AREC 815: Experimental and Behavioral Economics

Prospect Theory & Loss Aversion

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Violations of Expected Utility Theory

Allais' Paradoxes: the Common Consequence Effect

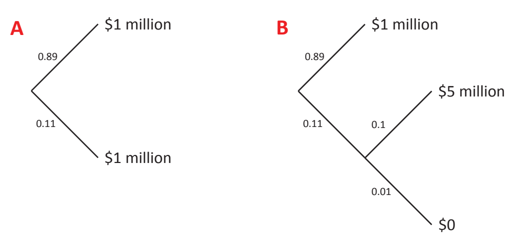
Which would you prefer?

- Lottery A: 1 million dollars with certainty
- Lottery B:
  - 5 million dollars with probability 0.1
  - 1 million dollars with probability 0.89
  - 0 with probability 0.01

Which would you prefer?

- Lottery C: 1 million dollars with probability 0.11
- Lottery D: 5 million dollars with probability 0.1

Allais' Paradoxes: the Common Consequence Effect



Allais' Paradoxes: the Common Consequence Effect

It is apparent that EU implies that those who prefer A also prefer C:

$$A \succsim B$$

$$\Leftrightarrow \underbrace{0.89u(1,000,000) + 0.11u(1,000,000)}_{=u(1,000,000)} \geq 0.10u(5,000,000) + 0.89u(1,000,000) + 0.01u(0)$$

$$\Leftrightarrow 0.11u(1,000,000) \geq 0.10u(5,000,000) + 0.01u(0)$$

$$\Leftrightarrow 0.89u(0) + 0.11u(1,000,000) \geq 0.89u(0) + 0.10u(5,000,000) + 0.01u(0)$$

$$\Leftrightarrow C \succsim D$$

Allais' Paradoxes: the Common Ratio Effect

Which would you prefer?

- Lottery A′: 1 million dollars with certainty
- Lottery B′: 5 million dollars with probability 0.98

Which would you prefer?

- Lottery C′: 1 million dollars with probability 0.01
- Lottery D′: 5 million dollars with probability 0.0098

Allais' Paradoxes: the Common Consequence Effect

It is apparent that EU implies that those who prefer A' also prefer C':

$$A' \succsim B'$$

$$\Leftrightarrow u(1,000,000) \geq 0.98u(5,000,000)$$

$$\Leftrightarrow [u(1,000,000)]/100 \geq [0.98u(5,000,000)]/100$$

$$\Leftrightarrow 0.01u(1,000,000) \geq 0.0098u(5,000,000)$$

$$\Leftrightarrow C' \succsim D'$$

Importantly, both violations involve certain outcomes

The Reflection Effect

PREFERENCES BETWEEN POSITIVE AND NEGATIVE PROSPECTS

Positive prospects				Negative prospects			
Problem 3: $N=95$	(4,000, .80) [20]	<	(3,000). [80]*	Problem 3′: $N=95$	(−4,000, .80) [92]*	>	(−3,000). [8]
Problem 4: $N=95$	(4,000, .20) [65]*	>	(3,000, .25). [35]	Problem 4′: $N=95$	(−4,000, .20) [42]	<	(−3,000, .25). [58]
Problem 7: $N=66$	(3,000, .90) [86]*	>	(6,000, .45). [14]	Problem 7′: $N=66$	(−3,000, .90) [8]	<	(−6,000, .45). [92]*
Problem 8: $N=66$	(3,000, .002) [27]	<	(6,000, .001). [73]*	Problem 8′: $N=66$	(−3,000, .002) [70]*	>	(−6,000, .001). [30]

Gains and losses are treated differently:

- Preferences appear risk-loving in the loss domain
- Choices near probabilities near 0, 1 are different

Reference Points Matter

PROBLEM 11: In addition to whatever you own, you have been given 1,000. You are now asked to choose between

A: (1,000, .50), and B: (500).

$N = 70$ [16] [84]*

PROBLEM 12: In addition to whatever you own, you have been given 2,000. You are now asked to choose between

C: (−1,000, .50), and D: (−500).

$N = 68$ [69*] [31]

The Fallacy of Large Numbers

Nobel laureate Paul Samuelson asks a colleague:

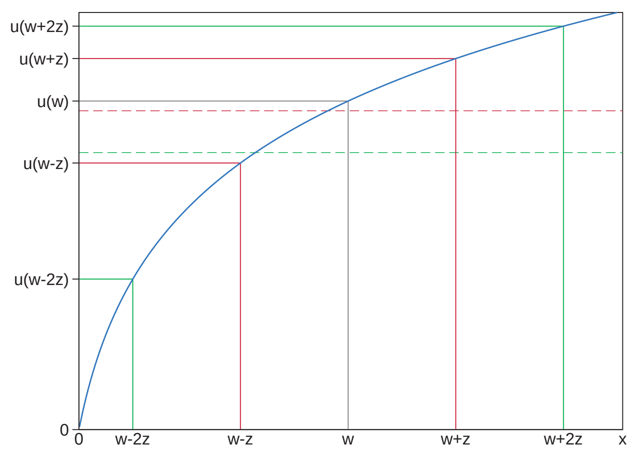
"Would you accept a 50/50 *bet in which you either gained $200 or lost $100?"*

His colleague responds:

"I won't bet because I would feel the $100 loss more than the $200 gain. But I'll take you on if you promise to let me make 100 such bets."

