# Behavioral Economics

Lecture 1: Choice under Uncertainty
Part (c): Prospect Theory

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# Our Outline

# Guiding Principle #2

## Use Extreme Cases to Clarify Your Thinking

Some concepts are hard to get your head around. It can be easier to think about things in the extreme limit.

- E.g., "risk aversion" will continue to trip you up throughout this section.
- Think about the limit case: a person who is *infinitely* risk averse.
- Now think about the other limit case: a person who is risk neutral.
- In between those lies reality. The **definition** of the term only offers that a person is a teensy tiny itty bitty bit above risk neutrality. How she actually behaves depends on **how** risk averse she is

**Your task:** think about limit cases.

# Contrasts Matter

- Moe: “If you want to signal me, use this bird call.”

  *[Moe whistles like a bird. An eagle swoops down and pecks him on the face.]*

- “Ow! Not the face!”

  *[The eagle switches to pecking Moe in the groin.]*

- “Ooh! Ooh! Okay, the face!

  *[The eagle switches back.]*

- “Ooh! Whoa, that actually feels good after the crotch!”

# Reference-Dependent Preferences

In virtually all physiological and psychological reactions, people's responses tend to reflect adaptation, change, and contrast, rather than solely absolute levels of outcomes.

- Feelings (and, just as importantly, choice) are reference-dependent:

$\Rightarrow$ We should consider the modified utility function $u(x; r)$, not just $u(w + x)$, where $r$ is some reference point or reference level.

We'll explore this idea for the next few lectures. There are deep implications for economics in this simple observation.

# Prospect Theory (an alternative to EU Theory)

Figure – Amos Tversky and Daniel Kahneman in 1970s. Kahneman won the Nobel Prize in Economics for their joint work in 2002.

Propect Theory proposes two phases of choice process:

- Editing
- Evaluation

# Prospect Theory: Editing Stage

Editing Stage: organize & reformulate the problem

What's going on? A choice problem is described to you, and then you transform it into the lotteries that you will evaluate.

For instance:

- Coding: code outcomes as gains & losses relative to some reference point.
- Cancellation: discard shared components.
- Simplification: rounding off probabilities.
- Eliminating dominated alternatives.

This is an example of the type of thing we won't spend a lot of time on in this course, but it was important to early pioneers.

# Prospect Theory: Evaluation Stage

Kahneman and Tversky (1979, p. 277) stress that attending to changes from reference points is a basic aspect of human nature:

> *Our perceptual apparatus is attuned to the evaluation of changes or differences rather than to the evaluation of absolute magnitudes ... The same principle applies to non-sensory attributes such as health, prestige, and wealth.*

Two features of evaluation emphasized by Kahneman and Tversky (1979) and others:

- Loss Aversion
- Diminishing Sensitivity

# Introduction to Reference Dependence

## 1. Loss Aversion

- People dislike losses more than they like same-sized gains.

- Vast majority turn down 50/50 lose $600, gain $700 bet
  - As touched on last time, **not** because of curvature in utility function.
  - Strongest such aversion involve mix gains and losses.

- Previewing situations in which loss aversion is important:
  - Moral considerations, Hippocratic Oath
  - “Endowment Effect” or “Status Quo Bias” in trades
  - Disposition effects, in investments and houses
  - Aversion to (nominal) wage and consumption declines
  - Income-targeting

## 2. Diminishing Sensitivity

In the following pairs, which “feel” like a bigger difference?

| | | |
|---|---|---|
| visually 101 ft. away vs. 100 ft. away | | 1 ft. v. 0 ft. |
| gaining \$101 v. gaining \$100 | | gaining \$1 v. gaining \$0 |
| losing \$101 v. losing \$100 | vs. | losing \$1 v. losing \$0 |
| losing \$101 v. losing \$100 | | losing \$2 v. losing \$1 |
| gain 100 days from now v. 101 days | | gain 0 days v. 1 day |
| saving \$10 on \$1,000 item | | saving \$10 on \$20 item |
| carrying a suitcase 21 blocks v. 20 blocks | | 2 blocks v. 1 block |
| 19% chance v. 18% chance | | 1% chance v. 0% |
| 19% chance v. 18% chance | | 100% chance v. 99% |
| 17 heads/13 tails v. 16 heads/14 tails | | 4 heads/0 tails v. 3 h/1 t |

# Introduction to Reference Dependence

**2. Diminishing Sensitivity**

- People pay less attention to incremental differences when changes are further away from the reference point.
- Prefer \$420 for sure or 50/50 chance at \$900?
- **Prefer losing \$420 for sure or 50/50 chance to lose \$900?**

Reflects big and general fact about human psychology:

- We most often think in terms of proportions rather than absolutes.

