AREC 815: Experimental and Behavioral Economics

Measuring Risk Preferences

Professor: Pamela Jakiela

Department of Agricultural and Resource Economics
University of Maryland, College Park

Expected Utility

Risk Preferences: the Standard Model

A simple lottery: $L = \{p_1, \ldots, p_K; x_1, \ldots, x_K\}$ s.t. $\sum_k p_k = 1$

- A set of probabilities (that sum to 1) and associated payoffs

Continuity: for all simple lotteries L_1, L_2, L_3, the sets

$$\{\alpha \in [0,1] : \alpha L_1 + (1-\alpha)L_2 \succsim L_3\} \in [0,1]$$

and

$$\{\alpha \in [0,1] : L_3 \succsim \alpha L_1 + (1-\alpha)L_2\} \in [0,1]$$

are closed.

Continuity means that preferences don't change discontinuously (for example, at the ends of the probability space)

Risk Preferences: the Standard Model

Independence: for all simple lotteries L_1, L_2, L_3 and all $\alpha \in (0,1)$,

$$L_1 \succsim L_2 \Leftrightarrow \alpha L_1 + (1-\alpha)L_3 \Leftrightarrow \alpha L_2 + (1-\alpha)L_3.$$

When a rational preference relation over lotteries satisfies the continuity and independence axioms, it admits an expected utility representation

Risk Preferences: the Standard Model

VNM EU-maximizing preferences:

- Individuals have well-defined preferences over outcomes
- Outcome utilities are weighted by probabilities
- Risk aversion $\Leftrightarrow$ concave utility function over outcomes

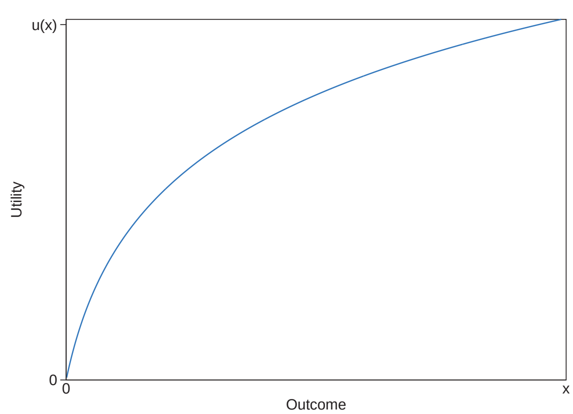
The expected utility of lottery L is given by:

$$EU(L) = \sum_k p_k u(x)$$

where $u(\cdot)$ is a well-defined Bernoulli utility function over outcomes

Risk Preferences: the Standard Model

What is risk aversion?



Risk Preferences: the Standard Model

The following are equivalent:

- The agent is **risk averse**
- $u(\cdot)$ is concave
- The **certainty equivalent** for all lotteries below the expected value
- For all $x, \varepsilon > 0$, the **probability premium** $\pi(x, \varepsilon, u)$ such that

$$u(x) = \left[\frac{1}{2} - \pi(x, \varepsilon, u)\right] u(x - \varepsilon) + \left[\frac{1}{2} + \pi(x, \varepsilon, u)\right] u(x + \varepsilon)$$

  is positive.

Risk Preferences: the Standard Model

Arrow-Pratt coefficients of risk aversion:

$$a = -\frac{u''(x)}{u'(x)} \quad \text{and} \quad r = -\frac{xu''(x)}{u'(x)}$$

Can't always rank utility functions in terms of risk aversion

- Arrow-Pratt coefficients depend on payoff level, x
- $u(\cdot)$ is **strictly more risk averse than** $v(\cdot)$
  $\Leftrightarrow$ exists a strictly concave function $f(\cdot)$ such that $u(\cdot) = f(v(\cdot))$

Some utility functions can be ranked in terms of a single parameter

- CARA: $u(x) = -e^{-\alpha x}$
- CRRA: $u(x) = \frac{x^{1-\rho}}{1-\rho}$

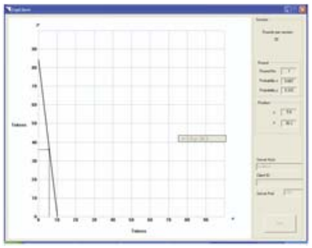
Measuring Risk Preferences

Portfolio Choice Designs

Choices from continuous sets ⇒ power to estimate precise parameters

Jakiela-Ozier (2016): simple portfolio choice design

Choi et al (2007, 2014): state-contingent securities



⇒ Different strategies for presenting the same (type of) choice problem

- Early examples: Loomes (1991), Gneezy and Potters (1997)