"One toss is not enough to make it reasonably sure to come out in my favor. But in 100 tosses of a coin, the law of large numbers will make it a darn good bet. I am, so to speak, virtually sure to come out ahead in such a sequence, and that is why I accept the sequence while rejecting the single bet."

The Fallacy of Large Numbers



Market Experiments: the Endowment Effect

Research suggests disparities between WTP for X and WTA to give up X, even when goods are not "owned" in the conventional sense

SUMMARY OF PAST TESTS OF EVALUATION DISPARITY

	Means			Medians		
Study and Entitlement	WTP	WTA	Ratio	WTP	WTA	Ratio
Hypothetical surveys:						
Hammack and Brown (1974): marshes	$247	$1,044	4.2			
Sinclair (1978): fishing				35	100	2.9
Banford et al. (1979):						
Fishing pier	43	120	2.8	47	129	2.7
Postal service	22	93	4.2	22	106	4.8
Bishop and Heberlein (1979): goose hunting permits	21	101	4.8			
Rowe et al. (1980): visibility	1.33	3.49	2.6			
Brookshire et al. (1980): elk hunting*	54	143	2.6			
Heberlein and Bishop (1985): deer hunting	31	513	16.5			
Real exchange experiments:						
Knetsch and Sinden (1984): lottery tickets	1.28	5.18	4.0			
Heberlein and Bishop (1985): deer hunting	25	172	6.9			
Coursey et al. (1987): taste of sucrose octa-acetate†	3.45	4.71	1.4	1.33	3.49	2.6
Brookshire and Coursey (1987): park trees†‡	10.12	56.60	5.6	6.30	12.96	2.1

* Middle-level change of several used in study.
† Final values after multiple iterations.
‡ Average of two levels of tree plantings.

Market Experiments: the Endowment Effect

Induced-value tokens: experimental tickets which individuals can redeem post-experiment for pre-specified amount, v_i

- Tokens have no innate value
- Their value is exactly the amount they can be traded in for

Experimental markets:

- Subjects randomly assigned to buyer, seller roles
- Each subject assigned random redemption value: $v_i \in [v_{min}, v_{max}]$
- Distributions of v_i identical for buyers, sellers
- Experimenter creates market in which tokens are bought, sold
- Transactions occur at market-clearing price

Experimental Markets for Tokens

Individual Decisions:

At a price of $8.75: I will sell ___ I will not sell ___

At a price of $8.25: I will sell ___ I will not sell ___

At a price of $7.75: I will sell ___ I will not sell ___

- At high prices, sellers want to sell, but buyers don't want to buy
- At low prices, buyers want to buy, but sellers don't want to sell
- Experimenter determines market-clearing price such that supply equals demand (or gets as close to that price as possible)

On average, what fraction of buyers (or sellers) should end up trading their tokens for money (or money for tokens) at the market-clearing price?

Experimental Markets for Tokens

Experimental markets for tokens "work" as theory predicts:

RESULTS OF EXPERIMENT 1

INDUCED-VALUE MARKETS

Trial	Actual Trades	Expected Trades	Price	Expected Price
1	12	11	3.75	3.75
2	11	11	4.75	4.75
3	10	11	4.25	4.25

Experimental Markets for Mugs, Pens

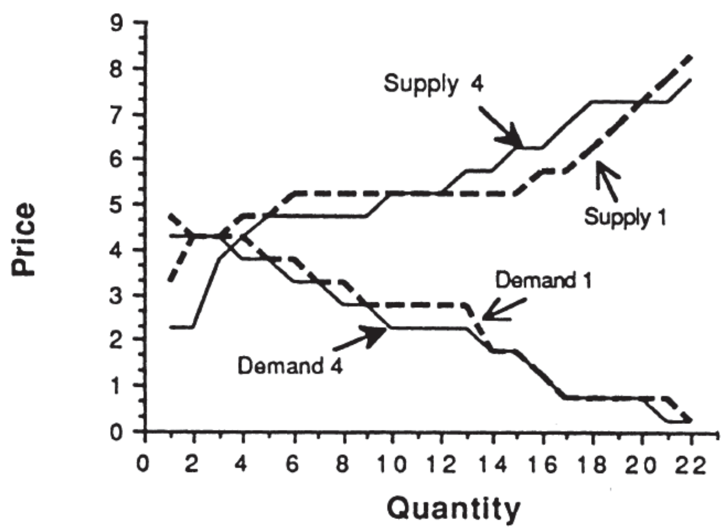
What about similar experimental markets for mugs and pens?