# Prospect Theory: Evaluation Stage

A person evaluates a prospect $(x, p; y, q)$ according to:

$$V(x, p; y, q) \quad = \quad \pi(p)\, v(x) \quad + \quad \pi(q)\, v(y).$$

Reminder: EU theory says evaluate according to:

$$U(x, p; y, q) = pu(w + x) + qu(w + y) + (1 - p - q)\, u(w)$$

What's new?

- $\pi(\cdot)$ is the **probability-weighting function**.
- $v(\cdot)$ is the **value function**.

# Prospect Theory: Evaluation Stage

Put in a different notation, a person evaluates a prospect $(x_1, p_1; \ldots; x_n, p_n)$ according to:

$$V(x_1, p_1; \ldots; x_n, p_n) = \sum_{i=1}^{N} \pi(p_i)\, v(x_i).$$

Contrast this with the Expected Utility definition

$$EU(x_1, p_1; \ldots; x_n, p_n) = \sum_{i=1}^{N} p_i u(x_i)$$

and that of Expected Value

$$EV(x_1, p_1; \ldots; x_n, p_n) = \sum_{i=1}^{N} p_i x_i.$$

# Prospect Theory: Value Function

Three key features of the value function $v(\cdot)$:

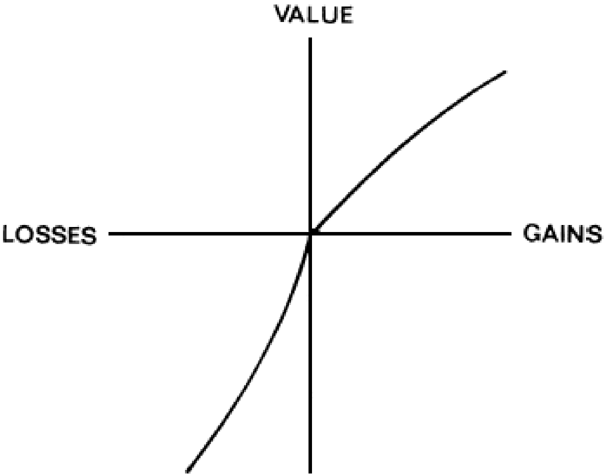
1. The carriers of value are **changes** in wealth
   Thus: $v(0) = 0$.
   - Implicit in this assumption is that the reference point is current wealth.
   - There are lots of examples where this is a bad assumption.
   - We'll discuss many of those later.

2. *Diminishing sensitivity* to the magnitude of changes
   Formally: $v'(x) > 0$ for all $x$, and
   $v''(x) < 0$ for $x > 0$, $v''(x) > 0$ for $x < 0$.

3. *Loss aversion*: losses loom larger than gains.
   Sloppy formality: $v(x) < v(-x)$ for all $x > 0$.
   Formally: $v(x) + v(-x) < v(y) + v(-y)$ for all $x > y$.

# Prospect Theory: Value Function

These assumptions lead to the following visual form of the value function:



# Prospect Theory: Value Function

A functional form that's often used:

$$v(x) = \begin{cases} x^{\alpha} & \text{if } x \geq 0 \\ \lambda(x)^{\beta} & \text{if } x \leq 0 \end{cases}$$

An even easier functional form that we will mostly use:

$$v(x) = \begin{cases} x & \text{if } x \geq 0 \\ \lambda(x) & \text{if } x \leq 0 \end{cases}$$

*Note:* This second functional form removes diminishing sensitivity and isolates the effect of loss aversion on decision-making. In lots of settings this will greatly simplify the problem while leaving the fun stuff intact.

# Implications (and non-Implications) for Risky Choice

So if a person maximizes her preferences meeting the assumptions above, she...

⇒ ...will turn down any 50/50 lose \$X, gain \$X bets.
*Implication 1 is implied by Loss Aversion.*
*Non-Implication 1. "...is necessarily averse to all fair bets."*
*The assumptions do not guarantee a person will turn down all fair bets.*

⇒ ... is risk averse among bets involving only gains.
*Implication 2 is implied directly by Diminishing Sensitivity.*

⇒ ... is risk-*loving* among bets involving only losses.
*Implication 3 is also implied directly by Diminishing Sensitivity.*

⇒ ... is "first-order risk-averse."
*Implication 4 requires important additional assumption.*

# First-Order Risk Aversion

Let $x$ be a **random variable** with distribution $F(x)$.