Portfolio Choice Designs

Portfolio choice problem:

- Choose $x \leq m$ to invest in risky (but profitable) asset
- Agents maximize: $p_{success} \cdot u(m + \lambda x) + (1 - p_{success}) \cdot u(m - x)$
- Functional form assumptions lead to analytical solutions

State-contingent securities problem:

- Make allocation to state-contingent securities s.t. $y + q \cdot z \leq m$
- Agents maximize: $p_y u(y) + p_z u(z)$
- Analogous to portfolio choice problem when $p_y + p_z = 1$

Binswanger's Methodology

Binswanger (1980) is: the original lab-in-the-field experiment, seminal experimental strategy for measuring individual risk aversion

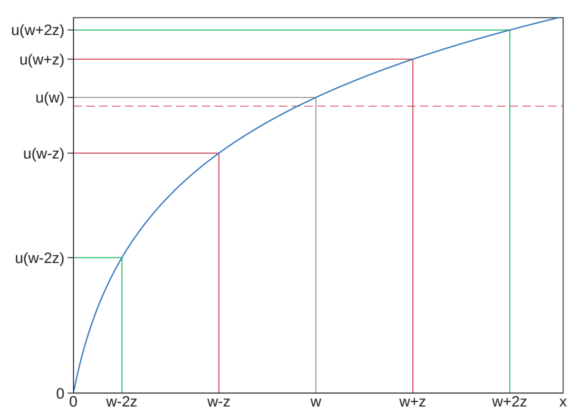
- Menu of lotteries increasing in expected value, risk
- Subjects were Indian villagers (ICRISAT villages)
- Sequence of real and hypothetical choices over many weeks
- Stakes increased over time

Binswanger's Methodology

Menu of lotteries in Binswanger's experiment:

Choice	Panel A: Heads—Low Payoff	Panel A: Tails—High Payoff	Risk Aversion Class	S Approximate Partial Risk Aversion Coefficient[a]
O	50	50	Extreme	∞ to 7.51
A	45	95	Severe	7.51 to 1.74
B	40	120	Intermediate	1.74 to .812
D*	35	125	Inefficient	
C	30	150	Moderate	.812 to .316
D	20	160	Inefficient	
E	10	190	Slight-to-neutral	.316 to 0
F	0	200	Neutral-to-negative	0 to −∞

Risk Preferences: the Standard Model



Binswanger's Methodology

Table 2. Sequence of Games and Hypothetical Questions

Game Number	Minimum Delay Since Last Event[a]	Game Level (Rs.)	Real or Hypothetical
1	First Day	0.50	Real
2	One day	0.50	Real
3	One day	0.50	Real
4	One day	0.50	Real
5	One day	0.50	Real
6	Two weeks	50.00	Hypothetical
7	Same day	5.00	Real
	Same day	Hand out Rs.5.00 for next day game	
8	One day	50.00	Hypothetical
9	Same day	5.00	Real
10	Same day	5.00·	Hypothetical
11	Two Weeks	500.00	Hypothetical
12	Same day	50.00	Real
13	Same day	50.00	Hypothetical
14	Same day	50.00	Hypothetical
15	Same day	5.00	Hypothetical
16	Two weeks	500.00	Hypothetical
17	Same day	50.00	Hypothetical