- Half of all subjects are randomly chosen to be sellers, given a Cornell coffee mug or fancy ballpoint pen which is theirs to keep or sell
- Valuations are no longer induced; WTP/WTA will depend on how much each subject likes the coffee mugs and/or pens
- Since buyers are chosen at random, the average (expected) value of v_{mug} or v_{pen} should be the same among the buyers and sellers
- Prediction: on average, approximately half of the buyers should end up buying, and about half of the sellers should end up selling

Experimental Markets for Mugs, Pens

Trial	Trades	Price	Median Buyer Reservation Price	Median Seller Reservation Price
Consumption Goods Markets				
	Mugs (Expected Trades = 11)			
4	4	4.25	2.75	5.25
5	1	4.75	2.25	5.25
6	2	4.50	2.25	5.25
7	2	4.25	2.25	5.25
	Pens (Expected Trades = 11)			
8	4	1.25	.75	2.50
9	5	1.25	.75	1.75
10	4	1.25	.75	2.25
11	5	1.25	.75	1.75

Experimental Markets for Mugs, Pens



Variations: Buyers vs. Sellers vs. Choosers

Could wealth effects explain the pattern?

- New experiment randomly assigns subjects to one of three categories: buyers, sellers, and "choosers"
  - For every possible market-clearing price, choosers were asked whether they'd prefer a mug or that amount of money in cash
- Median prices for the three groups in two related experiments:

Sellers	Choosers	Buyers
$7.12	$3.12	$2.87
$7.00	$3.50	$2.00

Variations: Mugs vs. Chocolate

- Subjects are given a gift as compensation for completing a survey
- Gift was either a mug, a Swiss chocolate bar, or a choice between a mug and a Swiss chocolate bar (treatments conducted separately)
- Gifts awarded prior to survey, subjects allowed to "switch" gifts (mugs for chocolate) at close of experiment
- What fraction of subjects chose mugs in the end?

Chocolates	Choosers	Mugs
0.10	0.56	0.89

The Endowment Effect

The **endowment effect:** "people often demand much more to give up an object than they would be willing to pay to acquire it"

- Losses loom larger than gains — as in the case of Samuelson's colleague — but not because the marginal utility of wealth declines
  - **Loss aversion**
- In the lab, people do not own things because they value them
  - Subjects rapidly adapt to "owning" an object, making it seem like a loss to sell it in the experimental market

Prospect Theory

Prospect Theory

Big issues with expected utility models:

- Preference for certainty
- Endowment effect
- Fourfold pattern (?): gains vs. losses, diminishing sensitivity

"Anomalies" accommodated in model of **prospect theory**

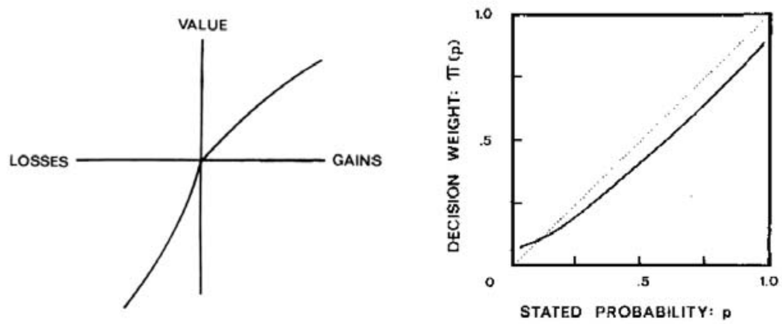
- **Value function** is carrier of risk aversion, loss aversion
- Value defined over departures from **reference point**
- **Probability-weighting function** overweights small probabilities, allows for certainty premium above and beyond risk premium

Prospect Theory

Utility of prospect L: $\pi(p)\, v(y-r) + \pi(1-p)\, v(z-r)$

- L is a lottery: $(p, 1-p; y, z)$
- r is a **reference point**, for example the status quo
- Value defined over departures from **reference point**, r
  - Value function kinked at r
  - Looks like a consumption utility function above r, steeper below
- Non-linear probability weighting function $\pi(p)$
  - Over-weighting of low probabilities
  - Under-weighting of high probabilities

Prospect Theory



Value Function

Probability-Weighting Function

Prospect Theory: "Recent" Advances

Cumulative prospect theory:

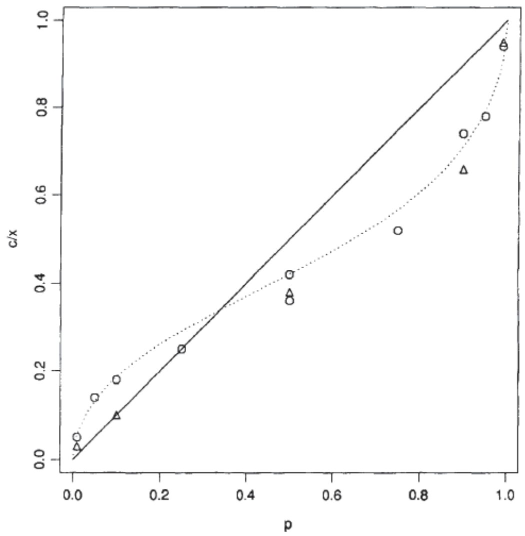
- Tversky & Kahneman (1992) propose revised weighting function
- For prospects involving gains relative to the reference point:

$$w^+(p) = \frac{p^\gamma}{[p^\gamma + (1-p)^\gamma]^{1/\gamma}}$$

- For prospects involving losses relative to the reference point:

$$w^-(p) = \frac{p^\delta}{[p^\delta + (1-p)^\delta]^{1/\delta}}$$

Prospect Theory: “Recent” Advances

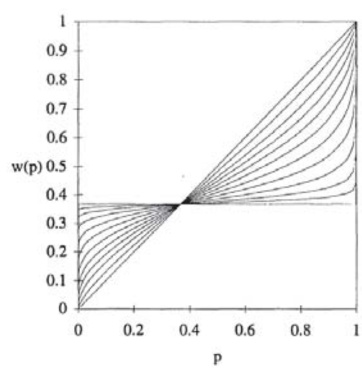


Prospect Theory: “Recent” Advances

Prelec (1998) derives a probability-weighting function from preference axioms motivated by a range of experimental results

