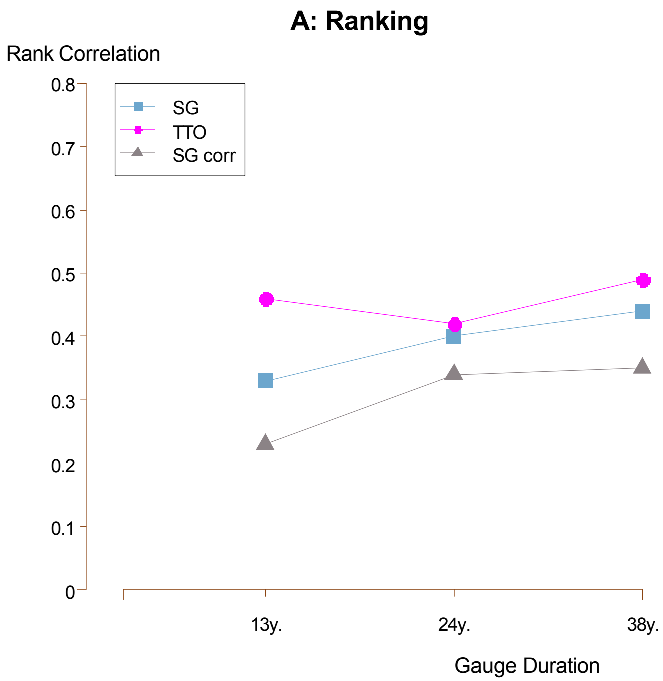
Risky prospects
(11A, 0.63,Death) (17A, 0.5, Death) (11B, 0.5, 7A) (6B, 0.5, 6FH) (14A, 0.45, 7B)
Intertemporal profiles
14A+3FH 9A+4B+4FH 4FH+13B 1FH+13B+3FH 2FH+4A+8B

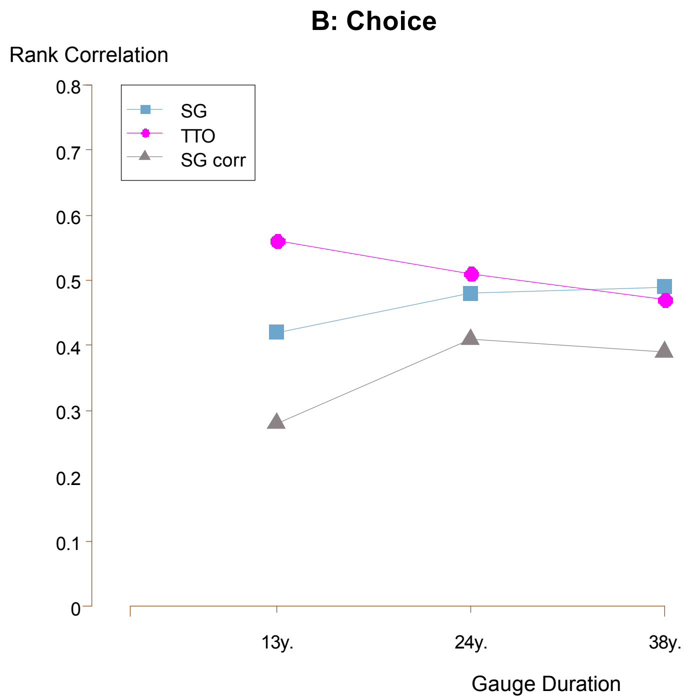
Risk


A: Ranking
Rank Correlation
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
SG
TTO
SG corr
13y.
24y.
38y.
Gauge Duration


B: Choice
Rank Correlation
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
SG
TTO
SG corr
13y.
24y.
38y.
Gauge Duration

Time


A: Ranking
Rank Correlation
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
SG
TTO
SG corr
13y.
24y.
38y.
Gauge Duration


B: Choice
Rank Correlation
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
SG
TTO
SG corr
13y.
24y.
38y.
Gauge Duration

Conclusions

- Prospect theory does better than EU
- Utility context-dependent
- Don’t use SG or algorithms based on it