Binswanger's Methodology

Table 6. Regression of Personal Characteristics on Partial Risk Aversion

	0.5 Rupees		5 Rupees		50 Rupees	500 Rupees
	No. 2 (1)	No. 5 (2)	No. 7 (3)	No. 9 (4)	No. 12 (5)	No. 16 (6)
Intercept	−2.975	−1.894	−0.238	−3.498	0.202	0.421
Village 1	0.734	−0.018	−0.320	1.859	0.404	−0.314
	(1.194)	(0.032)	(0.696)	(3.792)*	(1.295)	(1.804)*
Village 2	1.569	−0.526	−0.776	1.809		
	(2.663)	(0.873)	(1.766)*	(3.851)*		
Village 3	1.576	1.286	0.252	2.343	0.573	−0.165
	(2.620)*	(2.112)*	(0.567)	(4.938)*	(1.965)*	(1.010)
Village 4	0.918	−0.484	−0.304	1.378		
	(1.563)	(0.797)	(0.686)	(2.880)*		
Village 5	−0.387	−1.165	−0.918	1.254		
	(0.692)	(2.051)*	(2.222)*	(2.838)*		
Women	0.810	1.100	0.204	−0.878	−0.073	−0.027
	(1.337)	(1.1785)*	(0.456)	(1.832)*	(0.184)	(0.122)
Progressive farmer dummy	−0.245	−1.187	−1.141	0.088	−0.193	−0.320
	(0.391)	(1.869)*	(2.473)*	(0.179)	(0.424)	(1.259)
Working age adults (weighted share age 15–59)	0.452	−0.761	0.092	1.070	0.081	0.328
	(0.594)	(0.992)	(0.167)	(1.794)	(0.161)	(1.167)
Salary (Rs.1000/month)	0.232	−0.051	−0.493	−0.294	−0.141	−0.208
	(0.769)	(0.164)	(2.213)*	(1.232)	(0.645)	(1.700)*
Land rented (hectares)	−0.092	−0.233	−0.049	0.012	0.053	0.0008
	(1.232)	(3.072)*	(0.891)	(0.210)	(0.748)	(0.000)
Gambler dummy	−1.087	−0.591	0.381	−1.300	−0.125	0.210
	(0.837)	(0.447)	(0.397)	(1.268)	(0.195)	(0.583)
Age (years)	0.017	0.023	0.009	0.021	−0.016	−0.0025
	(1.202)	(1.573)	(0.848)	(1.894)	(1.648)	(0.465)
Schooling (years)	0.061	−0.027	−0.105	−0.012	−0.038	−0.037
	(0.984)	(0.424)	(2.311)*	(0.241)	(0.915)	(1.586)
Assets (in 1000 Rs.)	−0.019	−0.0055	−0.0041	−0.012	0.0032	−0.001
	(2.491)*	(0.735)	(0.744)	(2.068)*	(0.568)	(0.345)
Net transfers (received in 1000 Rs.)	−0.247	−0.502	−0.388	−0.241	−0.055	0.005
	(1.021)	(2.048)*	(2.176)*	(1.265)	(0.437)	(0.071)
Luck	−0.240	−0.269	−0.156	−0.145	−0.133	−0.043
	(1.428)	(3.015)*	(2.549)*	(2.399)*	(2.641)*	(1.672)*
$\bar{R}^2$	0.110	0.179	0.202	0.205	0.034	0.088
F	2.762	4.096	4.598	4.653	1.302	1.814
N observations	228	228	228	228	111	111

Holt-Laury Methodology

Multiple price list decision task:

TABLE 1—THE TEN PAIRED LOTTERY-CHOICE DECISIONS WITH LOW PAYOFFS

Option A	Option B	Expected payoff difference
1/10 of \$2.00, 9/10 of \$1.60	1/10 of \$3.85, 9/10 of \$0.10	\$1.17
2/10 of \$2.00, 8/10 of \$1.60	2/10 of \$3.85, 8/10 of \$0.10	\$0.83
3/10 of \$2.00, 7/10 of \$1.60	3/10 of \$3.85, 7/10 of \$0.10	\$0.50
4/10 of \$2.00, 6/10 of \$1.60	4/10 of \$3.85, 6/10 of \$0.10	\$0.16
5/10 of \$2.00, 5/10 of \$1.60	5/10 of \$3.85, 5/10 of \$0.10	−\$0.18
6/10 of \$2.00, 4/10 of \$1.60	6/10 of \$3.85, 4/10 of \$0.10	−\$0.51
7/10 of \$2.00, 3/10 of \$1.60	7/10 of \$3.85, 3/10 of \$0.10	−\$0.85
8/10 of \$2.00, 2/10 of \$1.60	8/10 of \$3.85, 2/10 of \$0.10	−\$1.18
9/10 of \$2.00, 1/10 of \$1.60	9/10 of \$3.85, 1/10 of \$0.10	−\$1.52
10/10 of \$2.00, 0/10 of \$1.60	10/10 of \$3.85, 0/10 of \$0.10	−\$1.85

