Behavioural Economics
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Outline
Expected Utility Theory
Axioms
Risk Aversion
Anomalies In EUT
Prospect Theory
Two Stages
Editing
Evaluation
What can it explain?
Loss aversion
Risk seeking
Nonlinear preferences

Behavioural Economics

PSYC3310: Specialist Topics In Psychology

Mark Hurlstone
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Seminar 5: Decision Making Under Risk and Uncertainty

CSIRO-UWA BEL Behavioural Economics Laboratory

Today

- Examine preferences (**4**), beliefs (**3**), and utility maximisation (**1**) in standard model—**Expected Utility Theory (EUT**; von Neumann & Morgenstern, 1947)

(1) **(2)** **(3)** **(4)**

$$\max_{x_i^t \in X_i} \sum_{t=0}^{\infty} \delta^t \sum_{s_t \in S_t} p(s_t) U(x_i^t \mid s_t)$$

- Decision Making Under Risk and Uncertainty
  - anomalies in EUT
  - behavioural economic alternative—**Prospect Theory** (Kahneman & Tversky, 1979)

Today

- Examine preferences (**4**), beliefs (**3**), and utility maximisation (**1**) in standard model—**Expected Utility Theory (EUT**; von Neumann & Morgenstern, 1947)

$$\underbrace{\max_{x_i^t \in X_i}}_{(1)} \underbrace{\sum_{t=0}^{\infty} \delta^t}_{(2)} \underbrace{\sum_{s_t \in S_t} p(s_t)}_{(3)} \underbrace{U(x_i^t \mid s_t)}_{(4)}$$

- Decision Making Under Risk and Uncertainty
  - anomalies in EUT
  - behavioural economic alternative—**Prospect Theory** (Kahneman & Tversky, 1979)

Expected Utility Theory

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- Decision making under risk can be considered a process of choosing between different **prospects** or gambles
- A prospect consists of a number of possible outcomes along with their associated probabilities
- A simple example of a decision under risk would involve choosing between the following two courses of action
  - **Prospect A**: 50% chance to win 100; 50% chance to win nothing
  - **Prospect B**: Certainty of winning 45

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- A prospect can be described formally as
  - $\boldsymbol{q} = (x_1, p_1; \ldots\ x_n, p_n)$
  - where x_i represents the outcomes and p_i represents the associated probabilities
- Prospect A on the previous slide could be represented as $\boldsymbol{q}$ = (100, 0.5; 0, 0.5) or more simply as (100, 0.5)
- Prospect B on the previous slide could be represented as $\boldsymbol{r}$ = (45)

Expected Utility Theory: Axioms

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- The axioms of EUT were developed by von Neumann and Morgenstern (1947), and are related to the axioms of preference discussed in **Seminar 3**
- **Completeness**
  - This requires that for all $\boldsymbol{q}$, $\boldsymbol{r}$:
  - Either $\boldsymbol{q} \succeq \boldsymbol{r}$ or $\boldsymbol{r} \succeq \boldsymbol{q}$ or both
- **Transitivity**
  - If we take any three prospects, $\boldsymbol{q}$, $\boldsymbol{r}$, $\boldsymbol{s}$
  - if $\boldsymbol{q} \succeq \boldsymbol{r}$ and $\boldsymbol{r} \succeq \boldsymbol{s}$, then $\boldsymbol{q} \succeq \boldsymbol{s}$

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- **Independence**
  - Any state of the world that results in the same outcome regardless of one's choice should be cancelled or ignored
  - If you prefer the prospect ***q*** = ($3000) to the prospect ***r*** = ($4000, 0.8) ...
  - ... you should prefer the prospect ***q'*** = ($3000, 0.25) to the prospect ***r'*** = ($4000, 0.2)
  - The final two prospects have 25% of the probabilities of the first two prospects
  - These should cancel one another out

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Monotonicity

Objective imrovements to a prospect—increasing some of its payoffs while holding others constant—should make it at least as attractive if not more so than before

Which of the following lotteries do you prefer?