Part 3

Using behavioral biases to improve applications

Biases in health utility measurement

Ambiguity in treatment choice

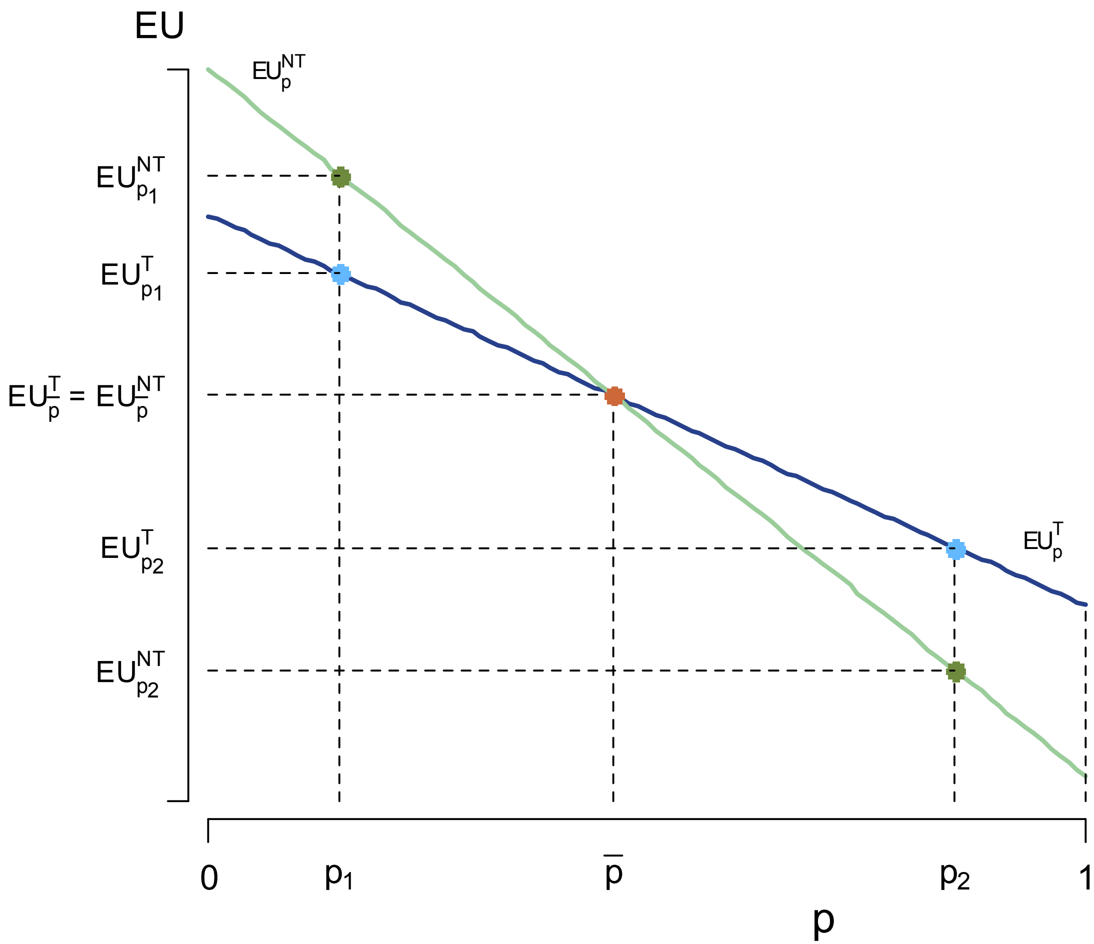
Pauker and Kassirer (1975)

- Diagnostic risk:
  - Patient is sick (s) or healthy (h)
  - Probability of being sick: p
  - Choice between treatment and no treatment
  - $$H_h^{NT} > H_h^{T} > H_s^{T} > H_s^{NT}$$
  - Extension: probability of illness ambiguous
    - $p_1 < p_2$
    - μ subjective belief that p_1 is true probability of illness