Weighting function:

$$w(p) = e^{[-(-\ln p)^{\alpha}]}$$



Prospect Theory: Summary

Kahneman and Tversky's model of prospect theory explains:

- Risk aversion over small stakes
- The endowment effect (and the preference for certainty)
- Diminishing sensitivity, the fourfold pattern of risk preferences

The Endowment Effect: Field Evidence

Endowment Effects Outside the Lab?

Endowment effects well-documented in lab environments

Can we observe the endowment effects in typical non-lab markets?

Two examples of completely typical markets:

Sports memorabilia **Commemorative pins**

Endowment Effects Outside the Lab?

SELECTED CHARACTERISTICS OF PARTICIPANTS

	Sportscard market I		Pin market	Sportscard market II
	Dealers mean (std. dev.)	Nondealers mean (std. dev.)	Consumers mean (std. dev.)	Nondealers mean (std. dev.)
Trading experience	14.82 (11.0)	5.66 (6.42)	6.98 (13.63)	6.84 (7.98)
Years of market experience	10.36 (6.75)	6.95 (9.37)	5.05 (5.64)	7.13 (9.05)
Income	4.26 (1.92)	4.04 (2.06)	4.06 (2.25)	4.36 (1.82)
Age	34.68 (11.98)	34.70 (14.06)	31.48 (13.68)	34.83 (12.51)
Gender (percent male)	0.93 (0.25)	0.86 (0.34)	0.48 (0.50)	0.89 (0.32)
Education	3.42 (1.42)	3.84 (1.49)	3.10 (1.53)	3.85 (1.50)
Good B	0.527 (0.50)	0.527 (0.50)		—
Good D	—	—	0.50 (0.50)	—
Good F	—	—	—	0.53 (0.50)
N	74	74	80	53

Endowment Effects Outside the Lab?

SUMMARY TRADING STATISTICS FOR EXPERIMENT I: SPORTSCARD SHOW

Variable	Percent traded	p-value for Fisher's exact test
Pooled sample (n = 148)		
Good A for Good B	32.8	<0.001
Good B for Good A	34.6	
Dealers (n = 74)		
Good A for Good B	45.7	0.194
Good B for Good A	43.6	
Nondealers (n = 74)		
Good A for Good B	20.0	<0.001
Good B for Good A	25.6	

a. Good A is a Cal Ripken, Jr. game ticket stub, circa 1996. Good B is a Nolan Ryan certificate, circa 1990.
b. Fisher's exact test has a null hypothesis of no endowment effect.

Endowment Effects Outside the Lab?

NONDEALER SUMMARY STATISTICS FOR EXPERIMENT I: SPORTSCARD SHOW

Variable	Percent traded	p-value for Fisher's exact test
Experienced nondealers (n = 30)	46.7	0.32
Inexperienced nondealers (n = 44)	6.80	<0.001

a. Experienced nondealers are those consumers who trade 6 or more times per month (5.66 is the mean level of monthly trades for nondealers). Inexperienced nondealers trade less than 6 times per month.
b. Fisher's exact test has a null hypothesis of no endowment effect.

Endowment Effects Outside the Lab?

ESTIMATION RESULTS FOR EXPERIMENT I: SPORTSCARD SHOW

Variable	Dealers		Nondealers	
	Logit trade function	Logit trade function	Logit trade function	Logit trade function
Constant	−0.58	−0.41	−4.41**	−5.12**
	(1.20)	(1.25)	(1.93)	(1.96)
Trading experience	0.03	0.01	0.14**	0.50**
	(0.02)	(0.06)	(0.05)	(0.16)
(Trading experience)^2	—	0.0005	—	−0.014**
		(0.001)		(0.005)
Years of market experience	−0.04	−0.04	−0.001	0.02
	(0.04)	(0.04)	(0.04)	(0.04)
Income	−0.28	−0.29	0.19	0.14
	(0.18)	(0.18)	(0.21)	(0.23)
Age	0.01	0.01	0.002	−0.02
	(0.03)	(0.03)	(0.03)	(0.04)
Gender	0.30	0.30	1.59	1.11
	(1.01)	(0.99)	(1.29)	(1.19)
Education	0.30	0.31	−0.006	−0.02
	(0.21)	(0.21)	(0.21)	(0.22)
Good B	−0.30	−0.30	0.13	0.37
	(0.51)	(0.50)	(0.70)	(0.74)
N	74	74	74	74

a. Dependent variable equals 1 if subject chose to trade, 0 otherwise. Gender = 1 if male, 0 otherwise; Good B = 1 if subject was endowed with Good B, 0 otherwise.
b. Standard errors are in parentheses beneath coefficient estimates. Parameter estimates in columns 2 and 4 are logit coefficients.

