Choice and Risk

ADEC781001: Empirical Behavioral Economics

Lawrence De Geest (`lrdegeest.github.io`)

BOSTON COLLEGE
Woods College of Advancing Studies

OUTLINE

Expected Utility

Prospect theory

Reference points

ST PETERSBURG PARADOX

▶ Bernoulli (1738): Peter proposes a game to Paul

    ◇ Peter flips a coin until it lands heads
    ◇ Paul gets 2^k ducats if heads is observed on the k_{th} toss

▶ How much should Peter sell this game for?

    ◇ expected payoffs to Paul: $\mathbb{E}[\pi] = \frac{1}{2}2 + \frac{1}{4}4 + \cdots + \frac{1}{8}8 + \cdots = \sum_{k=1} \frac{1}{2^k}2^k = \infty$
    ◇ Bernoulli: Peter realistically does not require ∞ ducats to sell
    ◇ Insight: diminishing marginal utility of money

        ● people care about expected utility of an outcome, not the expected outcome

EXPECTED UTILITY

PROSPECTS

- ▶ Prospect: set of outcomes and their probabilities
  - ◇ $A = (p_1, x_1; p_2, x_2; \ldots; p_n, x_n)$

Table 3.1 The possible consequences of Alan buying insurance

|	Car is stolen	Car is in an accident	Stopped by police	No theft, accident, or police.
Probability	0.05	0.05	0.10	0.80
Final wealth if buys full insurance	$61	$61	$61	$61
Insurance against theft	$64	$14	$64	$64
No insurance	$20	$20	$30	$70

EXCEPTED VALUE VS EXPECTED UTILITY

▶ Expected value is just the sum of the outcomes weighted by their probabilities
  ◇ $\mathbb{E}[A_j] = \sum_{i=1}^{n} p_{ji} x_{ji}$
  ◇ e.g. $\mathbb{E}[A_3] = (0.05)(20) + (0.05)(20) + (0.10)(30) + (0.80)(70) = 61$

▶ Expected utility is the sum of the *utility* of the outcomes weighted by their probabilities
  ◇ $\mathbb{E}[A_j] = \sum_{i=1}^{n} p_{ji} u(x_{ji})$
  ◇ The *curvature* of $u(x)$ is going to matter

CURVATURE OF THE UTILITY FUNCTION

Table 3.2 Alan's expected utility depends on his utility function

Utility function	Expected utility if chose			Predicted choice
	full insurance	insurance for theft	no insurance	
Linear: u(x) = x	61.0	61.5	61.0	insurance for theft
Concave: u(x) = $10\sqrt{x}$	78.1	77.9	76.9	full insurance
Convex: u(x) = $x^2/50$	74.4	78.0	81.0	no insurance
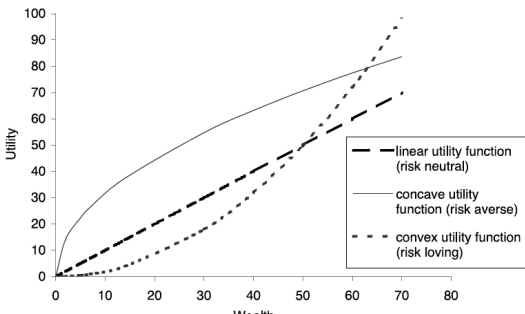
PEOPLE VS EXPECTED UTILITY

▶ In the standard model we assume people are risk neutral
  ◇ Implication: their *expected utility* over a prospect is the same as the *expected value*
  ◇ The only information that matters is the probability distribution

▶ Loads of evidence that people are in fact risk averse (concave utility function)
  ◇ e.g. people tend to put too much money in savings accounts (low but guaranteed interest) rather than investments (risky interest)
  ◇ e.g. people who believe vaccines cause autism (they don't)
  ◇ other examples?