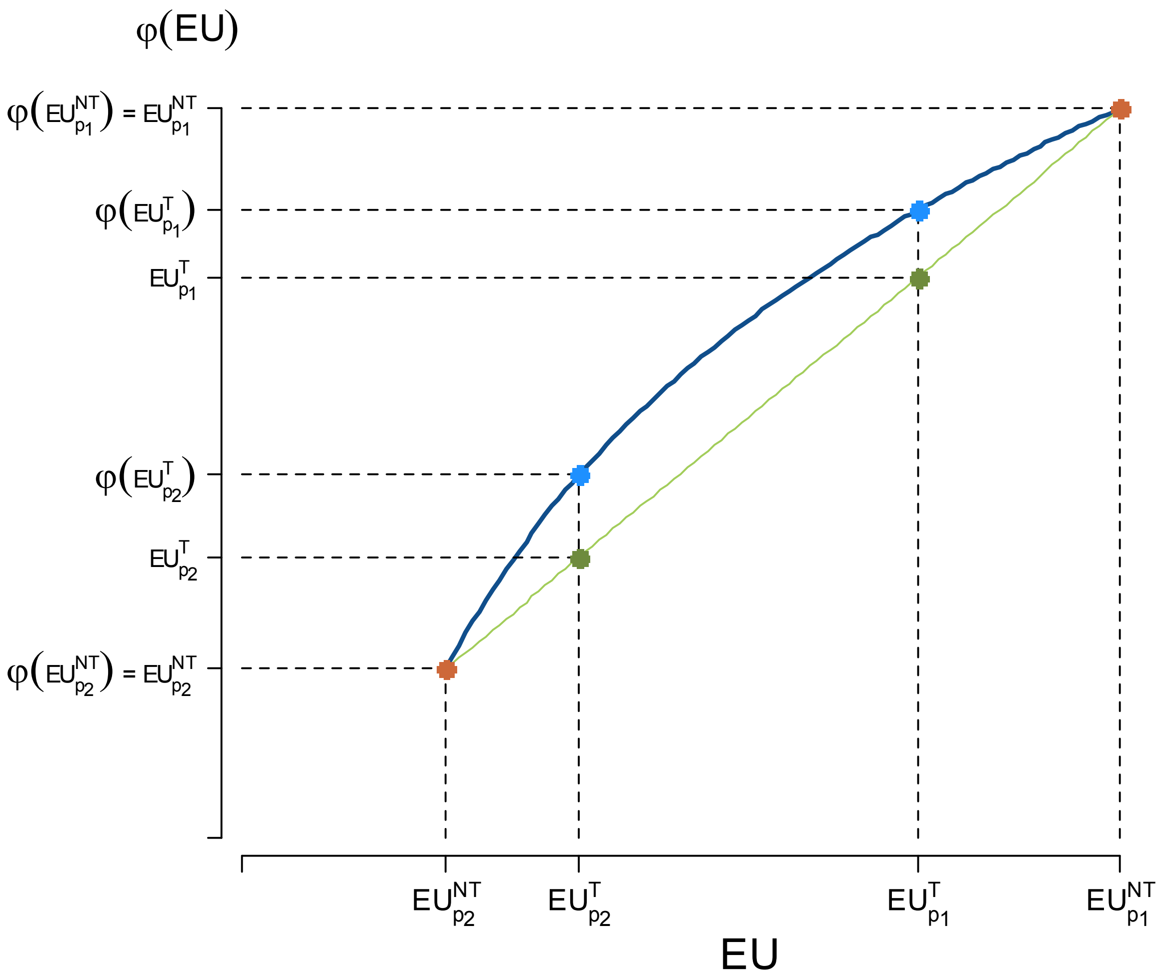
Smooth ambiguity model

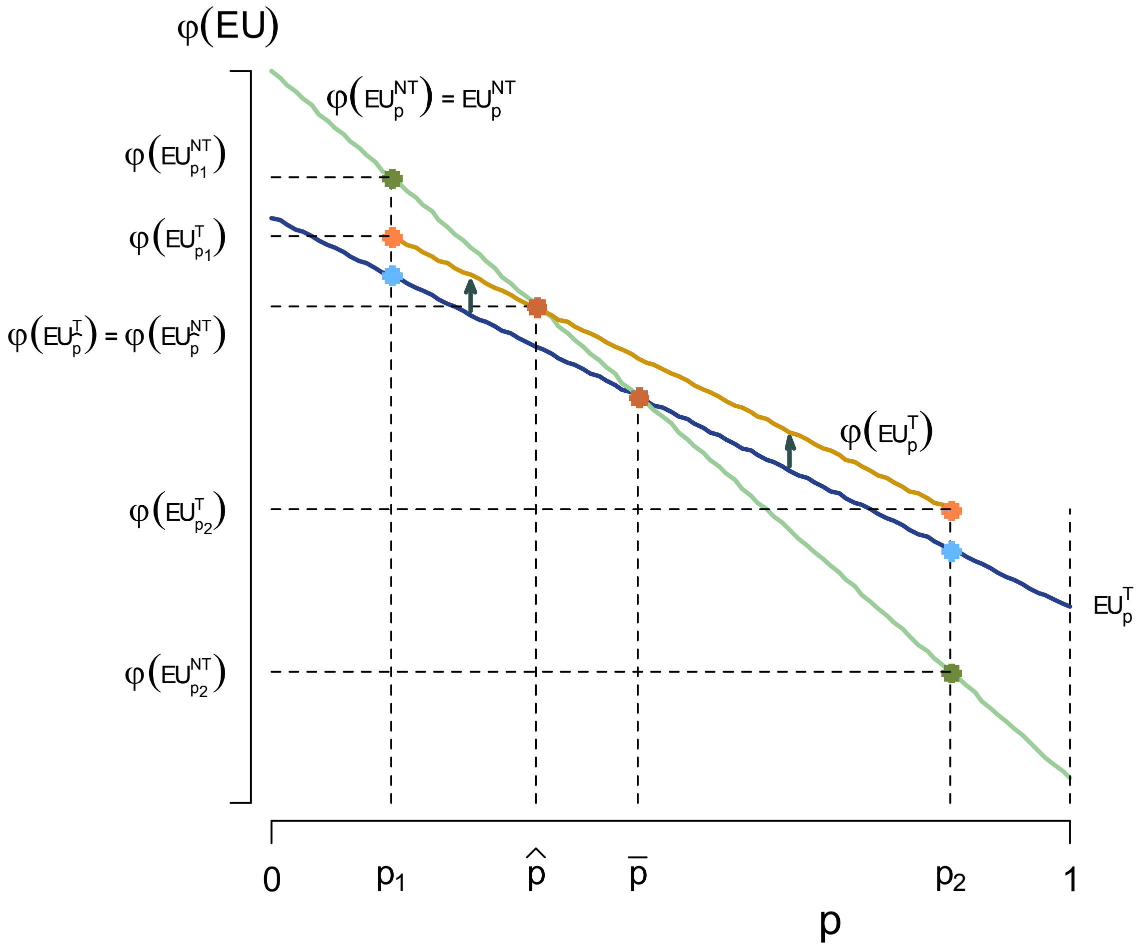
- $V^{T} = \mu\varphi\left(p_1 U(H_s^T) + (1-p_1)U(H_h^T)\right) + (1-\mu)\varphi\left(p_2 U(H_s^T) + (1-p_2)U(H_h^T)\right)$

