Professorship for Economics
TUMCS for Biotechnology and Sustainability & TUM School of Management
Technical University of Munich

Behavioral Economics

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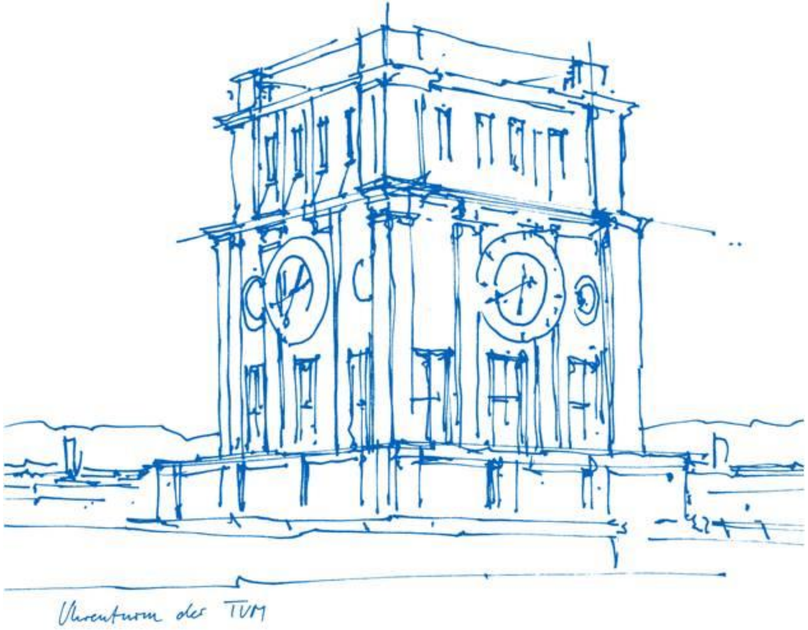

Semester Plan

I. What is Behavioural Economics
II. Principles of Experimental Economics
III. The Standard Economic Model: Consumer Theory
IV. Reference dependence & departures from the standard model
V. Decisions Under Risk and Uncertainty (I)
VI. Decisions Under Risk and Uncertainty (II)
VII. Intertemporal Choice
VIII. Interaction with others: Game Theory
IX. Interaction with others: Social Preferences

Last lecture

V. Decisions Under Risk and Uncertainty (I)

- Preliminaries (notation and how to set up the problem)
- Expected Value Theory and the St. Petersburg Paradox
- Expected Utility Theory: axioms and representation theorem
- Risk aversion and risk premium
- Application: Jen’s stock market decision
- Limitations of Expected Utility Theory

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Today

VI. Decisions Under Risk and Uncertainty (II)

- Prospect Theory and Cumulative Prospect Theory
  - Overview
  - Value function and reference dependence
  - Simple probability weighting
  - Cumulative decision weights
  - Overview and applications
  - Challenges and limitations
  - Beyond Prospect Theory: e.g. Regret Theory

Prospect Theory (Kahneman and Tversky, 1979)

- Introduced 3 psychological principles to the standard model
  - Reference dependence
  - Loss aversion
  - Diminishing sensitivity
- Revolutionised economics and established behavioral economics
- Resulted in a Nobel prize and thousands of citations

Prospect theory: An analysis of decision under risk
D Kahneman, A Tversky - Handbook of the fundamentals of financial …, 2013 - World Scientific
This paper presents a critique of expected utility **theory** as a descriptive model of decision making under risk, and develops an alternative model, called **prospect theory**. Choices among risky prospects exhibit several pervasive effects that are inconsistent with the basic …
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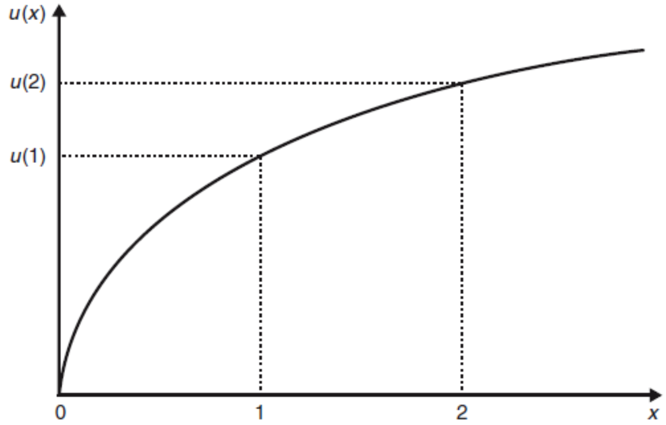
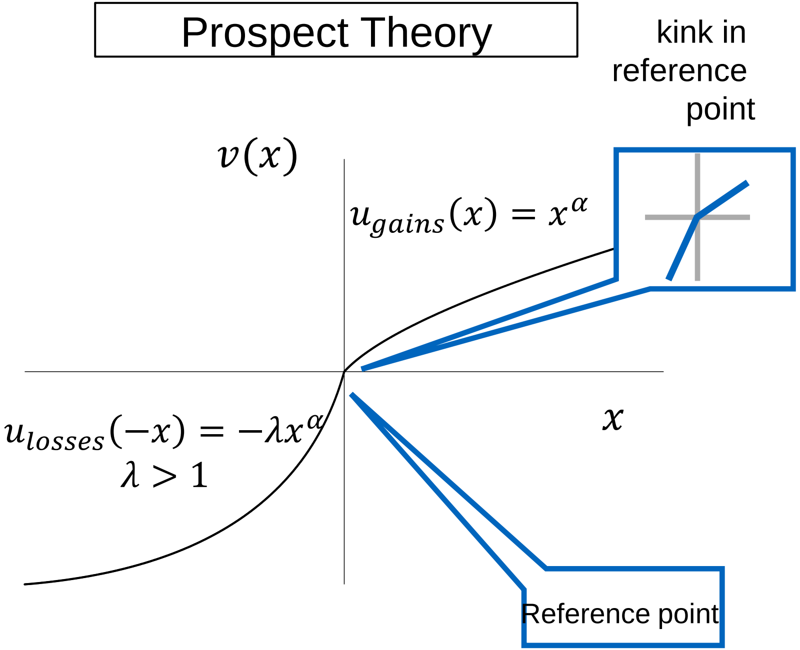
Prospect Theory: reference dependent utility