Endowment Effects Outside the Lab?

ESTIMATION RESULTS FOR EXPERIMENT II: PIN TRADING STATION

Variable	Pin consumers		
	Logit trade function	Logit trade function	Logit trade function
Constant	−2.44**	−2.57**	−4.65
	(0.91)	(0.95)	(1.37)
Trading experience	0.05**	0.08*	0.74**
	(0.02)	(0.05)	(0.24)
(Trading experience)^2	—	−0.004	−0.04**
		(0.006)	(0.02)
(Trading experience)^3	—	—	0.007**
			(0.003)
Years of market experience	0.03	0.03	0.04
	(0.05)	(0.05)	(0.05)
Income	−0.11	−0.10	−0.03
	(0.18)	(0.18)	(0.19)
Age	0.005	0.006	0.005
	(0.02)	(0.03)	(0.03)
Gender	0.90	0.90	0.41
	(0.55)	(0.55)	(0.61)
Education	0.20	0.20	0.26
	(0.23)	(0.23)	(0.26)
Good D	0.26	0.29	0.84
	(0.55)	(0.56)	(0.63)
N	80	80	80

a. Dependent variable equals 1 if subject chose to trade, 0 otherwise. Gender = 1 if male, 0 otherwise; Good D = 1 if subject was endowed with Good D, 0 otherwise.
b. Standard errors are in parentheses beneath coefficient estimates. Parameter estimates in column 2 are logit coefficients.
c. **(*) Denotes that coefficient estimate is significant at the $p < .05$ (.10) level.

Endowment Effects Outside the Lab?

ESTIMATION RESULTS USING PANEL DATA FROM EXPERIMENTS I AND III

	Logit trade function			Chamberlain trade function		
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Constant	−1.57**	−2.01**	−2.91**	—	—	—
	(0.34)	(0.44)	(0.65)			
Trading experience	0.11**	0.21**	0.55**	0.23*	0.45**	1.33**
	(0.04)	(0.07)	(0.17)	(0.12)	(0.20)	(0.51)
(Trading experience)^2	—	−0.003*	−0.03**	—	−0.005*	−0.07**
		(0.002)	(0.01)		(0.003)	(0.03)
(Trading experience)^3	—	—	0.004**	—	—	0.009**
			(0.002)			(0.004)
χ^2 ($\mu_i = 0$)	—	—	—	3.98**	5.29*	8.47**
N	106	106	106	106	106	106

a. Dependent variable equals 1 if subject chose to trade, 0 otherwise.
b. Standard errors are in parentheses beneath coefficient estimates.
c. **(*) Denotes that coefficient estimate is significant at the $p < .05$ (.10) level.
d. χ^2 ($\mu_i = 0$) is a simple Hausman test of the Chamberlain fixed effects model. Each test suggests that there are unobserved fixed effects at the $p < .10$ level; hence the Chamberlain trade estimates are appropriate.

Reference Dependent Expected Utility

Reference Dependent Expected Utility

In the RD EU model (Kőszegi and Rabin, *QJE*, 2006):

- Bundle $c \in \mathbf{R}^K$ is evaluated relative to reference level $r \in \mathbf{R}^K$
- In risky contexts, F denotes the distribution of c
- The reference point is also stochastic, with distribution G
- RD EU is given by:

$$U(F|G) = \int \int u(c|r)\, dG(r) dF(c)$$

Reference Dependent Expected Utility

Consider a riskless outcome $c \in \mathbf{R}^K$

- Utility is the sum of consumption utility, gain/loss utility

$$\begin{aligned} u(c|r) &= m(c) + n(c|r) \\ &= \sum_{k=1}^{K} m_k(c_k) + \sum_{k=1}^{K} n_k(c_k|r_k) \end{aligned}$$

- $m(c)$ is classical **consumption utility**
- $n(c|r)$ is additively separable **gain/loss utility**

Reference Dependent Expected Utility

Gain/loss utility can be written as

$$n_k\left(c_k|r_k\right) = \mu\left(m_k\left(c_k\right) - m_k\left(r_k\right)\right)$$

where $\mu(\cdot)$ is a universal gain/loss function

Assumptions about $\mu(x)$:

A0. Continuous, twice differentiable except at $x = 0$, $\mu(0) = 0$

A1. Strictly increasing

A2. If $y > x > 0$, then $\mu(y) + \mu(-y) < \mu(x) + \mu(-x)$

A3. $\mu''(x) \leq 0$ for $x > 0$, and $\mu''(x) \geq 0$ for $x < 0$

A4. $\frac{\lim_{x\to 0} \mu'(-x)}{\lim_{|x|\to 0} \mu'(-|x|)} = \lambda > 1$

Reference Dependent Expected Utility

Given the above assumptions:

- For a given outcome, agents prefer a lower reference point
- If A is weakly preferred to B when B is the reference point, then A is strictly preferred to B when A is the reference point

It is often reasonable to assume that $m(\cdot)$ is locally linear

$\Rightarrow$ Utility function exhibits same properties as $\mu(\cdot)$

$\Rightarrow$ Not true when changes are large relative to absolute consumption, or when the marginal consumption utility is changing rapidly

RD EU Example: Two Lotteries

RD EU implies risk aversion, even when consumption utility is linear

- Example: $u(c|r) = m(c) + \mu(c|r)$
  - $m(c) = c$
  - $\mu(c|r)$ is piecewise linear
  - $r = w_0$

Consider 50/50 lottery in which you either gain $x > 0$ or lose $y > x$

- What is the reference dependent expected utility of this lottery?