- $V^{NT} = \mu\varphi\left(p_1 U(H_s^{NT}) + (1-p_1)U(H_h^{NT})\right) + (1-\mu)\varphi\left(p_2 U(H_s^{NT}) + (1-p_2)U(H_h^{NT})\right)$



EU
EU_p^NT
EU_p1^NT
EU_p1^T
EU_p̄^T = EU_p̄^NT
EU_p2^T
EU_p2^NT
EU_p^T
0
p1
p̄
p2
1
p


φ(EU)
φ(EU_p1^NT) = EU_p1^NT
φ(EU_p1^T)
EU_p1^T
φ(EU_p2^T)
EU_p2^T
φ(EU_p2^NT) = EU_p2^NT
EU_p2^NT
EU_p2^T
EU_p1^T
EU_p1^NT
EU

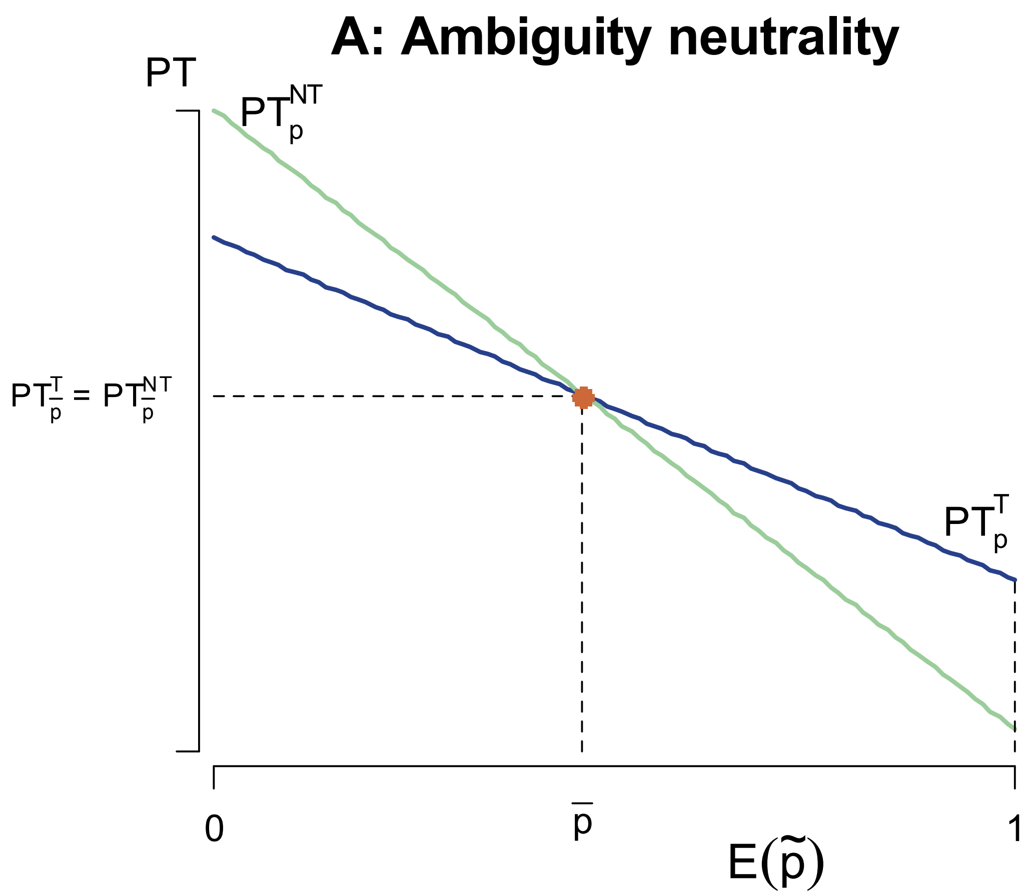


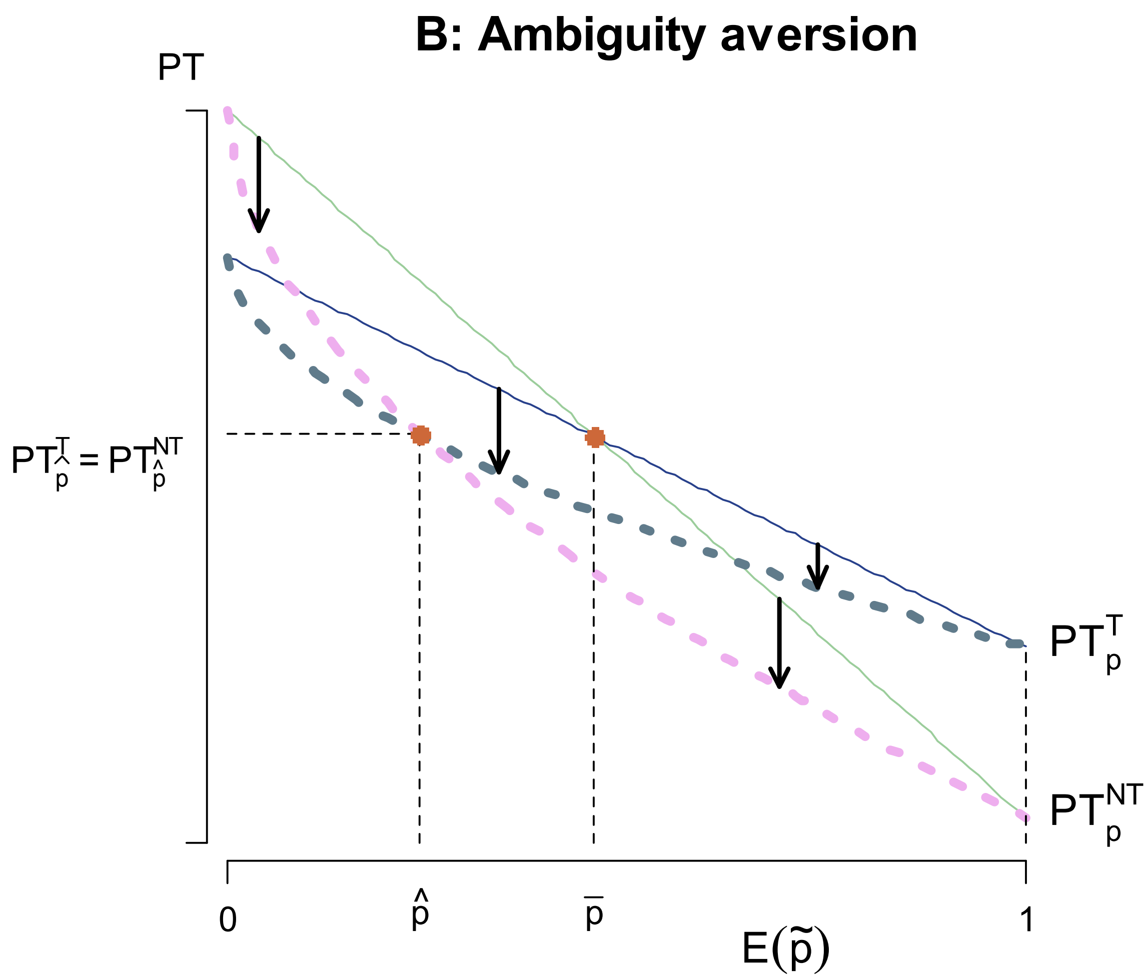
φ(EU)
φ(EU_p^NT) = EU_p^NT
φ(EU_p1^NT)
φ(EU_p1^T)
φ(EU_p̂^T) = φ(EU_p̂^NT)
φ(EU_p^T)
φ(EU_p2^T)
EU_p^T
φ(EU_p2^NT)
0
p1
p̂
p̄
p2
1
p

Result

- In the case of diagnostic ambiguity, ambiguity aversion leads to more treatment choice