Standard model

e.g. $u(x) = x^{\alpha}, 0 < \alpha < 1$

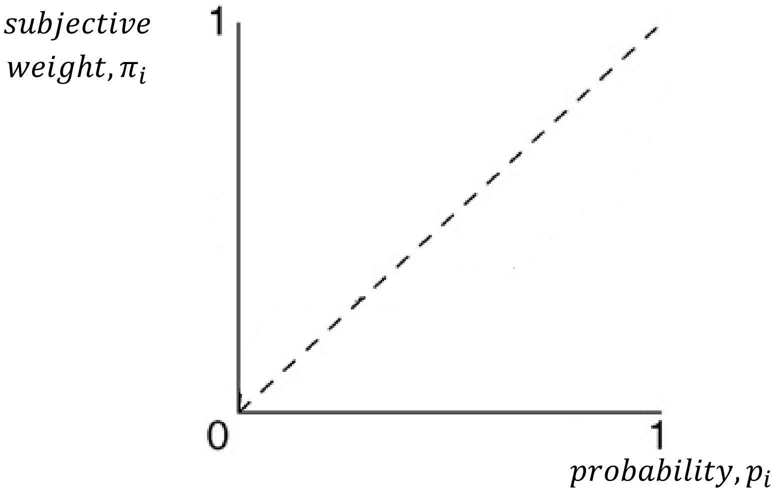


Prospect Theory

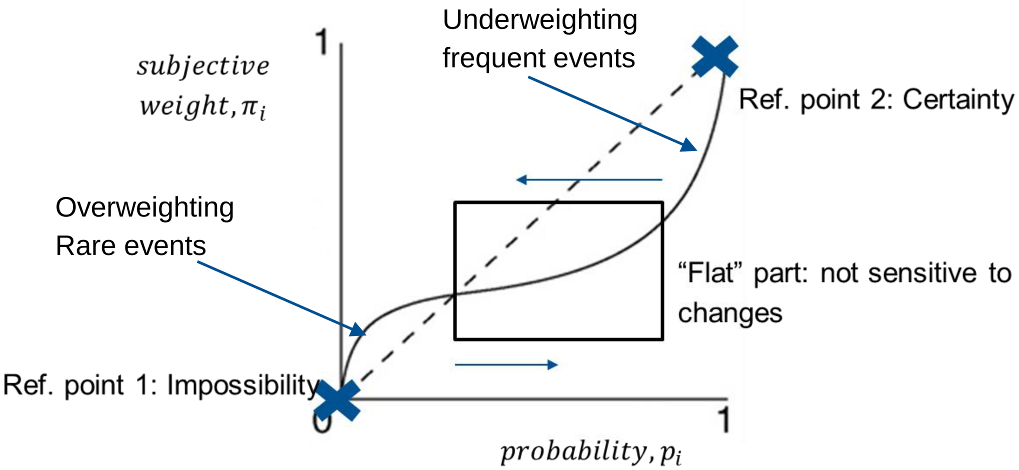


Prospect Theory: probability weighting

Standard model



Prospect Theory



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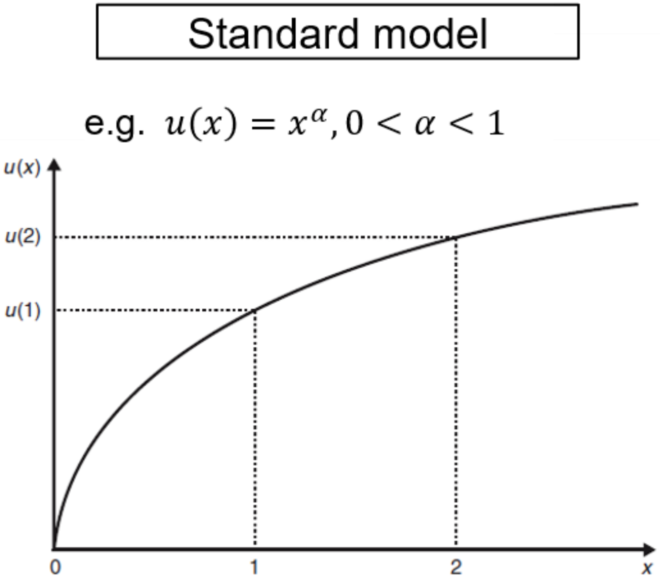
Value function overview

- Prospect Theory's value function uses 3 psychological concepts:
  - **Reference dependence**: preference are defined on a reference point as well as on consequences. Unlike Expected Utility Theory, total wealth is not important – only changes to wealth given a reference point.
  - **Diminishing sensitivity**: The impact of increasing a gain or loss by some amount gets smaller with the size of that gain or loss. For example, the impact of increasing a gain from $0 to $1 is larger than the impact of increasing a gain from $1000000 to $1000001
  - **Loss aversion**: losses loom larger than gains.

- Unlike the probability weighting function, the value function is common between first generation (Prospect Theory) and second generation (Cumulative Prospect Theory)

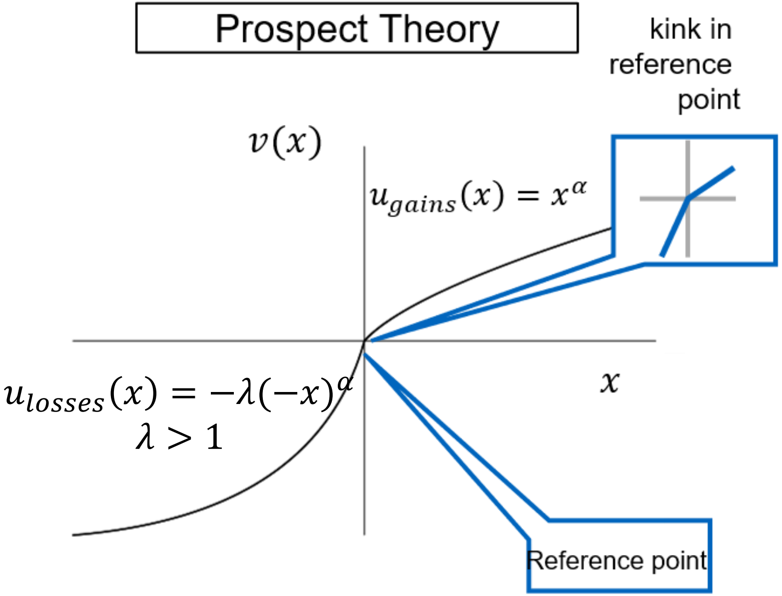
Value function under Expected Utility



$$EU(L) = \sum_i p_i u(x_i)$$

- No reference point – all that matters is the shape (concavity) of the function.
- If u() is concave -> 0<α<1 -> risk averse (like in the picture)
- If u() is convex -> α>1 -> risk seeking
- If u() is linear -> α=1 -> risk neutral (special case of EUT)

Value function: functional form



$$\boldsymbol{PT}: \; V(L) = \sum_i \pi_i v(x_i)$$
$$= \Sigma_{Gains} \pi_i u_G(x_i) + \Sigma_{Losses} \pi_i u_L(x_i)$$

- $v(x_i)$ differs from $u(x_i)$ in that losses are treated differently than gains (x_i) - reference dependence. And specifically, “losses loom larger than gains” – loss aversion.
  - How much larger? λ times larger (usually $\lambda = 2.25$)

Endowment effect under reference dependence

- Suppose your utility function over mugs is given by

$$v(x) = \begin{cases} u_G = x/2, & x \geq 0 \\ u_L = -2.25(-x), & x < 0 \end{cases}$$

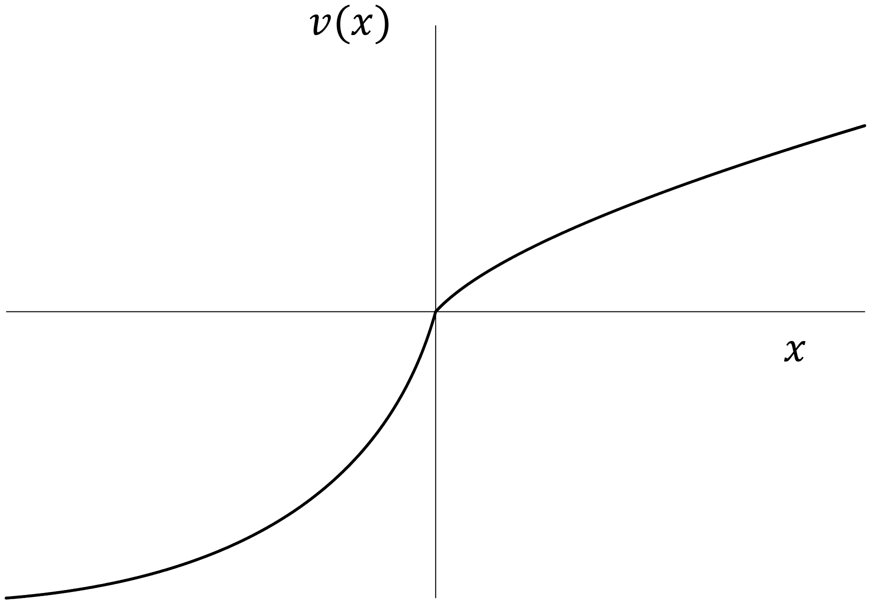
- The amount of utility of receiving one mug from 0 mugs is:

$$u_G(1) = \frac{1}{2} = 0.5$$

- The amount of utility lost from giving away that first mug is:

$$u_L(1) = -2.25 = -2.25$$

- Willingness To Accept: money corresponding to offsetting the disutility of losing one mug.
- Willingness To Pay: money corresponding to the positive utility of obtaining one mug.
- Disutility of losing one mug looms larger than the utility of obtaining one mug
- This would be in accord with empirical evidence that WTA>WTP and can explain the endowment effect



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Allais' paradox through EUT

- Choice scenario 1: A=(2500, 0.33; 2400, 0.66; 0, 0.01) or **B=(2400,1)**
- Choice scenario 2: **C=(2500, 0.33; 0)** or D=(2400, 0.34; 0)

- Preferring Prospect B over Prospect A implies that $EU(B) > EU(A) \Rightarrow$

$$u(2400) > 0.33u(2500) + 0.66u(2400) + 0.01u(0) \Rightarrow$$
$$0.34u(2400) > 0.33u(2500) \qquad (I)$$

- Preferring Prospect C over Prospect D implies that $EU(C) > EU(C) \Rightarrow$

$$0.33u(2500) > 0.34u(2400) \qquad (II)$$

Clearly, I and II cannot be true at the same time.