Option A

90% white	6% red	1% green	1% blue	2% yellow
\$0	win \$45	win \$30	lose \$15	lose \$15

Option B

90% white	6% red	1% green	1% blue	2% yellow
\$0	win \$45	win \$45	lose \$10	lose \$15

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Expected Utility Theory: Axioms

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$$V(A) = (0.9 \times 0) + (.06 \times 45) + (.01 \times 30) + (.01 \times -15) + (.02 \times -15) \quad (1)$$

$$V(A) = 2.55 \quad (2)$$

$$V(B) = (0.9 \times 0) + (.06 \times 45) + (.01 \times 45) + (.01 \times -10) + (.02 \times -15) \quad (3)$$

$$V(B) = \mathbf{2.75} \quad (4)$$

Expected Utility Theory: Axioms

Expectation principle

- EUT states that decision makers seek to maximise the following preference function
  - $V(\boldsymbol{q}) = \sum p_i \, u(x_i)$
- Where $\boldsymbol{q}$ is any prospect, and $u(.)$ is a utility function defined on the set of consequences $(x_1, x_2, \ldots x_n)$
- We have covered a simple example of this previously, where an individual must choose between taking one of two 3310 topics
- In addition to the axioms mentioned so far, there is another important assumption—viz. **risk aversion**

Expected Utility Theory: Risk aversion

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- A person is risk averse if she/he would reject a gamble in favour of a sure amount equal to its expected value
- For example, most people would prefer \$500 than a 50–50 chance of \$1000
- In EUT, risk aversion is caused by the **concavity** of the utility function
- This characteristic is caused in turn by the **law of diminishing marginal utility**—the more you have of something, the less you appreciate it
- *Concavity and risk aversion are best illustrated with a figure ...*

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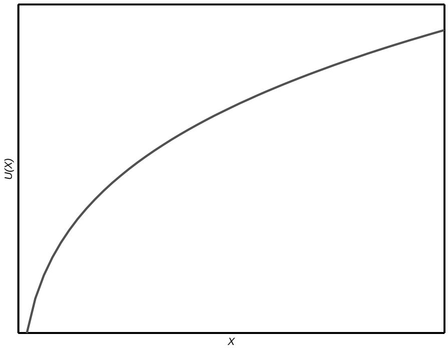

- The EUT utility function conforms to a power function of the form $u = x^b$, where $b < 1$

Expected Utility Theory: Risk aversion, risk seeking & risk neutrality

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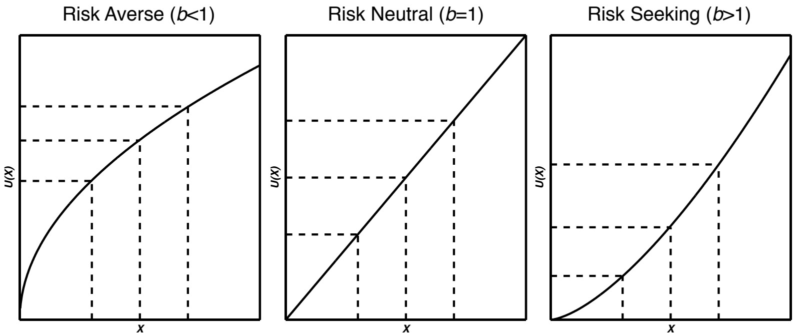

Expected Utility Theory: Risk aversion

- When performing expected utility calculations, we need to transform monetary values into utility values, using a utility function
- For example, the utility function two slides ago was created by setting the parameter b to a value of 0.5
- Suppose we want to calculate the expected utilities of the prospects $\boldsymbol{q}$ = (\$500) and $\boldsymbol{r}$ = (\$1000, 0.5)
- The utility of the former is calculated as $U(\boldsymbol{q}) = 500^{0.5}$ = 22.36, whilst the latter is calculated as $U(\boldsymbol{r})$ = 0.5 $\times$ $1000^{0.5}$ = 15.81

Expected Utility Theory: Risk aversion, risk seeking & risk neutrality

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- Suppose you own $2 and are offered a gamble giving you a 50% chance of winning $1 and a 50% chance of losing a dollar
- If you are **risk averse**, what should you do?
  - $U(Accept)$ = $(0.5 \times 3^{0.5}) + (0.5 \times 1^{0.5})$ = 1.37
  - $U(Reject)$ = $2^{0.5}$ = **1.41**
- If you are **risk seeking**, what should you do?
  - $U(Accept)$ = $(0.5 \times 3^{1.5}) + (0.5 \times 1^{1.5})$ = **3.1**
  - $U(Reject)$ = $2^{1.5}$ = 2.83
- If you are **risk neutral**, what should you do?
  - $U(Accept)$ = $(0.5 \times 3^{1}) + (0.5 \times 1^{1})$ = 2
  - $U(Reject)$ = 2^{1} = 2

Next... Anomalies in EUT

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- Speaker 1: framing effects
  - loss aversion and violations of invariance
- Speaker 2: bundling and mental accounting
  - loss aversion
- Speaker 3: Allais and Ellsberg problems
  - violations of independence axiom

Prospect Theory

Prospect Theory (PT) was originally developed by Kahneman and Tversky (1979) to take into account behavioural anomalies that EUT is unable to incorporate