THE ALLAIS PARADOX

Table 3.4 The Allais Paradox. Many people prefer B to A and C to D

Prospect	Amount with probability of outcome		
A	$2,500 with probability 0.33	$2,400 prob. 0.66	$0 prob. 0.01
B	$2,400 for sure.		
C	$2,500 with probability 0.33		$0 with probability 0.67
D	$2,400 with probability 0.34		$0 with probability 0.66

THE ALLAIS PARADOX

- ▶ If people prefer B to A this implies $u(2400) > 0.33u(2500) + 0.66u(2400)$
- ▶ Note that $C \equiv A - 0.66u(2400)$ and $D \equiv B - 0.66u(2400)$
    - ◇ Implication: we should see choices such that $D > C$
    - ◇ Instead we see $C > D$
- ▶ What is going on?
    - ◇ certainty effect: changing a sure thing to a risk matters more than changing a risk to a risk
    - ◇ D went from sure thing to risky
    - ◇ Another example where context matters
    - ◇ What information *might* people take from this?

CONSEQUENCES OF ALLAIS PARADOX

▶ The standard model assumes preferences are transitive and independent

  ◇ Consider three prospects X, Y, Z
  ◇ **Transitive**: if $X \geq Y$ and $Y \geq Z$ then $X \geq Z$
  ◇ **Independent**: if $X \geq Y$ then $(p, X; 1 - p, Z) \geq (p, Y; 1 - p, Z)$, $p \in [0, 1]$
    • Meaning: if X is preferred to Y, then a new prospect that mixes X and Z must be preferred to another new prospect that mixes Y and Z.

▶ Allais Paradox example where *independence* is not satisfied

  ◇ Certainty effect a consequence of fanning out: people are more risk averse the closer they get to being guaranteed \$2,400 or more
  ◇ Bigger picture: people perceive the same probabilities differently depending on context

PROSPECT THEORY

RANK DEPENDENT EXPECTED UTILITY

- ► How people perceive probabilities matters
  - ◇ People tend to overweight small probabilities
  - ◇ People tend to underweight large probabilities
- ► Need to a function that weights probabilities accordingly
  - ◇ $\pi(p) = \dfrac{p^{\gamma}}{p^{\gamma}+(1-p)^{\frac{1}{\gamma}}}, \gamma \in [0,1]$
    - • $\gamma = 1$: no weighting of p
    - • $\gamma < 1$: overweight small probabilities, underweight large probabilities
- ► **rank dependent expected utility**: rank outcomes from best to worst
  - ◇ then $U(X) = \sum_{i=1}^{n} w_i u(x_i)$ where $w_i = \pi(p_i + \cdots + p_n) - \pi(p_{i+1} + \cdots + p_n)$
    - • $\pi(p_i + \cdots + p_n)$: weighted probability of getting outcome equal to or better than i
    - • $\pi(p_{i+1} + \cdots + p_n)$: weighted probability of getting an outcome better than i

PROSPECT THEORY

- ▶ The work of KT and others on choice under risk became know as prospect theory
    - ◇ organizes findings on loss aversion and probability perception into one framework
    - ◇ extends rank dependent utility
- ▶ Two main components
    1. a value function that kinks at a reference point (status quo wealth)
    2. a function that weights probabilities

PROSPECT THEORY
VALUE FUNCTION

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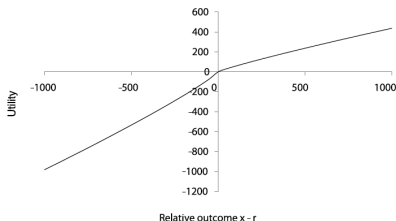

Figure 3.10 A prospect theory utility function for money with parameters $\lambda = 2.25$, α, $\beta = 0.88$, $\gamma = 0.61$ and $\delta = 0.69$.