Prospect theory

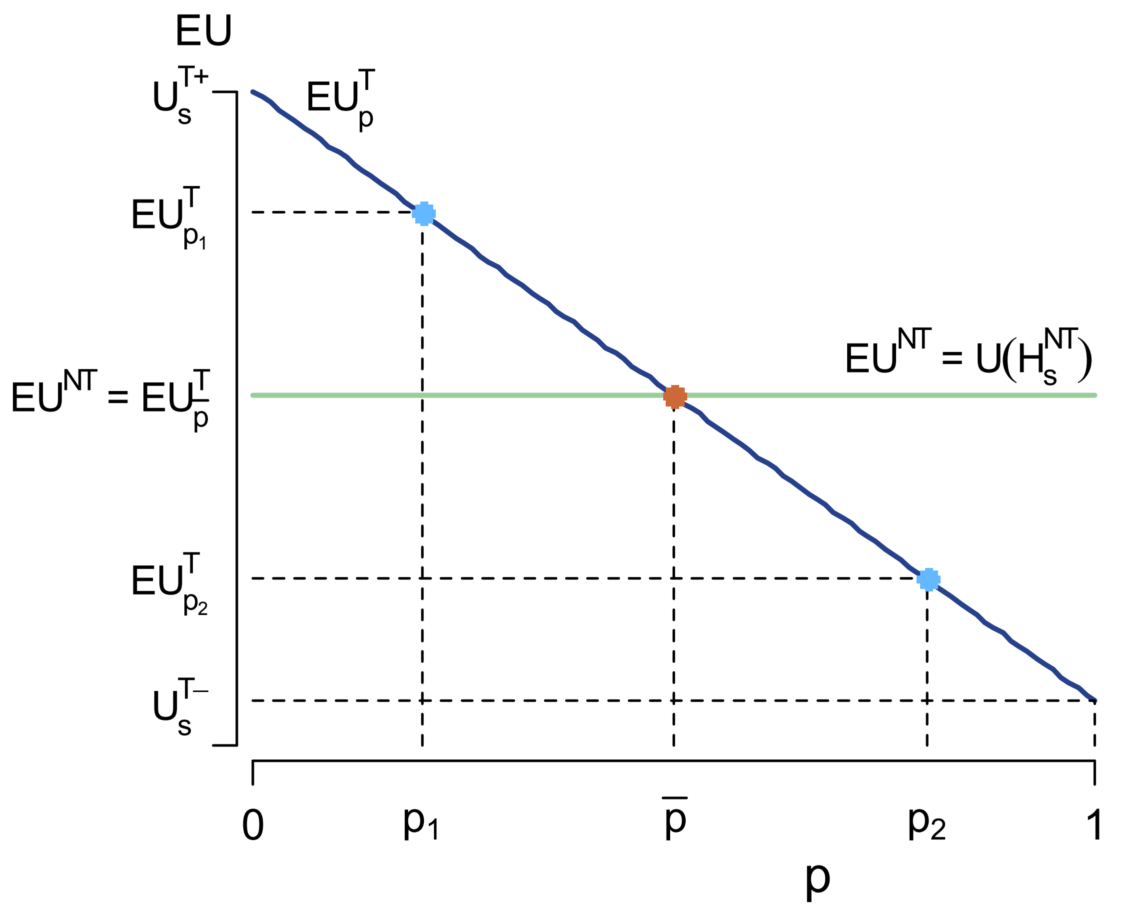



B: Ambiguity aversion
PT
PT^T_p̂ = PT^NT_p̂
PT^T_p
PT^NT_p
0
p̂
p̄
1
E(p̃)