Prospect Theory: At a glance

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- PT models choice as a two-stage process
  - stage 1 involves editing
  - stage 2 involves evaluation
- The editing phase distinguishes the theory from EUT
- The other major changes are as follows
  - outcomes are defined in terms of gains and losses relative to a reference point
  - there is a nonlinear probability decision weighting function that distorts individual probabilities

Prospect Theory: Two stages

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- Editing
- Evaluation

Prospect Theory: Two stages

- Editing
- Evaluation

Prospect Theory: Editing

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- The editing phase involves a preliminary analysis of the offered prospects, often yielding a simpler representation of these prospects
- The aim is to organize and reformulate the options so as to simplify subsequent evaluation and choice

Prospect Theory: Editing

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- The major operations of the editing phase are as follows
  - Coding
  - Combination
  - Segregation
  - Cancellation
  - Simplification

Prospect Theory: Editing

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Prospect Theory: Coding

- Empirical evidence suggests that people perceive outcomes as gains or losses relative to some reference point, rather than as final states of wealth
- The location of the reference point—and the consequent coding of outcomes as gains or losses—can be affected by the formulation of the offered prospects and by expectations of the decision maker
- Allows for framing effects

Prospect Theory: Editing

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Prospect Theory: Editing

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Prospect Theory: Combination

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- Prospects can sometimes be simplified by combining the probabilities associated with identical outcomes
- For example, the prospect (200, 0.25; 200, 0.25) will be reduced to (200, 0.50) and evaluated in this form

Prospect Theory: Editing

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Prospect Theory: Segregation

- Some prospects contain a riskless component that is segregated from the risky component during editing
- For example, the prospect (100, 0.70; 150, 0.30) can be decomposed into a sure gain of 100 and the risky prospect (50, 0.30)
    - viz. (0.7 $\times$ 100) + (0.3 $\times$ 100) = **100**; (0.3 $\times$ 150) + (0.7 $\times$ 150) = 150 = 150-100 = **(50, 0.30)**
- Similarly, the prospect (-200, 0.8; -300, 0.2) can be segregated into a sure loss of 200 and the risky prospect (-100, 0.2)
    - viz. (0.8 $\times$ -200) + (0.2 $\times$ -200) = **-200**; (0.2 $\times$ -100) + (0.8 $\times$ -100) = -200 = -200 - -100 = **(-100, 0.2)**

Prospect Theory: Editing

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Prospect Theory: Cancelation

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- When different prospects share certain identical components, these components may be discarded or ignored
- For example, the prospect (200, 0.20; 100, 0.50; -50, 0.30) and (200, 0.20; 150, 0.50; -100, 0.30) contain the common element (200, 0.20)
- These prospects can thus be reduced to (100, 0.50; -50, 0.30) and (150, 0.50; -100, 0.30)

Prospect Theory: Editing

- The major operations of the editing phase are as follows
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Prospect Theory: Editing

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Prospect Theory: Simplification

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- Prospects can be simplified by rounding either outcomes or probabilities
- For example, the prospect (99, 0.51) can be coded as an even chance of winning 100
- Outcomes that are extremely improbable are likely to be ignored, meaning the probabilities are rounded down to 0

Prospect Theory: Evaluation

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- Once the editing phase is complete, the decision maker must evaluate the edited prospects
- The decision maker is then assumed to choose the prospect with the largest value
- According to PT, the overall value V of an edited prospect is expressed in terms of two scales v and π
- The first scale, v, assigns to each outcome x a number, $v(x)$ which reflects the subjective value of that outcome
- The second scale, π, associates with each probability p a decision weight $\pi(p)$, which reflects the overall impact of p on the value of the prospect

Prospect Theory: Value function

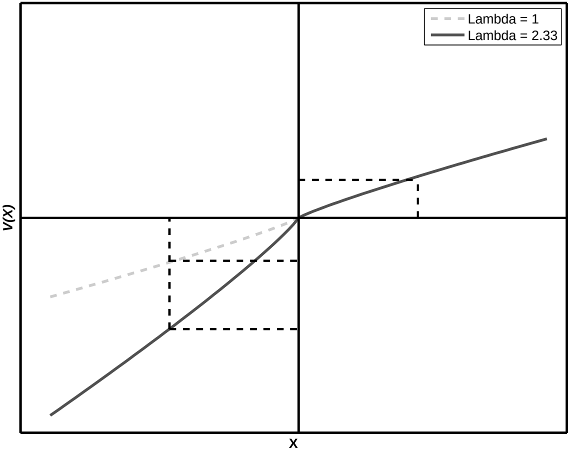
In PT, the EUT utility function $u(x)^b$ is replaced with the following value function:

$$v(x) = \begin{cases} (x-r)^{\alpha} & \text{if } x \geq r \\ -\lambda(r-x)^{\beta} & \text{if } x < r \end{cases}$$