Allais' paradox through Prospect Theory

Preferring Prospect B=(2,400, p=1) over Prospect A=(2,400,p=0.66; 2,500,p=0.33;0,p=0.01) implies that:

$$v(2400) > \pi(0.66)v(2400) + \pi(0.33)v(2500) + 0 \Rightarrow$$

$$[1 - \pi(0.66)]v(2400) > \pi(0.33)v(2500) \qquad I$$

Preferring Prospect C=(2,500, p=0.33; 0, p=0.67) over Prospect D=(2,400,p=0.34; 0,p=0.66) implies that:

$$\pi(0.33)v(2500) > \pi(0.34)v(2400) \qquad II$$

Taking I and II together we get that:

$$1 - \pi(0.66) > \pi(0.34) \Rightarrow \pi(0.66) + \pi(0.34) < 1$$

Allais paradox through Prospect Theory

$$\pi(p) + \pi(1 - p) < 1$$

- Unlike probabilities, probability weights do not (necessarily) add up to 1.
- The fact that probability weights of complementary events add up to less than one, is referred to as ***sub-certainty***.
- Subcertainty captures an essential element of people's attitudes to uncertain events, namely that the sum of the weights associated with complementary events is typically less than the weight associated with the certain event.

Preference for lotteries and insurance

Choice scenario III: **E=(5000,0.001;0)** or F=(5,1)
Choice scenario IV: G=(-5000, 0.001;0) or **H(-5,1)**

From *(I)*=> $\pi(0.001)v(5000) > v(5) \Rightarrow \pi(0.001) > \frac{v(5)}{v(5000)}$ assuming that v is concave (for gains) this implies that $\pi(0.001) > 0.001$ so $\pi(p) > p$, for small p.

$$e.g. u_G = x^{0.5} \Rightarrow \pi(0.001) > \frac{2.235}{70.710} = 0.031 > 0.001$$

The readiness to pay for insurance in *(IV)* implies the same conclusion, assuming the value function for losses is convex. Specifically: $v(-5) > \pi(0.001)v(-5000)$

$e.g. u_L = -\lambda(-x)^{0.5} \Rightarrow -\lambda 5^{0.5} > \pi(0.001)(-\lambda)5000^{0.5} \Rightarrow ..\text{dividing both sides with "-λ"}\ changes\ the\ inequality \Rightarrow$

$$\pi(0.001) > \frac{5^{0.5}}{5000^{0.5}} = \frac{2.235}{70.710} = 0.031 > 0.001$$

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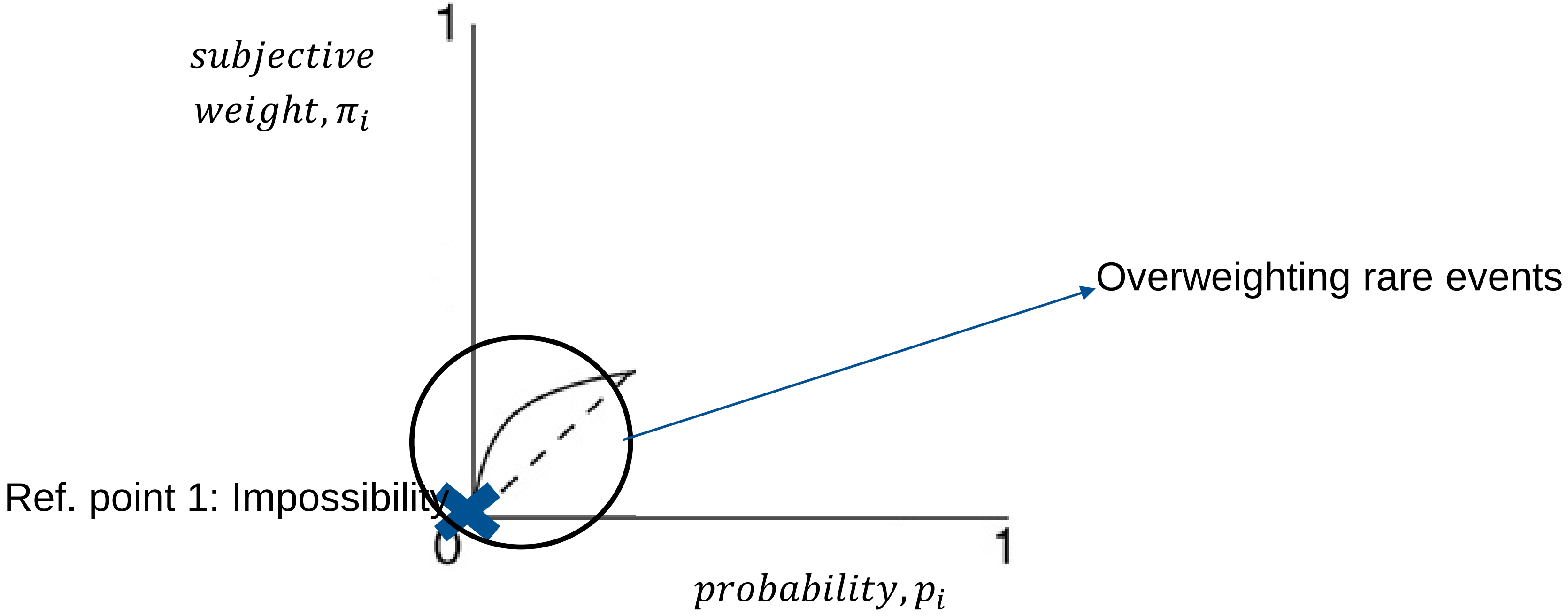
Probability weighting: reference points + dim. sensitivity



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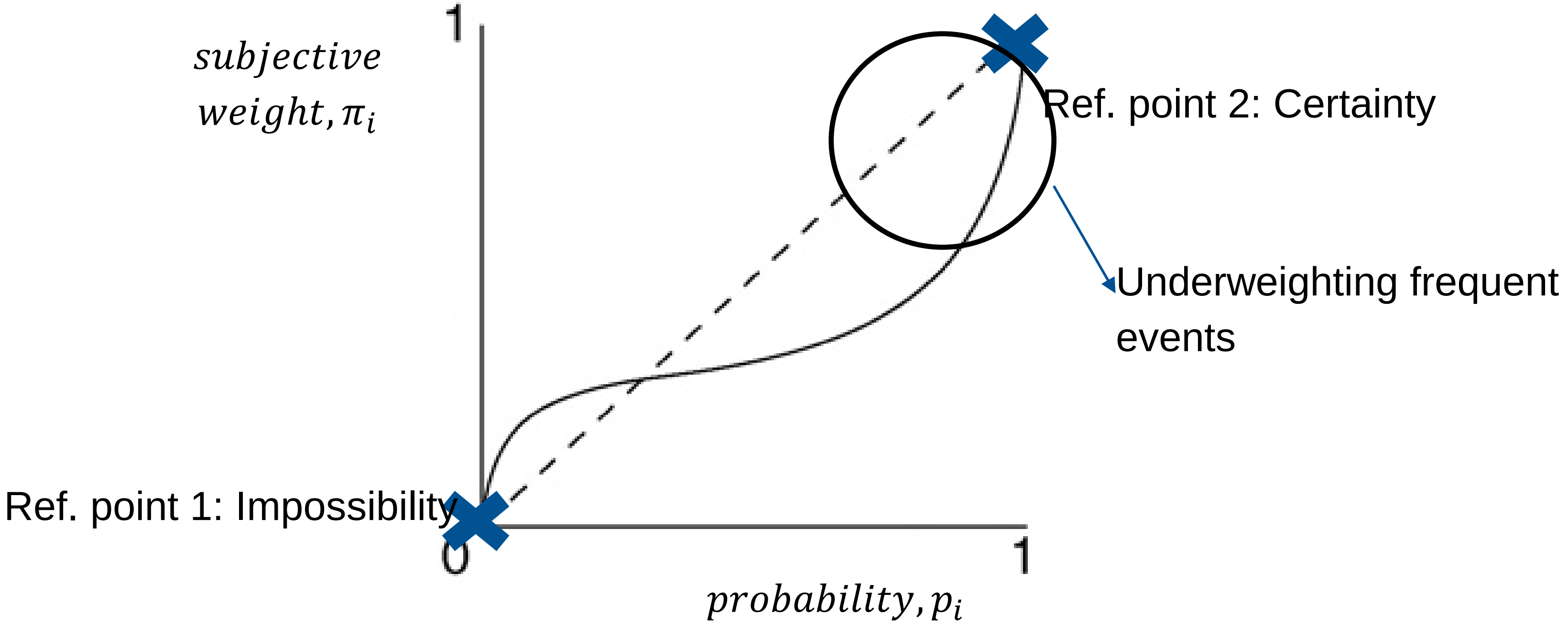
Taken together