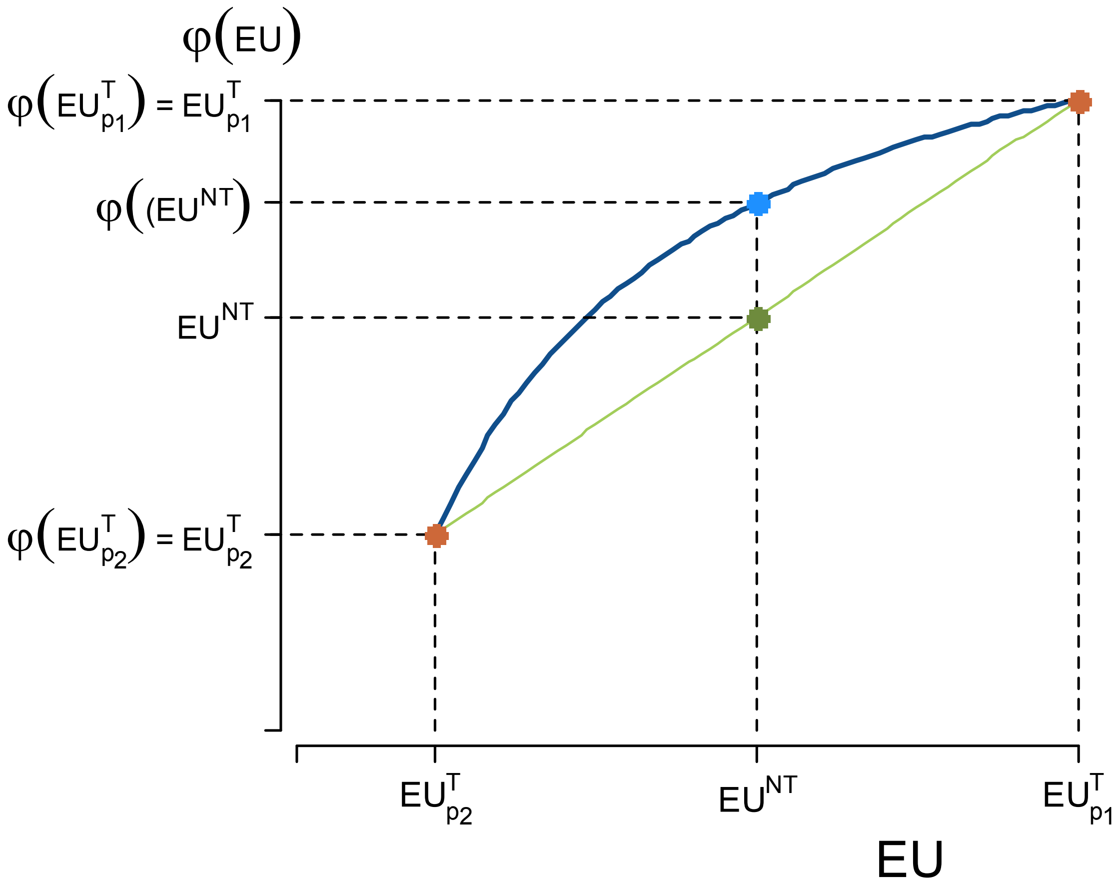
Therapeutic ambiguity

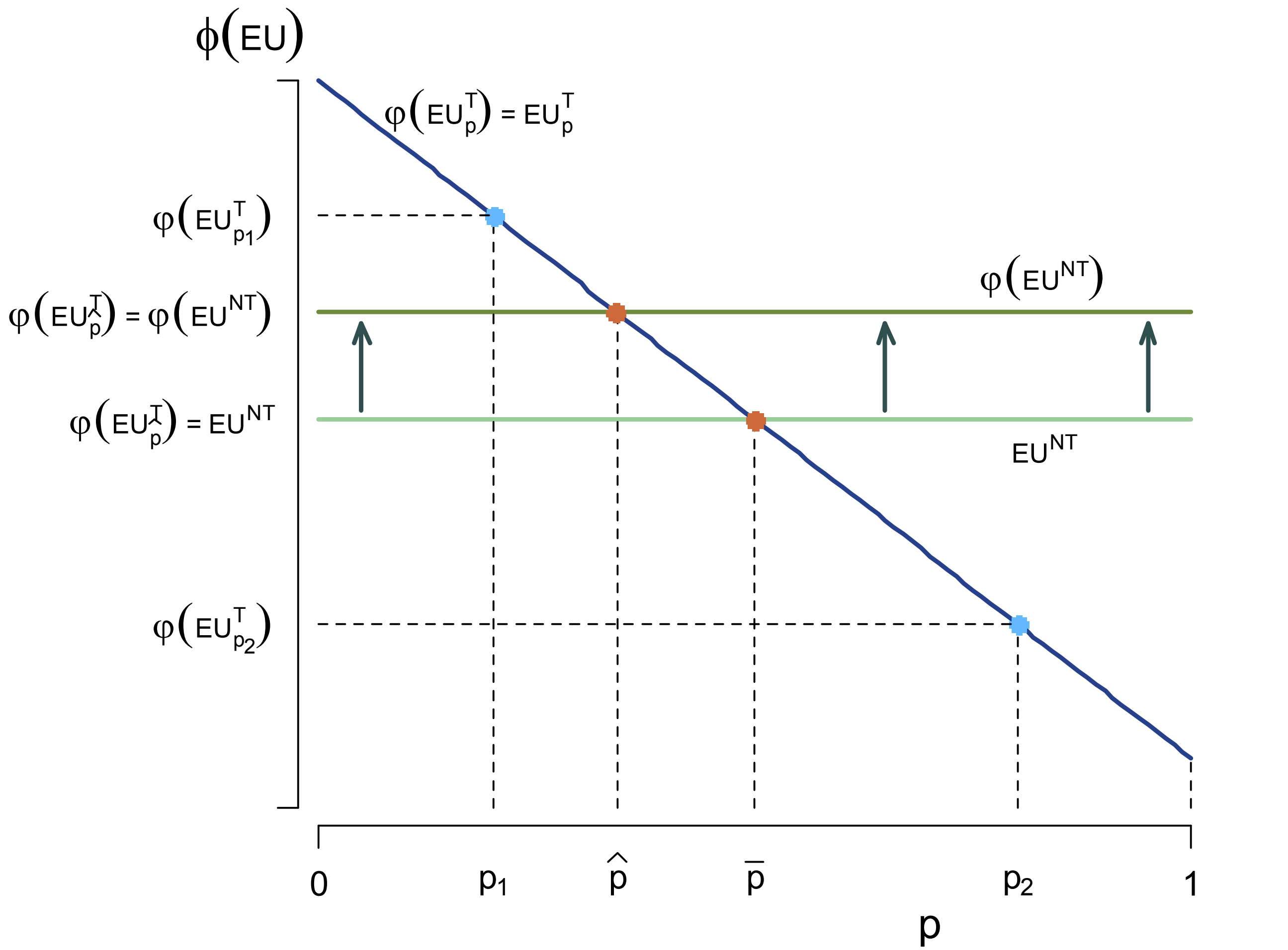
- Effects of treatment are unknown
- p: probability of treatment failure
- Choice between treatment and no treatment
- $H_s^{T^+} > H_s^{NT} > H_s^{T^-}$