Where:
r = reference point (**0**)
α = diminishing maringal sensitivity for gains (**0.88**)
β = diminishing maringal sensitivity for losses (**0.88**)
λ = coefficent of loss-aversion (**2.25**)

*Provides an explanation of **reference points**, **loss aversion**, and **diminishing marginal sensitivity***

Prospect Theory: Value function



Prospect Theory: Decision weighting

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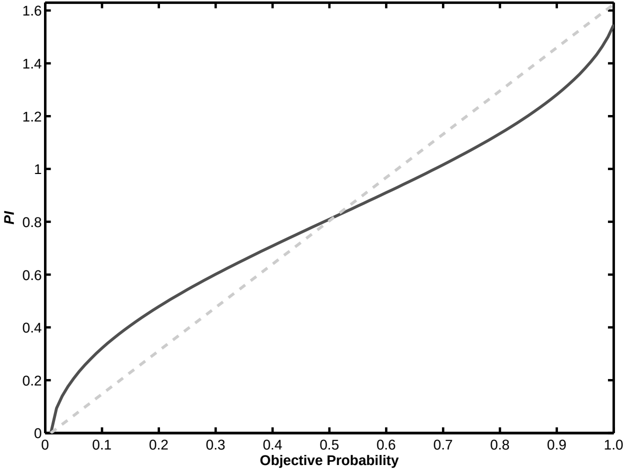
The second scale, for probability weighting, involves an inverted S-shaped curve, with the following form:

$$\pi(p) = \frac{p^\gamma}{(p^\gamma + (1-p)^\gamma)^{1/\gamma}} \tag{5}$$

Where:
γ = curvature of the weighting function (**0.61**)

*Provides an explanation of **decision weighting***

Prospect Theory: Decision weighting



Prospect Theory: Basic equation

According to PT, the value of a **regular prospect**—one with a positive and a negative outcome—$V(x, p : y, q)$ is given by the following formula:

$$V(x, p; y, q) = \pi(p)v(x) + \pi(q)v(y) \tag{6}$$

As in utility theory, V is defined on prospects and v is defined on outcomes

Prospect Theory: Example

Consider the regular prospects (100, 0.50; -50, 0.5) and (150, 0.50; -100, 0.5). The value, V, of the first prospect is:

$$v(100, 0.50; -50, 0.5) = \pi(0.5)v(100) + \pi(0.5)v(-50) \quad (7)$$

$$= (0.56 \times 57.54) + (0.56 \times -70.35) = \textbf{-7.17} \quad (8)$$

The value, V, of the second prospect is:

$$v(150, 0.50; -100, 0.5) = \pi(0.5)v(150) + \pi(0.5)v(-100) \quad (9)$$

$$= (0.56 \times 82.22) + (0.56 \times -129.47) = -26.46 \quad (10)$$

What can it explain?

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What can it explain?

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What can it explain?: Loss aversion

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- **Losses are felt longer and have more impact than gains do**
- For example, losing your house would be a more significant event than aquiring a new house
- Another example is the reluctance to accept losses on the stock market
  - volume of trades tends to be higher when prices are rising than when they are falling
- The phenomenon of loss aversion is consistent with PT's assumption that utility is coded in terms of gains and losses relative to a reference point

What can it explain?

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What can it explain?: Risk seeking

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- **Individuals are not always risk averse, sometimes they are risk seeking—e.g. gambling on unfair prospects in a lottery**
- Tversky and Kahneman (1992)
  - individuals are risk seeking for losses and risk averse for gains for prospects of moderate to high probability
  - individuals are risk averse for losses and risk seeking for gains for prospects with low probabilities
- Thus, individuals tend to prefer a large probability of a big loss than a sure smaller loss

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What can it explain?

- Loss aversion
- Risk seeking
- Non-linear preferences

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Outline
Expected Utility Theory
Axioms
Risk Aversion
Anomalies In EUT
Prospect Theory
Two Stages
Editing
Evaluation
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Loss aversion
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What can it explain?: Nonlinear preferences

Behavioural Economics

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Outline

Expected Utility Theory
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- What can it explain?
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- **The psychological weight assigned to an event may not correspond to the stated probability of that event**
- A classic example is Russian roulette:
  - people will pay more to decrease the number of bullets from 1 to 0 (1/6 – 0 = 0.17) than from 4 to 3 (4/6 – 3/6 = 0.17)
  - EUT predicts that this should not be the case
- We also see evidence of overweighting of small probabilities (e.g., Availability heuristic) and underweighting of large probabilities
- Implies people respond to probabilities in a nonlinear manner, suggesting a nonlinear transformation of the probability scale—*a la* PT