- Subcertainty: $\pi(p) + \pi(1-p) < 1$
- Overweighting small probabilities: $\pi(p) > p,$ for p close to 0 (e.g. $p<0.25$).
- Combining the two implies that $\pi(p) < p,$ for p close to 1: underweighting large probabilities (e.g. $p>0.75$)
  - Why? Consider the alternative, for which $\pi(p) > p$, for p close to 1 too. Then

$$\pi(p) + \pi(1-p) > p + 1 - p = 1$$

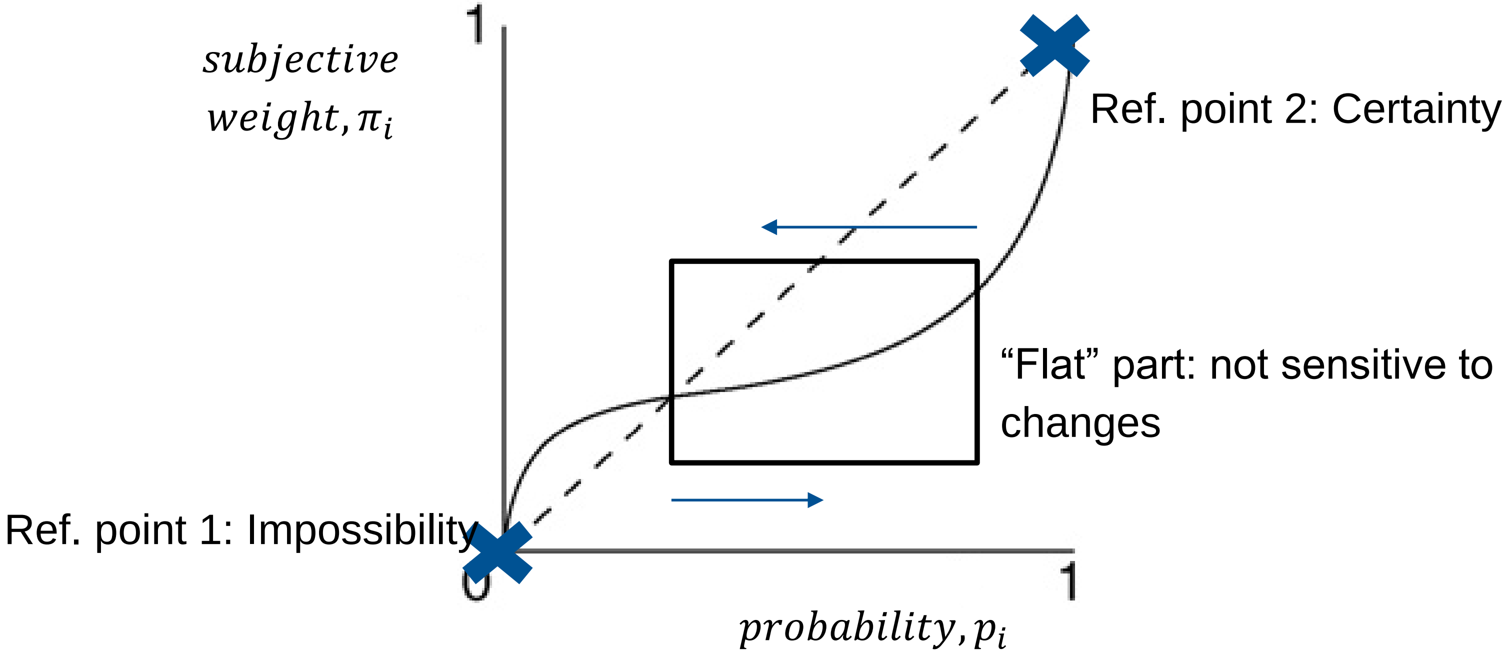
Probability weighting: reference points + dim. sensitivity



Taken together

- Subcertainty: $\pi(p) + \pi(1 - p) < 1$
- Overweighting small probabilities: $\pi(p) > p,$ for p close to 0 (e.g. p<0.25).
- Combining the two implies that $\pi(p) < p,$ for p close to 1: underweighting large probabilities (e.g. p>0.75)
- Note: overweighting small probabilities and underweighting large probabilities implies limited sensitivity to mid-range probabilities (e.g. $0.25 \leq p \leq 0.75$).

Probability weighting: reference points + dim. sensitivity



A drawback of simple probability weighting

- Consider a choice between: $A: (\$20{,}0.5; \$10{,}0.5)\ or\ B: (\$10{,}0.99; \$0{,}0.01)$
- Notice that A (first order stochastically) dominates B. That is, for every outcome x, A gives at least as high a probability of receiving at least x as does B, and for some x, A gives a higher probability of receiving at least x.
- Let:
  - u(20) = 2; u(10) = 1; u(0) = 0
  - $\pi(0.5)$ = 0.25 and $\pi(0.99)$= 0.95.
- Then, if $\mathrm{V}(L) = \sum_i \pi(p_i)\, u(x_i)$, we have $\mathrm{V(A)} = 0.75 < 0.95 = \mathrm{V(B)}$
- So: Simple probability-weighting of this form permits choice of a dominated gamble.
- To avoid this, 1st generation prospect theory postulated an editing phase.
- As the editing phase restricts mathematical tractability, a second generation of PT was developed

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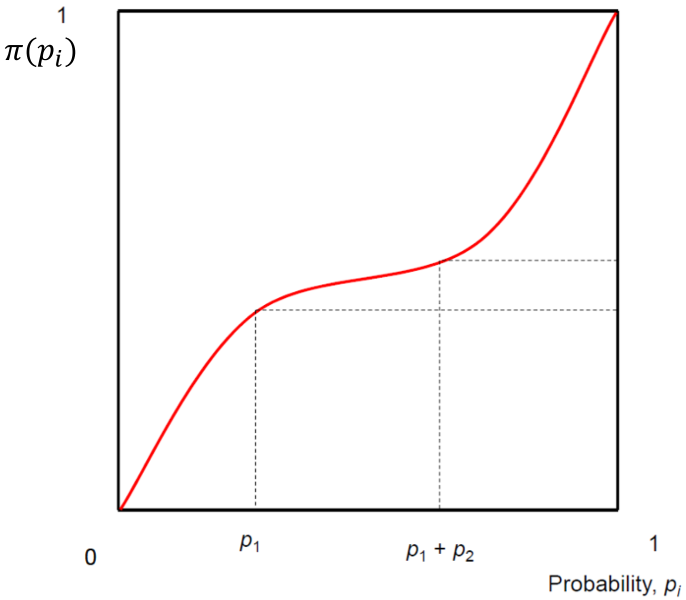
Cumulative Prospect Theory

- Second generation of Prospect Theory: Cumulative Prospect Theory (1992; Tversky & Kahneman)
- Borrows an idea from Rank Dependent Utility theories (see Quiggin, 1982).