► Diminishing sensitivity: differences harder to distinguish as you move away from reference point
  ◇ implies risk aversion over prospects where all outcomes are in the gain domain
  ◇ implies risk-seeking over prospects where all outcomes are in the loss domain
  ◇ loss aversion only relevant when considering prospects with outcomes in both

PROSPECT THEORY
WEIGHTING FUNCTION

► $\pi^G(p) = \dfrac{p^\gamma}{p^\gamma + (1-p)^{\frac{1}{\gamma}}}$

► $\pi^L(p) = \dfrac{p^\delta}{p^\delta + (1-p)^{\frac{1}{\delta}}}$

► KT (1992): $\gamma = 0.61, \delta = 0.69$
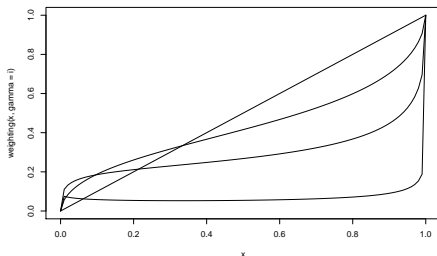
APPLICATION: AVERSION TO SMALL/MEDIUM RISK

► Kahneman and Tversky (1979) find subjects can in fact be *risk-loving* (or *risk-seeking*) in the loss domain (i.e. when all outcomes involve losses)

► Many people are averse to small risks relative to lifetime wealth/liquidity constraints (i.e. the reference point is current/future income)

► Consider the following lottery: 50-50 chance at winning \$550 or losing \$500

    ◇ Would you like to play?

    ◇ Barberis, Huang and Thaler (2006): 71% of MBA students, financial analysts and very rich investors say no.

        • "People should be less risk averse over prospects for small amounts of money if they are already exposed to risk."

► Sydnor (2010): calculates how homeowners choosing lower deductibles would have done with a \$1,000 deductible.

    ◇ people tradeoff premiums (paid each month) and deductibles (paid when a claim is made)

    ◇ why do people pay more in premiums to lower their deductibles?

    ◇ "no loss in buying": buying something is perceived as a foregone gain rather than a loss (means spending extra on insurance is not a perceived as a loss)

    ◇ $\gamma = 0.61$: 4 percent claim rate perceived as 12 percent (overestimating the probability of making a claim)

APPLICATION: FIRM PRICING
HEIDHUES AND KOSZEGI (2008)

Cigarette Prices in Hungary
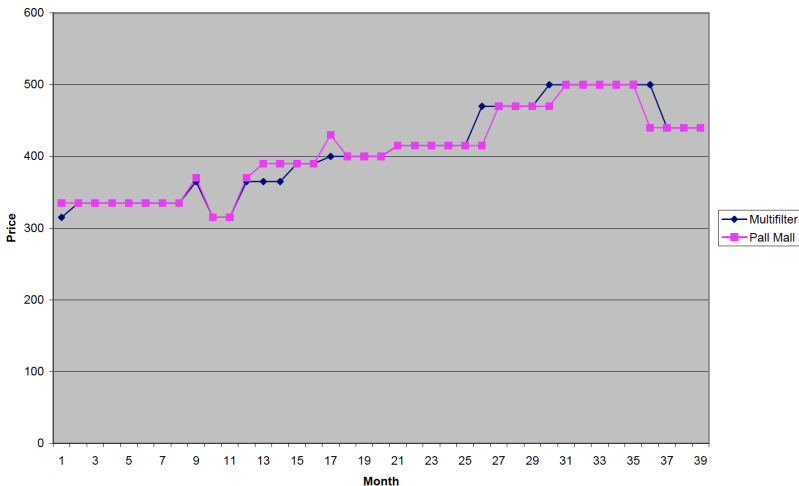
APPLICATION: FIRM PRICING
HEIDHUES AND KOSZEGI (2008)

- ▶ Prices in imperfectly competitive markets change less than we expect from the standard model (i.e. prices are sticky)
- ▶ Prices are also focal: firms set same price as competitor
- ▶ Explanation: consumers are loss averse
  - ◇ "Because consumers are especially averse to paying a price when it exceeds their expectation of the purchase price, the price responsiveness of demand - and hence the intensity of competition - is greater at higher than at lower market prices, reducing or eliminating price variation."