RD EU Example: Two Lotteries

Define $\mu(\cdot)$ as follows:

$$\mu(c|r) = \begin{cases} \eta(c-r) & \text{if } c \geq r \\ \eta\lambda(c-r) & \text{if } c < r \end{cases}$$

Consider two cases:

- A surprise lottery: reference point is pre-lottery wealth/income
- An expected lottery: wealth+lottery serves as the reference point

RD EU Example: a Surprise Lottery

$$E\left[U\left(L|R\right)\right] = w_0 + \frac{1}{2}x - \frac{1}{2}y$$

$$+\frac{1}{2}\underbrace{\eta\left(w_0 + x - w_0\right)}_{\text{gain utility}} + \frac{1}{2}\underbrace{\eta\lambda\left(w_0 - y - w_0\right)}_{\text{gain utility}}$$

$$= w_0 + \frac{1}{2}x - \frac{1}{2}y + \frac{1}{2}\eta x - \frac{1}{2}\eta\lambda y$$

$$= w_0 + \frac{1}{2}\left(1+\eta\right)x - \frac{1}{2}\left(1+\eta\lambda\right)y$$

RD EU Example: an Expected Lottery

$$E\left[U\left(L|R\right)\right] = w_0 + \frac{1}{2}x - \frac{1}{2}y$$

$$+\frac{1}{2}\underbrace{\left\{\frac{1}{2}\eta\left[w_0 + x - \left(w_0 + x\right)\right] + \frac{1}{2}\eta\left[w_0 + x - \left(w_0 - y\right)\right]\right\}}_{\text{gain utility}}$$

$$+\frac{1}{2}\underbrace{\left\{\frac{1}{2}\eta\lambda\left[w_0 - y - \left(w_0 + x\right)\right] + \frac{1}{2}\eta\lambda\left[w_0 - y - \left(w_0 - y\right)\right]\right\}}_{\text{loss utility}}$$

$$= w_0 + \frac{1}{2}x - \frac{1}{2}y + \frac{1}{2}\left[\frac{1}{2}\eta\left(x+y\right)\right] + \frac{1}{2}\left[\frac{1}{2}\eta\lambda\left(-y-x\right)\right]$$

$$= w_0 + \frac{1}{2}x - \frac{1}{2}y + \frac{1}{4}\left[\eta\left(1-\lambda\right)\left(x+y\right)\right]$$

What Is the Reference Point?

- Status quo vs. rational expectations
- Examples:
  - Mug, etc. experiments $\rightarrow$ status quo, expectations align
  - Salary increases, decreases
  - Consumption of non-durables
- Rational expectations also reduce number of degrees of freedom

Personal Equilibrium

Rational expectations:

"Reference point is probabilistic beliefs about the relevant consumption outcome held between the time she first focused on the decision determining the outcome and shortly before consumption occurs"

Personal equilibrium:

Expectations are consistent with chosen actions,
chosen action is the preferred given expectations

$$u(a|r=a) \geq u\left(a'|r=a\right) \text{ for all } a' \text{ in choice set } A$$

Personal Equilibrium: An Example

Consider Lyle, who is a sports memorabilia trader who owns
a unique 2004 World Series baseball autographed by Manny Ramirez

Lyle's utility depends on autographed baseballs, b, and dollars, d

$$u(c|r) = u_b(b|r_b) + u_d(d|r_d)$$

$$= m_b(b) + \mu_b(b|r_b) + m_d(d) + \mu_d(d|r_d)$$

$$= v_b b + v_b \mu(b - r_b) + d + \mu(d - r_d)$$

where $\mu(x)$ again takes the simple form

Personal Equilibrium: An Example

Lyle is considering selling his autographed baseball at price p

- Possible pure strategies: sell, don't sell
- Possible beliefs: expect to sell, expect not to sell
- Possible personal equilibria?
    1. Expect to sell, actually sell
    2. Expect not to sell, don't sell

Personal Equilibrium: An Example

How do we identify personal equilibria?

- Work out RD EU of possible actions given possible beliefs
- Which actions are optimal given expectations?

	Expects to Sell	**Expects Not to Sell**
Sells	p	$(1+\eta)p - \eta\lambda v_b$
Does Not Sell	$(1+\eta)v_b - \eta\lambda p$	v_b

Preferred Personal Equilibrium

- **Preferred personal equilibrium**: the (usually unique) personal equilibrium which generates highest expected utility

$$E\left[u\left(a|r=a\right)\right] \geq E\left[u\left(a'|r=a'\right)\right] \text{ for all } a' \in \text{PE}$$

- Sell/Expect to sell is PPE $\Leftrightarrow p > v_b$
- (Verifiable) claim: given piece-wise linear gain/loss utility, the unique PPE in deterministic environments maximizes consumption utility
- So, what explains the mug experiments?