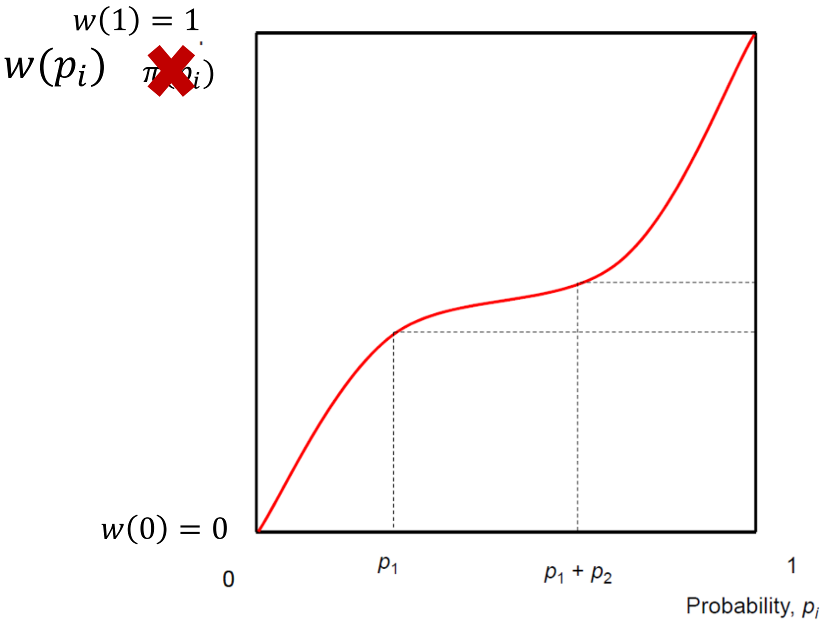
$$V(L) = \sum_i \pi_i v(x_i)$$

- The function form resembles that of original PT but π_i are now modified:
- π_i: are decision weights. They are no longer a simple transformation of p. Instead, they depend on the **position** of x_i in the ordering of outcomes as well as on probabilities.
- $w(p)$: probability weighting function. It replaces the role of $\pi(.)$ in first generation PT.

From probability weights ($w(p_i)$) to decision weights π_i



From probability weights ($w(p_i)$) to decision weights π_i



Probability transformation takes place in two steps now.

1. First through a probability weighting function and then
2. through a cumulative decision weight rule.

Under Cumulative Prospect Theory: probability weights and decision weights are two different things.

From probability weights $w(p_i)$ to decision weights π_i

- Let's consider $L = (x_1, p_1; x_2, p_2; x_3, p_3)$
- Let $\pi_i = w(pr.\, outcome\ is\ at\ least\ as\ good\ as\ x_i) - w(pr.\, outcome\ is\ strictly\ better\ than\ x_i)$
- Example: $X = \{x_1, x_2, x_3\}, with\ x_1 \succ x_2 \succ x_3$. Then the decision weights are:

$$\pi_1 = w(p_1) - w(0) = w(p_1)$$

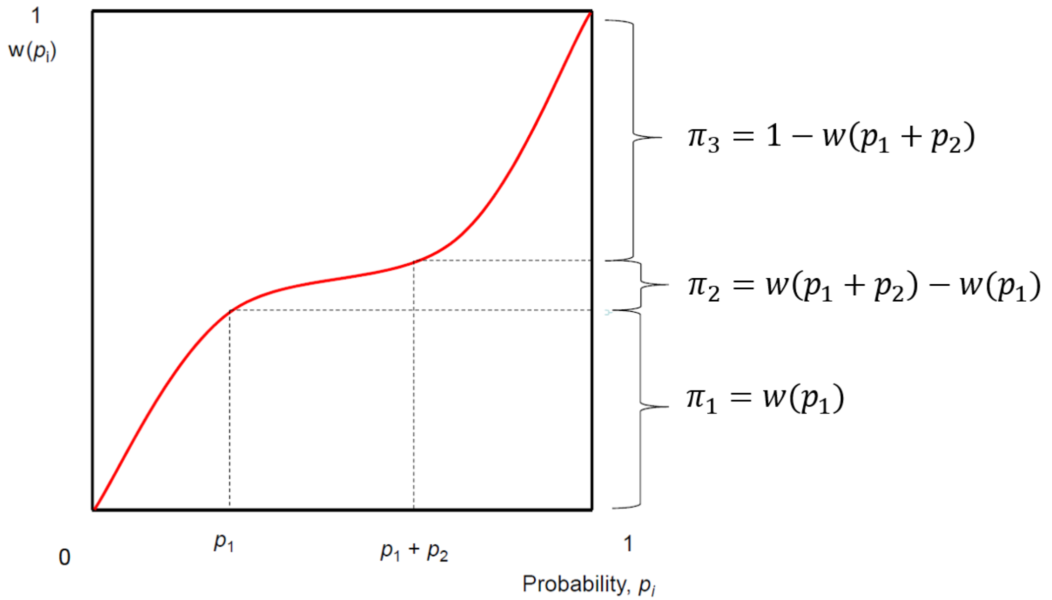
$$\pi_2 = w(p_1 + p_2) - w(p_1)$$

$$\pi_3 = w(p_1 + p_2 + p3) - w(p_1 + p_2) = w(1) - w(p_1 + p_2) = 1 - w(p_1 + p_2)$$

- Note: $\pi_1 + \pi_2 + \pi_3 = 1$

- Decision weights add to 1 (but probability weights not necessarily)

From probability weights ($w(p_i)$) to decision weights π_i



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Intuition

- $V(L) = w(p_1)v(x_1) + \big(w(p_1 + p2) - w(p_1)\big)v(x_2) + (1 - w(p_1 + p_2)v(x_3) \Rightarrow$
  $\Rightarrow v(x_3) + \big(v(x_2) - v(x_3)\big)w(p_1 + p_2) + \big(v(x_1) - v(x_2)\big)w(p_1)$
- Interpretation: $V(L)$ has three components:
  - Utility of getting at least x_3 is guaranteed
  - Extra utility of getting from x_3 to x_2 has “weight” given by the probability of the outcomes at least as good as x_2
  - Extra utility of getting from x_2 to x_1 has “weight” given by the probability of the outcome at least as good as x_1
- On this interpretation, cumulative (rank-dependent) weighting of utility levels is like simple probability weighting, but applied to utility increments instead of levels.

Dominance no longer violated

- Consider a choice between: $A: (\$20{,}0.5; \$10{,}0.5)\ or\ B: (\$10{,}0.99; \$0{,}0.01)$
- Lottery A first order stochastically dominates B.
- Under PT, we showed that it is possible that B is preferred to A.
- Under CPT, this is no longer possible
- Suppose as before that
  - u(20) = 2; u(10) = 1; u(0) = 0
  - $w(0.5)$ = 0.25 and $w(0.99)$= 0.95
    - Notice that we now use "w" for probability weights and π for decision weights. Under Prospect Theory w and π were the same. Under Cumulative Prospect Theory, they are different
- $V(A) = \pi(0.5)u(20) + \pi(0.5)u(10) = w(0.5)u(20) + [1 - w(0.5)] * u(10) = 1.25$
- $V(B) = \pi(0.99)u(10) + \pi(0.01)u(0) = w(0.99)u(10) + [1 - w(0.99)u(0) = 0.95$
- V(A)>V(B), thus under Cumulative Prospect Theory the dominated option is ***not*** chosen

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Expected Utility Theory vs. Prospect Theory

Expected Utility Theory

- Linear weighting of probabilities
- Risk preferences depend only on the shape of utility over wealth
- People are either always risk averse, always risk seeking or always risk neutral

(Cumulative) Prospect Theory

- Non-linear probability weighting
- Risk preferences depend on utility over wealth AND probability weighting AND reference points AND loss aversion coefficient
- 4-fold pattern:
  - risk seeking for small probability gains
  - risk averse for high probability gains
  - risk averse for small probability losses
  - risk seeking for high probability losses

Overview of probability weighting and applications

- Probability weighting uses psychological principles of: i) reference dependence (certainty and impossibility) and ii) diminishing sensitivity (away from these reference points).
- Prospect Theory: probabilities are not treated linearly (as in EUT).
- Rare events are overweighted – Frequent events are underweighted – Changes in medium probability events are not perceived as much.
- The theory can explain systematic violations of EUT such as the Allais paradox & the simultaneous preference for risky lotteries and risk averse insurance.
- Simple non-linear weighting cannot exclude violations of first order stochastic dominance
- Cumulative decision weights solve this problem

Overview of probability weighting and applications

- It can explain why people buy insurance AND play the lottery
  - Buying insurance is considered to be a risk averse move
  - Playing the lottery is considered risk seeking
  - Standard model: a person is either risk averse or risk seeking, but not both (stable and consistent preferences).
  - Overweighting small probabilities can explain this.