APPLICATION: DISPOSITION EFFECT
ODEAN (1998)

- ▶ Data on 10,000 customer accounts at a nationwide discount brokerage house
- ▶ Constructs a measure of how often investors realize losses and gains relative to their opportunities to do so
    - ◇ on any sale date count the number of "loser" and "winner stocks"
    - ◇ of these, count the "realized losses" and "realized gains"
        - Proportion of losers realized: # of realized losses / # of total losers
        - Proportion of gains realized: # of realized gains / # of total winners
- ▶ Disposition effect: investors tend to hold on to losers and sell winners
    - ◇ investor's valuation of stock is reference-dependent (reference point: purchase price)
    - ◇ pleasant to sell a winner and unpleasant to sell a loser
    - ◇ and due to diminishing sensitivity, individuals are willing to take more risks with losing stocks than with winning stocks

REFERENCE POINTS

CANDIDATES FOR REFERENCE POINTS

- ▶ **Status quo** (i.e. the endowment), common assumption in prospect theory
    - ⋄ extension: *lagged* consumption or endowment
- ▶ **Social preferences**: compare other people's outcomes to yours
- ▶ **Goals or aspirations**: less tangible but could also serve as reference points (though less evidence of this)
- ▶ New idea: **expectations**

EXPECTATIONS

ABELER ET AL (2011)

▶ Experiment: students perform a boring task for piecerate, working as long as they want

▶ When they stop they flip a coin:
  ◇ Heads: receive what they earned
  ◇ Tails: receive a fixed wage €3 or €7

▶ Prediction: should work as much as possible in hopes of earning above fixed wage

▶ Finding: most subjects stop working once they reach fixed wage

▶ Interpretation: the fixed wage becomes their reference point since it forms their expectation about how much they will get paid
  ◇ so reference point is not status quo
  ◇ if earnings were determined by piecerate, and reference point is fixed wage, then earnings below fixed wage feel like a loss

EXPECTATIONS
ENDOWMENT EFFECT REVISITED

- ▶ List (2003): experienced traders show less endowment effect than inexperienced traders
- ▶ Apicella et al. (2014): hunter-gatherer tribes exposed to markets less likely to show endowment effect
- ▶ Plott and Zeiler (2004,2007): inexperienced traders more likely to trade if they are repeatedly told they can trade their endowment object
- ▶ Interpretation: experience traders *expect* to trade acquired or endowed goods, while inexperienced traders *expect* to trade if they primed to trade

EXPECTATIONS
TAXI DRIVERS REVISITED

- ▶ Evidence of income targeting, but also countervailing evidence
    - ◇ Oettinger (1999): stadium vendors are more likely to go to work for games that attract many fans
    - ◇ Farber (2005,2008): weak evidence for income targeting, strong evidence for effort targeting
- ▶ Expectations:
    - ◇ if wage increase expected, worker sets higher income target and thus works longer (so labor supply positively responds to wage increase)
    - ◇ if target is already set and there is a surprise wage increase, worker reaches target faster (so labor supply negatively responds to wage increase)

EXPECTATIONS

KOSZEGI AND RABIN (2006,2007,2009)

- ▶ Where do expectations come from?
- ▶ Koszegi and Rabin: recent expectations are the reference points for evaluating outcomes
    - ◇ scope for status quo (expectations may not change dramatically over time) and social preferences
- ▶ Assume expectations are consistent with rationality
    - ◇ Feedback loop: beliefs → preferences → behavior → beliefs
    - ◇ Leads to Preferred Personal Equilibrium: optional choice depends on what agent *expected* to choose
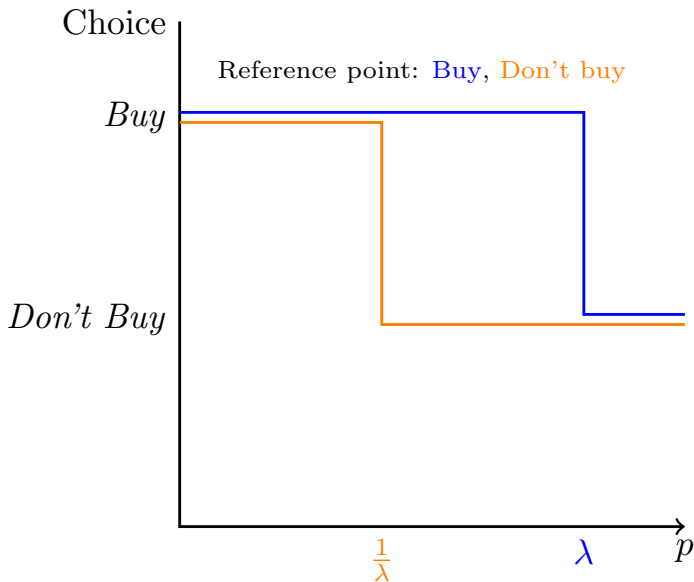
Expectations
Example of personal equilibrium