Holt-Laury Methodology

TABLE 3—RISK-AVERSION CLASSIFICATIONS BASED ON LOTTERY CHOICES

Number of safe choices	Range of relative risk aversion for $U(x) = x^{1-r}/(1-r)$	Risk preference classification	Proportion of choices: Low real[a]	20x hypothetical	20x real
0–1	$r < -0.95$	highly risk loving	0.01	0.03	0.01
2	$-0.95 < r < -0.49$	very risk loving	0.01	0.04	0.01
3	$-0.49 < r < -0.15$	risk loving	0.06	0.08	0.04
4	$-0.15 < r < 0.15$	risk neutral	0.26	0.29	0.13
5	$0.15 < r < 0.41$	slightly risk averse	0.26	0.16	0.19
6	$0.41 < r < 0.68$	risk averse	0.23	0.25	0.23
7	$0.68 < r < 0.97$	very risk averse	0.13	0.09	0.22
8	$0.97 < r < 1.37$	highly risk averse	0.03	0.03	0.11
9–10	$1.37 < r$	stay in bed	0.01	0.03	0.06

[a] Average over first and second decisions.

Holt-Laury Experimental Design

TABLE 2—SUMMARY OF LOTTERY-CHOICE TREATMENTS

Treatment	Number of subjects	Average earnings	Minimum earnings	Maximum earnings
20x Hypothetical Only	25	$ 25.74	$ 19.40	$ 40.04
20x Real Only	57	$ 67.99	$ 20.30	$116.48
20x Hypothetical and Real	93	$ 68.32	$ 11.50	$105.70
50x Hypothetical and Real	19	$131.39	$111.30	$240.59
90x Hypothetical and Real	18	$226.34	$ 45.06	$391.65