Personal Equilibrium Under Risk

- Risk-free environments: RE RD EU makes same predictions as EU
- Mug experiments: "surprise" opportunities to trade
- How do we deal with risk, stochastic reference points?

$$U(F|G) = \int \int u(c|r)dG(r)dF(c)$$

Personal Equilibrium Under Risk

Choosing a lottery ⇒ stochastic reference point

- Example: suppose you expected to have to play Samuelson's lottery, but instead someone simply gave you the expected value ($50)

$$u(c|r) = c + \mu(c|r)$$

$$\begin{aligned} &= w + 50 \\ &\quad + \frac{1}{2}\eta(\underbrace{w + 50 - (w - 100)}_{\text{gain relative to losing \$100}}) + \frac{1}{2}\eta\lambda(\underbrace{w + 50 - (w + 200)}_{\text{loss relative to winning \$200}}) \\ &= w + 50 + \frac{1}{2}\eta 150 - \frac{1}{2}\eta\lambda 150 \\ &= w + 50 + 75\eta(1 - \lambda) \end{aligned}$$

Example: Shopping

- Consider Botond, who is considering buying shoes

$$u(c, d) = c + d$$

where $c \in \{0, 1\}$ is shoes and d is dollars

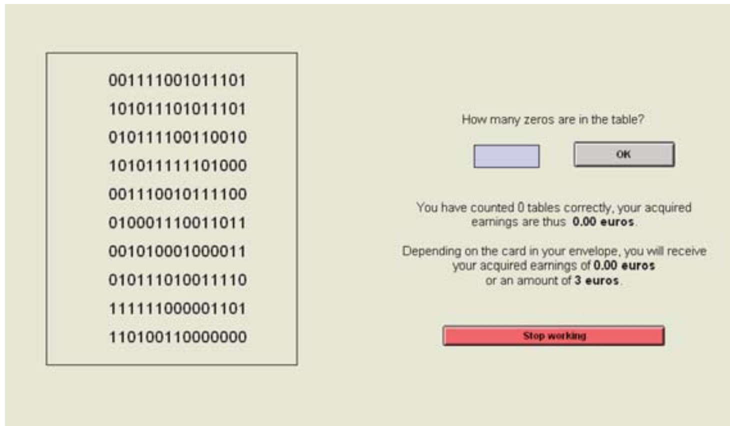
- Normalize endowment to $(0, 0)$
- Claims about the deterministic p case:
  - Botond more likely to buy if he expects to
  - Exists p_{min} (p_{max}) such that Botond will always (never) buy

Testing the RE RD Model: Effort Provision

Abeler et al (AER, 2011) test the RE RD EU model

- Subjects complete tedious effort task, paid piece rate
  - Receive piece rate earnings with probability 0.5
  - Otherwise, receive fixed payment regardless of effort
- Size of fixed payment varies across treatments
  - LO treatment: fixed payment is 3 euros
  - HI treatment: fixed payment is 7 euros

Testing the RE RD Model: Effort Provision



Theoretical Predictions: Standard Model

Assume utility depends on payout, effort:

$$E[U(y,e)] = E[u(y)] - E[c(e)]$$
$$= \frac{1}{2}u(we) + \frac{1}{2}u(f) - c(e)$$

where f denotes fixed payment, w denotes piece rate

- Interior solution independent of f
  - Prediction: no difference in effort across treatments
- Same is true in RD case if reference point is status quo
- What if reference point is rational expectations?

Theoretical Predictions: RE RD EU

Assumptions:

- Linear consumption utility
- Piecewise linear gain-loss utility

$$\mu\left(c_k - r_k\right) = \begin{cases} \eta\left(c_k - r_k\right) & \text{if } c_k - r_k \geq 0 \\ \eta\lambda\left(c_k - r_k\right) & \text{if } c_k - r_k < 0 \end{cases}$$

- Reference lottery (over payouts): $\mathcal{L} = \{0.5, 0.5; we, f\}$

Theoretical Predictions: RE RD EU

For $we \leq f$, utility function is given by:

$$U(e) = \frac{we + f}{2} - c(e) + \frac{1}{2}\left[\frac{1}{2}\eta(0) + \frac{1}{2}\eta\lambda(we - f)\right] + \frac{1}{2}\left[\frac{1}{2}\eta(f - we) + \frac{1}{2}\eta\lambda(0)\right]$$

$\Rightarrow$ FOC: $\frac{w}{2} - c'(e) + \frac{1}{4}\eta\lambda w - \frac{1}{4}\eta w = 0$

$\Leftrightarrow c'(e) = \frac{w}{2} + \frac{w}{4}\eta(\lambda - 1)$

For $we > f$, utility function is given by:

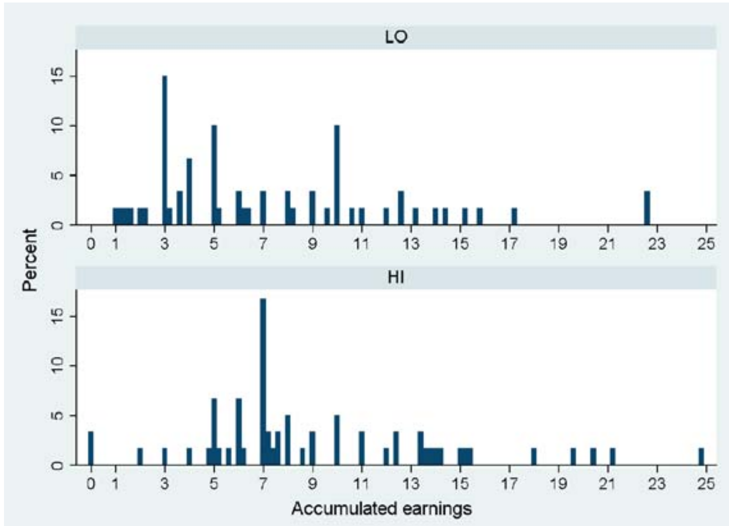
$$u(y, e) = \frac{we + f}{2} - c(e) + \frac{1}{2}\left[\frac{1}{2}\eta(0) + \frac{1}{2}\eta(we - f)\right] + \frac{1}{2}\left[\frac{1}{2}\eta\lambda(f - we) + \frac{1}{2}\eta(0)\right]$$

$\Rightarrow$ FOC: $\frac{w}{2} - c'(e) + \frac{1}{4}\eta w - \frac{1}{4}\eta\lambda w = 0$

$\Leftrightarrow c'(e) = \frac{w}{2} - \frac{w}{4}\eta(\lambda - 1)$

Implication: the marginal utility of effort drops off at level of fixed payment

Main Results



Main Results

	OLS: Accumulated earnings			OLS: Time spent working (in min.)			Tobit: Time spent working (in min.)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1 if HI treatment	1.850**	1.942**	1.973**	6.430**	6.572**	6.784**	7.927**	8.091**	8.442**
	(0.917)	(0.885)	(0.900)	(3.163)	(3.153)	(3.231)	(3.841)	(3.814)	(3.833)
Productivity		0.059***	0.064***		0.091	0.096		0.098	0.103
		(0.019)	(0.020)		(0.067)	(0.070)		(0.080)	(0.083)
1 if Female			-0.039			1.619			1.577
			(0.950)			(3.412)			(4.035)
Controls for temperature	No	No	Yes	No	No	Yes	No	No	Yes
Controls for time of day	No	No	Yes	No	No	Yes	No	No	Yes
Constant	7.370***	10.607***	10.200***	31.715***	36.713***	34.362***	33.004***	38.389***	35.306***
	(0.648)	(1.206)	(1.445)	(2.237)	(4.297)	(5.190)	(2.697)	(5.143)	(6.116)
N.Obs.	120	120	120	120	120	120	120	120	120
Adjusted or Pseudo R^2	0.03	0.09	0.08	0.03	0.03	0.00	0.00	0.01	0.01

Main Results

	(1a) Stop at 3	(1b) Stop at 7	(2a) Stop at 3	(2b) Stop at 7	(3a) Stop at 3	(3b) Stop at 7
1 if HI treatment	-2.197**	1.609**	-2.191**	1.620**	-2.318**	1.781**
	(1.073)	(0.801)	(1.074)	(0.802)	(1.115)	(0.829)
Productivity			0.003	0.005	-0.003	0.004
			(0.014)	(0.016)	(0.019)	(0.020)
1 if Female					-1.094	0.106
					(0.789)	(0.661)
Controls for temperature	No		No		Yes	
Controls for time of day	No		No		Yes	
Constant	-1.695***	-3.199***	-1.523*	-2.946***	-1.437	-3.032**
	(0.363)	(0.721)	(0.848)	(1.121)	(1.215)	(1.326)
N.Obs.	120		120		120	
Pseudo R^2	0.09		0.09		0.17	

Interpretation

Model predicts that proximity to f related to loss aversion

- Measure loss aversion at individual level using lotteries
  - Lotteries which pay six euros with probability 0.5, $-Z$ otherwise
  - Z ranges from 2 to 7
  - How many are accepted is a measure of loss aversion
- Relate loss aversion to absolute distance between e and f

Interpretation

	$\lvert we - f \rvert$			
	(1)	(2)	(3)	(4)
Loss aversion	-0.489**	-0.500**	-0.518**	-0.472**
	(0.220)	(0.222)	(0.222)	(0.236)
Productivity			0.013	0.014
			(0.009)	(0.010)
1 if Female				-0.188
				(0.578)
Controls for treatments	No	Yes	Yes	Yes
Controls for temperature	No	No	No	Yes
Controls for time of day	No	No	No	Yes
Constant	6.040***	6.726***	7.522***	7.368***
	(0.934)	(1.050)	(1.191)	(1.273)
N.Obs.	238	238	238	238
Adjusted R^2	0.02	0.01	0.02	0.01