- ▶ Suppose you have linear utility with loss aversion
    - ◇ utility of gains is x
    - ◇ utility of losses is $-\lambda x$, $\lambda > 1$
- ▶ Suppose there is some good x for price p such that $u(x) = 1$
- ▶ Suppose reference point is a) buy x or b) don't buy x
    - ◇ **1.** buy x:
        - utility from buying: 0 (because you expect to buy it - you *already have* x and $u(x) = 1$)
        - utility from not buying: $p - \lambda x$
        - buy if $p - \lambda x < 0 \implies p < \lambda$
    - ◇ **2.** don't buy x
        - utility from not buying: 0
        - utility from buying: $1 - p\lambda x$
        - buy if $1 - p\lambda < 0 \implies p < \frac{1}{\lambda}$

EXPECTATIONS

EXAMPLE OF PERSONAL EQUILIBRIUM ILLUSTRATED

EXPECTATIONS AND RISK
KOSZEGI AND RABIN (2007)

- ▶ Recall KT (1979) find subjects are risk-loving in the loss domain
- ▶ Disposition effect another example of risk-loving in loss domain
- ▶ Buy consumers very risk averse in loss domain when buying small-scale insurance or choosing low deductibles on existing insurance
- ▶ How can expectations resolve this?
  - ⋄ if a possible loss is a surprise, the reference point is above possible outcomes, and loss aversion does not play a role in evaluating the risk
  - ⋄ If the possibility is expected, the reference point is lower, and loss aversion dominates the evaluation of the risk

EXTENSIONS: NARROW VERSUS BROAD BRACKETING (FRAMING)

▶ Endowment effect: WTA > WTP

▶ Suppose you offer the the owner of a mug two choices: a) sell the mug for $6, then b) buy an identical mug for $4

  ◇ narrow framing: she considers each offer separately (likely to reject)
  ◇ broad framing: considers offers jointly (likely to accept, since it amounts to her keeping the mug and earning $2)
  ◇ implication: how broad or narrow you bracket matters if you have reference-dependent utility

   • when mental accounting it is important to "think outside the account" (e.g. considering new risks in light of existing risks)
   • Prospect Theory originally had two stages: evaluation and editing. In editing, agent organizes prospects in a way that makes sense to them and codes outcomes as gains or losses.
   • Implication: how you present prospects to an individual will influence how they edit and evaluate them (could explain why we sometimes see preference reversals)

▶ Another example of bracketing: equity premium puzzle (bracketing: short versus long evaluation period)

▶ Webb and Shu (2017): broad bracketing leads to better risk preferences among subjects

EXTENSIONS: TRUE LOSS AVERSION OR MISTAKE?

- ▶ Projection bias: project current preferences onto your future self
  - ◇ Read and van Leeuwen (1998): people project their current appetite onto their future appetite (if I'm hungry now, I'll be hungry later)
- ▶ We may under-appreciate how changes in reference points impact our utility and thus temporarily overreact to gains and losses
  - ◇ if you currently have a mug, giving it up will feel like a loss - but you get over it quickly
  - ◇ projection bias means you under-appreciate how fast this loss will dissipate

REFERENCE DEPENDENCE: FINAL REMARKS

▶ Contrast is a key part of human cognition, and contrast requires a reference point

▶ We have seen that both outcomes and utility of outcomes in economic decisions are sensitive to reference points
▶ Can reference points be manipulated? How can this be exploited in policy design?