- Extension: probability of treatment failure is ambiguous
  - $p_1 < p_2$
  - μ subjective belief that p_1 is true probability of illness



EU
U_s^{T+}
EU_p^T
$EU_{p_1}^T$
$EU^{NT} = U(H_s^{NT})$
$EU^{NT} = EU_{\bar{p}}^T$
$EU_{p_2}^T$
U_s^{T-}
0
p_1
$\bar{p}$
p_2
1
p

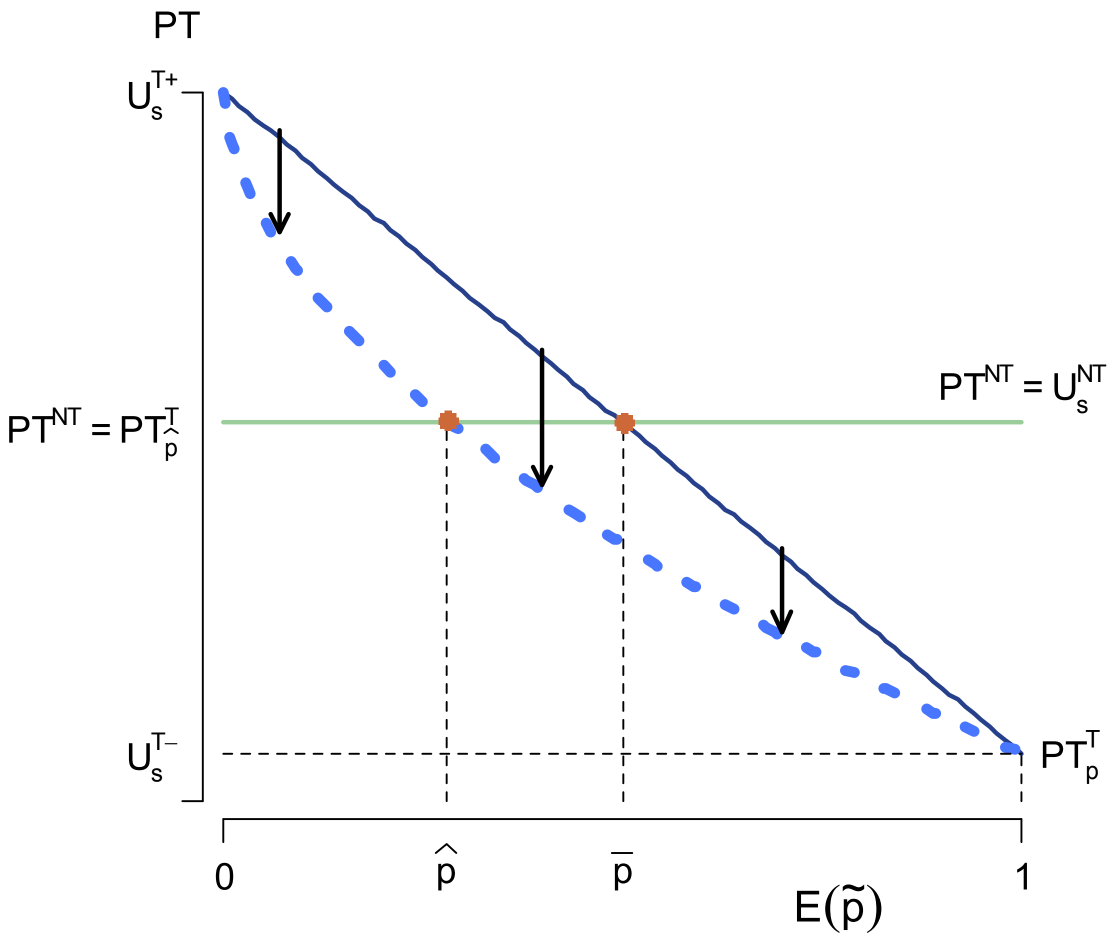

φ(EU)
φ(EU$_{p1}^{T}$) = EU$_{p1}^{T}$
φ((EU^{NT})
EU^{NT}
φ(EU$_{p2}^{T}$) = EU$_{p2}^{T}$
EU$_{p2}^{T}$
EU^{NT}
EU$_{p1}^{T}$
EU



φ(EU)
φ(EU_p^T) = EU_p^T
φ(EU_p1^T)
φ(EU_p̂^T) = φ(EU^NT)
φ(EU_p̄^T) = EU^NT
φ(EU_p2^T)
φ(EU^NT)
EU^NT
0
p1
p̂
p̄
p2
1
p

Result

- In the case of therapeutic ambiguity, ambiguity aversion leads to less treatment choice


PT
U_s^{T+}
$PT^{NT} = U_s^{NT}$
$PT^{NT} = PT^T_{\hat{p}}$
U_s^{T-}
PT^T_p
0
$\hat{p}$
$\bar{p}$
1
$E(\tilde{p})$