Let $\mathbb{E}(x)$ denote the expectation of $x$ and $\sigma_x^2$ the variance.

Consider the lottery $k + x$ as the lottery that pays $k$ plus the realization of the random variable $x$.

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**Claim:** Let $\mathbb{E}(x) = 0$ and consider an expected utility maximizer. Suppose $t > 0$ such that $-\pi \sim t \cdot x + k$. Then

$$\pi \approx \frac{-t^2\sigma_x^2}{2} \frac{u''(w+k)}{u'(w+k)}$$

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Put another way: the “risk premium” decreases at rate $t^2$, while the “size” of the risk decreases at rate $t$.

# First-Order Risk Aversion

Thus for small risks, a person must be almost *risk neutral*: the “premium” required to take on that risk would go to zero as the size of the risk goes to zero.

This is about the tenth time I’ve said this, so why again?

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**Assumption:** A decision maker is *first-order risk averse* if for prospect theory value function $v(\cdot)$:

$$\lim_{x \to 0} \frac{v'(-x)}{v'(x)} \equiv L > 1$$

when approached from the $x > 0$ direction.

We will carry this assumption through many of our functional forms.

# Probability-Weighting Function

Recall: $V(x,p;y,q) = \pi(p)\,v(x) + \pi(q)\,v(y)$

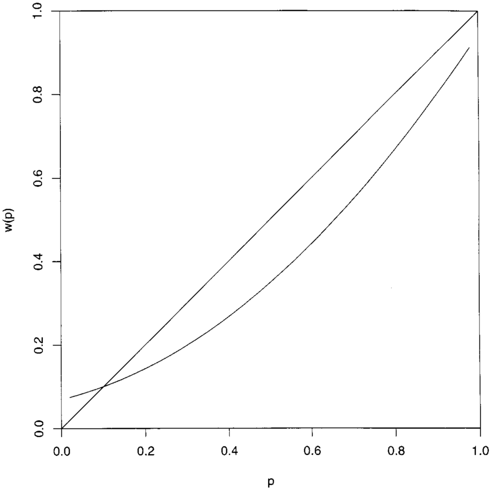
We turn to key features of the probability-weighting function $\pi(\cdot)$:

[EU theory says $\pi(p) = p$.]

- Natural assumptions: $\pi(0) = 0$, $\pi(1) = 1$, and $\pi$ is increasing.
- Subcertainty: $\pi(p) + \pi(1-p) < 1$.
- Subproportionality: $\pi(pq)/\pi(p) \leq \pi(pqr)/\pi(pr)$ for $p, q, r \in (0,1)$.
- For small $p$, $\pi(p) > p$.

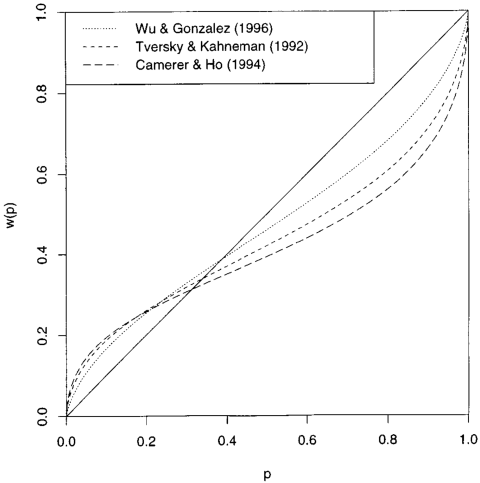
# Visualizing the Probability Weighting Function

Kahneman and Tversky suggest the weighting function could look like:



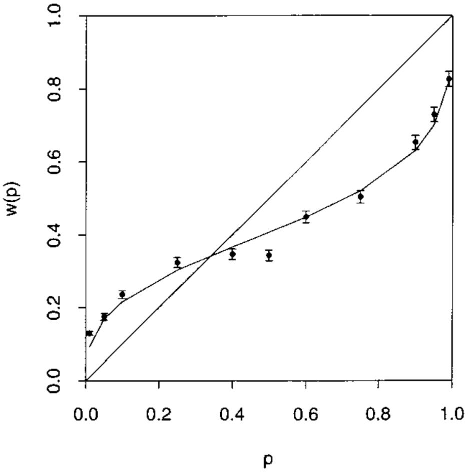
# Visualizing the Probability Weighting Function

Research began refining this function with focused lab evidence:



# Visualizing the Probability Weighting Function

(In my opinion) the best evidence to-date:



# Themes that Emerged from Prospect Theory

1. Non-linear decision weights
2. Reference dependence & loss aversion
3. Framing effects & mental accounting