- Probability-weighting also explains why people purchase extended warranties on equipment such as computers, in spite of the fact that they tend not to be a very good deal

Overview of probability weighting and applications

- Overweighting of rare events can account why people fear airplane crashes, terrorist attacks, and many other such extreme but rare events.
    - *Availability bias*: when thinking about the likelihood of an event, people tend to think different scenarios about what might happen. Extreme events (which are typically rare) stimulate more vivid representations and thus seem more likely than they are.

- In many cases, resources are devoted more to very rare and vivid social problems compared to more common problems.

Overview of probability weighting and applications

- Underweighting of high probabilities: people become more conservative than they should when the odds are in their favor.
  - Law: plaintiffs might settle for a lesser amount even though they have a very strong case
  - Medical decision making: people often seek out unnecessary treatments to deal with a medical challenge that has a good prognosis.

Overcoming probability weighting

- Translate abstract probabilities into natural frequencies.
  - Slovic et al., 2000
  - If a certain drug helps avoid serious illness in 20% of the patients, think that 2 out of 10 people avoid serious illness.

- Availability bias: Dampen your internal narrator – think that you are advising a friend.

Loss aversion and framing effects

- Framing effects: Essentially equivalent descriptions of the same facts lead to different choices.

- Loss aversion helps explain why politicians argue about whether cancelling tax cuts amounts to raising taxes. Voters find the foregone gain associated with a cancelled tax cut easier to stomach (gains domain) than they do the loss associated with a tax increase (loss domain).
- Consequently, politicians favoring higher taxes will talk about “cancelled tax cuts” whereas politicians opposing higher taxes will talk about “tax increases.”

Loss aversion and the equity premium puzzle

- Equity premium puzzle: the investor returns on equities (stock) have been on average so much higher than returns on bonds, that it is hard to explain why investors buy bonds, even after allowing for a reasonable amount of risk aversion.
- To quantify the level of risk aversion implied if these figures represented the *expected* outperformance of equities over bonds, investors would prefer a certain payoff of $51,300 to a 50/50 bet paying either $50,000 or $100,000 (Mankiw et al. 1991)

Loss aversion and the equity premium puzzle

	Period 1	Period 2	Period 3	…	Overall
Bond	+0.01	0.02	0	…	+0.1
Stock	+1	-2	+1.8	…	+2

- Myopic loss aversion: Investors are "**loss averse**" and evaluate their portfolios frequently.
  - Benartzi and Thaler, 1995

Loss aversion and status quo bias

- Harvard University Clinic offered in the 80s a new optional health insurance for its employees. Already employed personal had to choose between the new or the old insurance plan. Newly employed personal also had to chose between the two insurance plans. New employees were significantly more likely to pick the new plan, while the other employees remained mostly in the old plan

- Similar effects have been observed for retirement and investment plans

- If current situation (status quo) is perceived as a reference point, then loss aversion would not favor giving it away for something else

- Remember also the experiments with mugs and chocolates from Lecture 4

Overcoming reference dependence

- Shift your reference point: example of checking stock-portfolio infrequently
- Charity giving: What would pay for this if I didn’t have it already? WTP vs WTA. Might make it easier to donate some of your old clothes.
- Create hypothetical alternatives. Should you splurge on family trip. What else could you spend the money? Additional retiring savings, a different vacation?

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Challenge to PT: Description – Experience gap

Decisions from **Description**:

- Numerical statistics about probability and outcomes
- E.g. weather forecast, performance of an asset in the stock market

Decisions from **Experience**:

- Sequential sampling of events – uncertainty regarding
- E.g. should I park my bike in this neighbourhood?

A simple experiment: Description vs. Experience

Description:

Choice 1: A=(20, 0.1; 0) or B=(2, 1)

Would you prefer lottery A that offers 20 euros with probability 10% and 0 otherwise or lottery B that offers 2 euros for sure?

Experience:

A

B

A simple experiment: Description vs. Experience

Description:

Choice 1: A=(20, 0.1; 0) or B=(2, 1)

Would you prefer lottery A that offers 20 euros with probability 10% and 0 otherwise or lottery B that offers 2 euros for sure?

Experience:

Option A	Option B
0	

A simple experiment: Description vs. Experience

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Experience:

Option A	Option B
0	

A simple experiment: Description vs. Experience

Description:

Choice 1: A=(20, 0.1; 0) or B=(2, 1)

Would you prefer lottery A that offers 20 euros with probability 10% and 0 otherwise or lottery B that offers 2 euros for sure?

Experience:

Option A

Option B

2

A simple experiment: Description vs. Experience

Description:

Choice 1: A=(20, 0.1; 0) or B=(2, 1)

Would you prefer lottery A that offers 20 euros with probability 10% and 0 otherwise or lottery B that offers 2 euros for sure?

Experience:

Option A

0

Option B

A simple experiment: Description vs. Experience

Description:

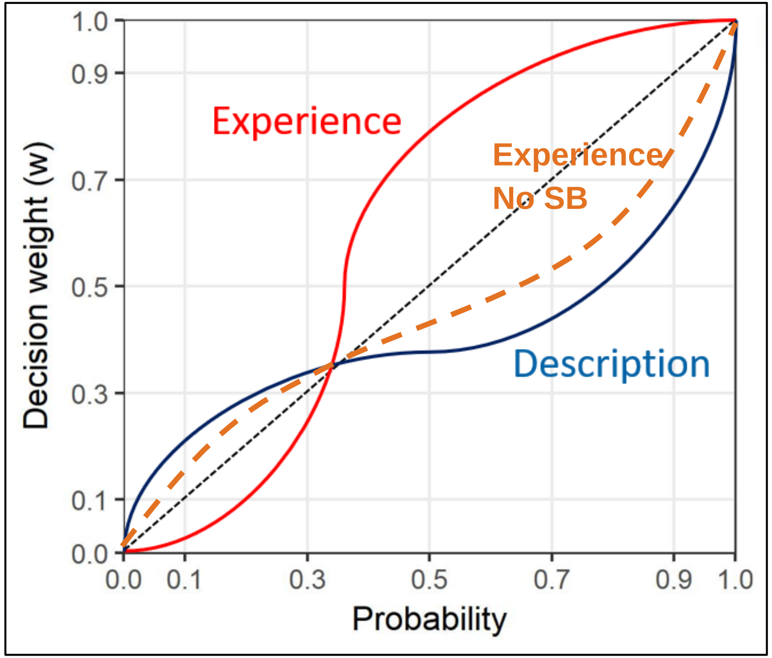
Choice 1: A=(20, 0.1; 0) or B=(2, 1)

Would you prefer lottery A that offers 20 euros with probability 10% and 0 otherwise or lottery B that offers 2 euros for sure?

Experience:

Option A	**Option B**
	2

Challenge to PT: Description – Experience gap



- Description: inverse S-shaped weighting function - > overweighting rare events
- Experience: S-shaped weighting function -> underweighting rare events
  - See Hertwig et al., (2004);

- Experience – Without Sampling Bias: less overweighting
  - See Kopsacheilis (2018); Cubitt, Kopsacheilis & Starmer (2020)

- Problem: the way information is obtained – even when it is mathematical equivalent – influences behaviour.

- Easy (but not ideal) fix: Decision makers have multiple weighting functions. Their shape depend on the context in which the decision takes place.

More problems: preference reversals

Scenario 1:

$-bet: low probability of high outcome. E.g.
How much do you value a bet with a 0.08 chance of winning $100?

CE($-bet)

Scenario 2:

P-bet: High probability of smaller outcome. E.g.
How much do you value a bet with a 0.8 chance of winning $10?

CE(P-bet)

Scenario 3:

Choose: would you prefer a bet with
a 0.08 chance of winning $100 ($-bet)
or one with
a 0.8 chance of winning $10? (P-bet) ?