Low Stakes vs. High Stakes

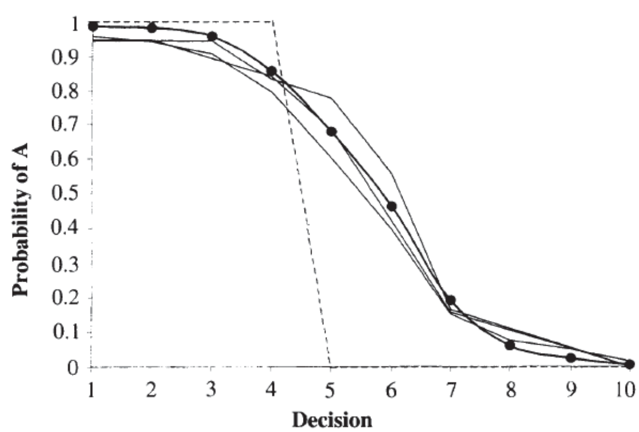


FIGURE 1. PROPORTION OF SAFE CHOICES IN EACH DECISION: DATA AVERAGES AND PREDICTIONS

Low Stakes vs. High Stakes

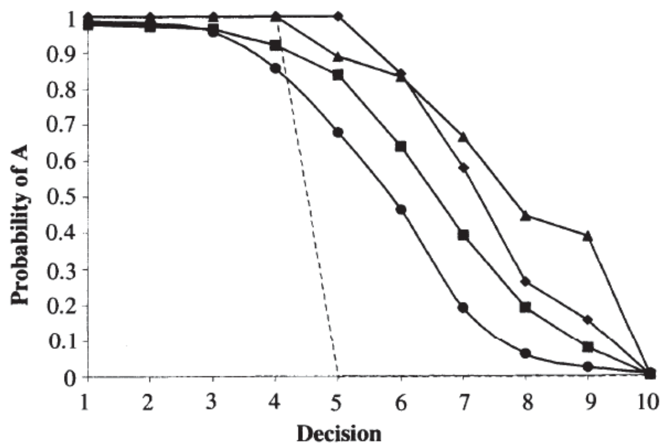


FIGURE 2. PROPORTION OF SAFE CHOICES IN EACH DECISION: DATA AVERAGES AND PREDICTIONS

Utility Parameters

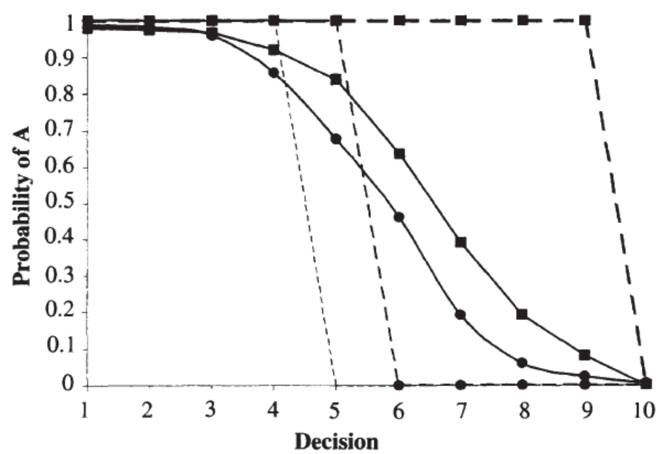


FIGURE 3. PROPORTION OF SAFE CHOICES IN EACH DECISION: DATA AVERAGES AND PREDICTIONS

Utility Parameters

Propose to estimate a utility function of the "power-expo" form:

$$u(x) = \frac{1 - e^{-\alpha x^{1-\rho}}}{\alpha}$$

Approaches CARA as $\rho \to 0$, approaches CRRA as $\alpha \to 0$

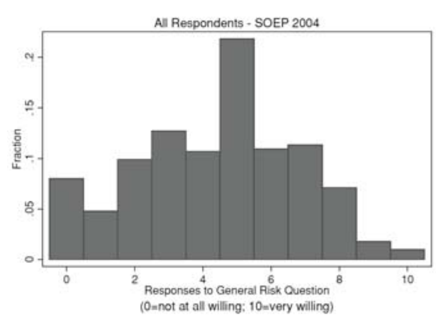
Pool data across subjects, estimate a single set of parameters

Parameter	Estimate
α	0.029
ρ	0.269

Survey Questions Measuring Risk Attitudes

Dohmen et al (JEEA, 2011) embed a simple question about risk in a large, representative survey of the adult German population

"How willing are you to take risks, in general?"



Survey Questions Measuring Risk Attitudes

Does a survey question capture risk attitudes/preferences?

- As a test of construct validity, they conduct an incentivized MPL experiment with a smaller representative sample of German adults

Dependent variable: value of safe option at switching point

	(1)	(2)	(3)
Willingness to take risk in general	0.611***	0.484***	0.401***
	[0.123]	[0.125]	[0.131]
Controls for gender, age, height	No	Yes	Yes
Other controls	No	No	Yes
Constant	5.919***	−5.923	−14.287
	[0.661]	[7.916]	[10.724]
Log sigma	1.867***	1.848***	1.736***
	[0.037]	[0.037]	[0.040]
Log pseudo-likelihood	−1,348	−1,341	−1,111
Observations	450	450	383

Interval regression coefficient estimates. The dependent variable is the value of the safe option at the switching point. Other controls include controls for marital status, number of dependent children under 16, lived in GDR in 1989, lived abroad in 1989, location in 1989 missing, nationality, student, educational achievement, dummies for occupational level within public and private sector, health status, body weight, net household income, and life satisfaction, see also Table A.1. Robust standard errors in brackets; ***, **, * indicate significance at the 1%, 5%, and 10% level, respectively.

Are Risk Preferences Stable across Domains?

TABLE 4. Correlations between risk attitudes in different contexts.

	General	Car driving	Financial matters	Sports/ Leisure	Career	Health
Mean	4.420	2.927	2.406	3.486	3.605	2.934
Standard Deviation	2.379	2.535	2.225	2.613	2.708	2.465
Mean (men)	4.909	3.523	2.882	3.961	4.039	3.318
Mean (women)	3.967	2.346	1.963	3.044	3.190	2.580
General	1.0000					
Car driving	0.4891	1.0000				
Financial matters	0.5036	0.5190	1.0000			
Sports/Leisure	0.5595	0.5426	0.4992	1.0000		
Career	0.6088	0.5070	0.4978	0.6033	1.0000	
Health	0.4768	0.5041	0.4564	0.5205	0.5311	1.0000
Observations	21,877	20,600	21,687	21,570	19,898	21,864

Correlations are based on individuals' risk attitudes in each context, reported on an eleven-point scale. Choosing 0 indicates "not at all willing take risks" and choosing 10 indicates "very willing to take risks". Correlations based on 19,043 observations with responses to all risk questions.

Measuring Risk Preferences

Experimental design questions:

- Assumptions: EU? CRRA/CARA functional form?
- Incentivized vs. hypothetical choices

Experimental designs:

- Discrete choices
  - Multiple price lists
  - Other discrete choice designs
- Continuous choice sets
- Other (e.g. survey) approaches