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Preference reversals

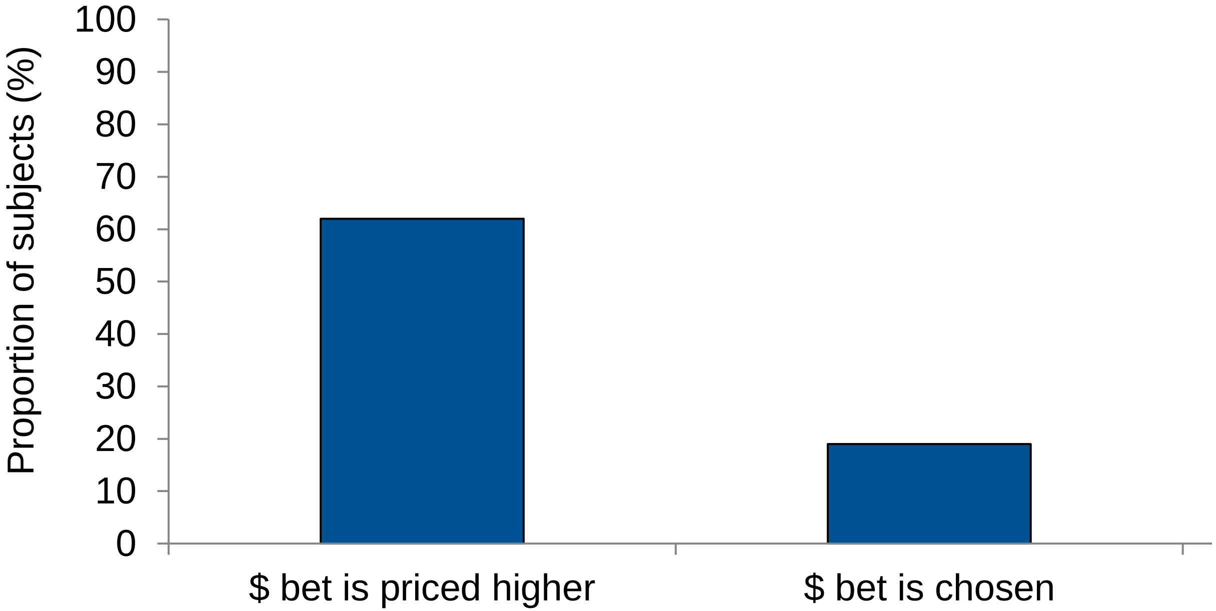
- People typically valuate the $-bet higher than the P-bet: CE($-bet)>CE(P-bet)

but

- Choose the P-bet over the $-bet when asked to choose between the two!
- These type of preferences violate transitivity.
- Assume that CE($-bet)=$8, CE(P-bet)=$6.
- Now, consider choices between a $-bet, a P-bet and a certain amount: C=$7.
- People often state the following cycle:
- Choice 1: $-bet ≻C
- Choice 2: C≻P-bet
- Choice 3: P-bet ≻$-bet
- How often do people exhibit such preferences?

Preference reversals

Tversky, Slovic and Kahneman (1990)



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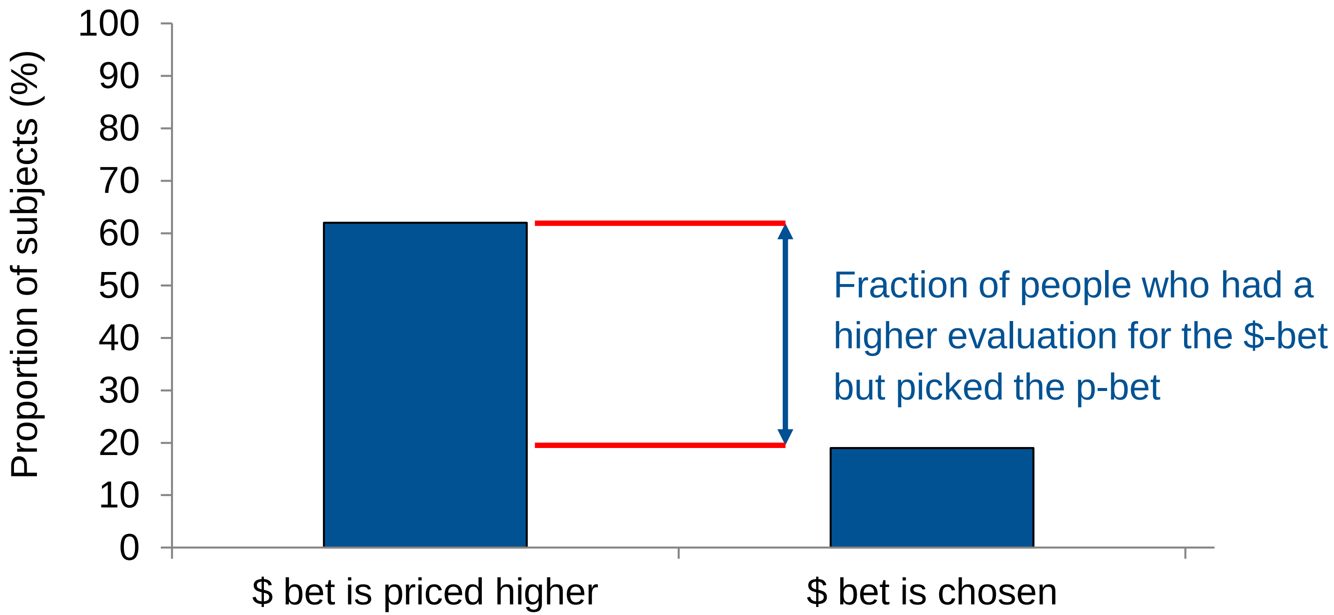
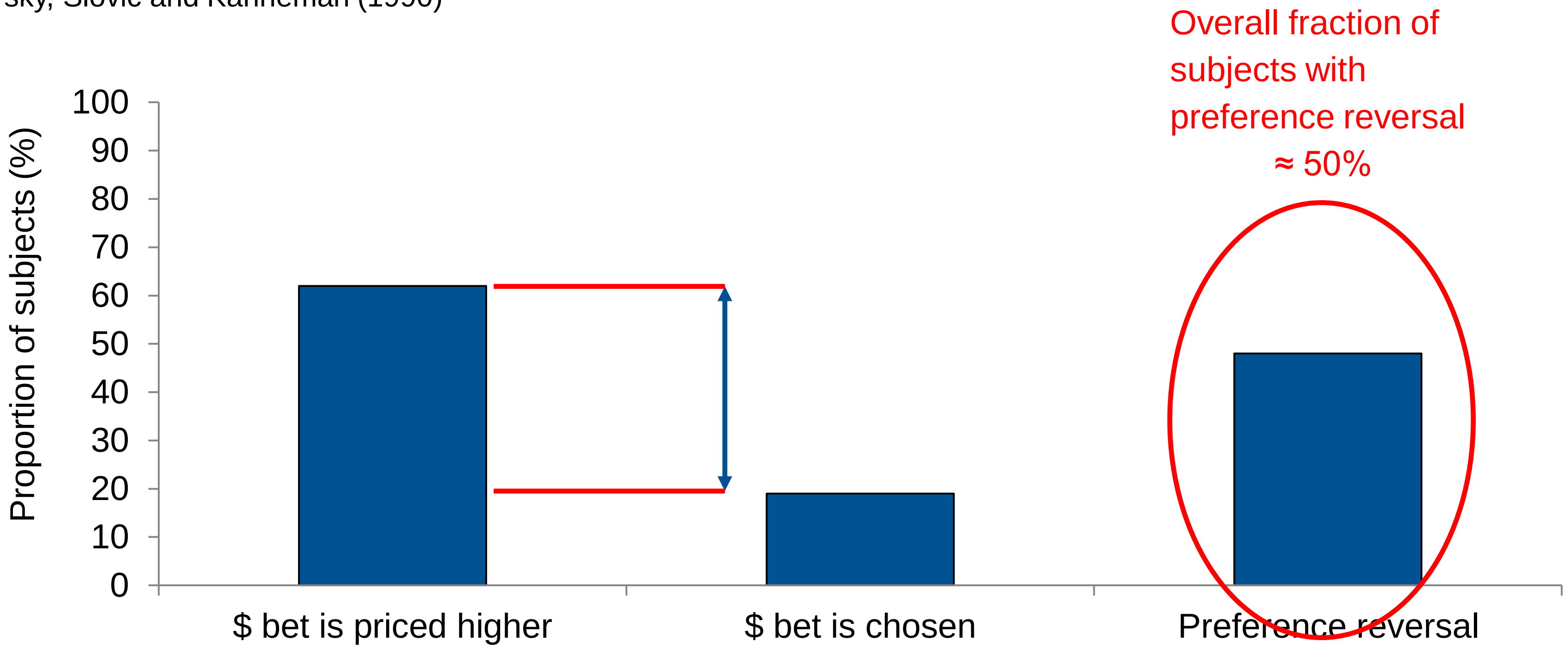
Preference reversals

Tversky, Slovic and Kahneman (1990)



Preference reversals

Tversky, Slovic and Kahneman (1990)



Today

VI. Decisions Under Risk and Uncertainty (II)

- Prospect Theory and Cumulative Prospect Theory
  - Overview
  - Simple probability weighting
  - Cumulative decision weights
  - Value function and reference dependence
  - Overview and applications
  - Challenges and limitations
  - Beyond Prospect Theory: e.g. Regret Theory

Regret Theory

- Neither EUT nor Prospect Theory (or Cumulative Prospect Theory) can explain violations of transitivity.
- We need a different type of model.
- Regret Theory (Loomes and Sugden, 1982; Fishburn, 1982; Bell, 1982):

"For example, compare the sensation of losing $100 as the result of an increase in income tax rates, which you could have done nothing to prevent, with the sensation of losing $100 on a bet on a horse race. <u>Our guess is that most people would find the latter experience more painful, because it would inspire regret</u>."

-Loomes and Sugden, 1982

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Most other models

	s_1	s_2	s_3	EV	EUT	CPT
	1-30	31-60	61-100			
$-bet	$18	$0	$0	$\Sigma_i p_i x_i$	$\Sigma_i p_i u(x_i)$	$\Sigma_i \pi_i v(x_i)$
P-bet	$8	$8	$0	$\Sigma_i p_i y_i$	$\Sigma_i p_i u(y_i)$	$\Sigma_i \pi_i y_i)$
C	$4	$4	$4	$\Sigma_i p_i z_i$	$\Sigma_i p_i u(z_i)$	$\Sigma_i \pi_i v(z_i)$

- Models we have seen thus far (EV, EUT, CPT): calculate a “value” for each lottery and compare this value across lotteries to determine which one is preferred.
- The state in which the outcome occurs does not matter

Regret Theory

	s_1	s_2	s_3
	1-30	31-60	61-100
$-bet	$18	$0	$0
P-bet	$8	$8	$0
C	$4	$4	$4

$$L_1 \succcurlyeq L_2 \; iff \; \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

u: is the utility of wealth. Similarly to EUT, let's assume it to be concave (e.g. $u(x) = x^{0.8}$). Moreover, $u(-x) = -u(x)$
Q: is the regret/ rejoice component. It is assumed to be convex $(e.g. Q(x) = x^{1.5})$. Moreover, $Q(-x) = -Q(x)$

Let's compare the choice between $-bet and P-bet first:

Regret Theory

	s_1	s_2	s_3
	1-30	31-60	61-100
$-bet	$18	$0	$0
P-bet	$8	$8	$0

$$L_1 \succcurlyeq L_2 \; iff \; \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

Let's compare the choice between $-bet and P-bet first:
We start by considering what would happen if state 1 is realised.
Notice that Regret Theory, unlike all models we have seen so far, operates with within state comparisons, across lotteries. Previous models, were calculating a weighted average across columns for each row and then comparing that value across rows.
To better understand the principle of Regret Theory, it's important to display lotteries in their "matrix contingent form"

Regret Theory

	s_1
	1-30
$-bet	$18
P-bet	$8

$$L_1 \succcurlyeq L_2 \; iff \; \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

Let's compare the choice between $-bet and P-bet first: We start by considering what would happen if state 1 is realised.

$$s_1\text{:}\ 0.3Q\big(u(18) - u(8)\big) = 0.3(18^{0.8} - 8^{0.8})^{1.5} = 3.174 + \cdots$$

Regret Theory

	s_2
	31-60
$-bet	$0
P-bet	$8

$$L_1 \succcurlyeq L_2 \; iff \; \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

Let's compare the choice between $-bet and P-bet first:
What if State 2 occurs?

$$s_1\!: \; 0.3Q\big(u(18) - u(8)\big) = 0.3(18^{0.8} - 8^{0.8})^{1.5} = 3.174 + \cdots$$

$$s_2\!: 0.3Q\big(u(0) - u(8)\big) = 0.3(0^{0.8} - 8^{0.8})^{1.5} = -3.638 + \cdots$$

Regret Theory

	s_3
	61-100
$-bet	$0
P-bet	$0

$$L_1 \succcurlyeq L_2 \; iff \; \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

Let's compare the choice between $-bet and P-bet first:
What if State 3 occurs? No difference there.

$$s_1: \; 0.3Q\big(u(18) - u(8)\big) = 0.3(18^{0.8} - 8^{0.8})^{1.5} = 3.174 + \cdots$$

$$s_2: 0.3Q\big(u(0) - u(8)\big) = 0.3(0^{0.8} - 8^{0.8})^{1.5} = -3.638 + \cdots$$

$$s_3: 0.4 * 0 = 0$$

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Regret Theory

	s_1	s_2	s_3
	1-30	31-60	61-100
$-bet	$18	$0	$0
P-bet	$8	$8	$0

$$L_1 \succcurlyeq L_2 \ iff \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

Let's compare the choice between $-bet and P-bet first:
What if State 3 occurs? No difference there.

$$s_1{:}\ 0.3Q\big(u(18) - u(8)\big) = 0.3(18^{0.8} - 8^{0.8})^{1.5} = 3.174 + \cdots$$

$$s_2{:}\ 0.3Q\big(u(0) - u(8)\big) = 0.3(0^{0.8} - 8^{0.8})^{1.5} = -3.638 + \cdots$$

$$s_3{:}\ 0.4 * 0 = 0$$

So, overall: $3.174 - 3.638 < 0$, therefore, P-bet≻$-bet
The intuition is that if the $-bet is selected, then the "regret" of ending up with $0 in s_2 is bigger than the "rejoice" of winning $18 instead of $8 in s_1

Regret Theory

	s_1	s_2	s_3
	1-30	31-60	61-100
P-bet	$8	$8	$0
C	$4	$4	$4

$$L_1 \succcurlyeq L_2 \; iff \; \sum_{j=1}^{n} p_j \, Q\{u[A_1(s_j)] - u[A_1(s_j)]\} \geq 0$$

The principle is similar (skipping the calculations here) for the comparison between the P-bet and the certain amount. The regret of not receiving anything at s_3 if the P-bet is selected, is overshadowing the rejoice of $8 instead of $4 in the other two states. Therefore, the C is selected over the P-bet.

Regret Theory

	s_1	s_2	s_3
	1-30	31-60	61-100
$-bet	$18	$0	$0
C	$4	$4	$4

$$L_1 \succcurlyeq L_2 \; iff \sum_{j=1}^{n} p_j \, Q\{u[L_1(s_j)] - u[L_2(s_j)]\}$$

But… the rejoice of $18 instead of $4, compensates for the regret of not receiving $4 in states 2 and 3, if the $-bet is selected over the certain amount.

Therefore, $-bet $\succ$ C

This completes the cycle that violates transtivity:

$$Pbet \succ Sbet \succ C \succ Pbet$$

Applications of regret aversion

- **The Dutch postcode lottery**:
  - The postcode of one's home is the ticket.
  - Even if someone does not pay to participate, one may still find out that one would have won had one played
  - Regret aversion urges people to buy a ticket

- **Fear of Missing out (FOMO)**:
  - Ever felt like relaxing home on a Saturday night until the phone rung with your friend inviting you to a party?
  - Sure, you feel tired and would prefer to stay home..
  - But what if it's a great party? You don't want to regret missing out…