RISK IN TIME

The Intertwined Nature of Risk Taking and Time Discounting

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Outline

Introduction

- Practically all important decisions involve consequences that
  1. are uncertain, and
  2. materialize in the future
- Future is inherently uncertain
- Therefore, the analysis of human behavior must take future uncertainty into account
- **Question:** How does future uncertainty affect our decisions?

Outline

Seven Observations on Risk Taking and Time Discounting

Dimension	**Observed risk tolerance**	**Observed patience**
Delay dependence	#1 increases with delay	#2 increases with delay
Process dependence	#3 higher for one-shot valuation	#4 higher for one-shot valuation
Timing dependence	#5 higher for late uncertainty resolution	—
Risk dependence	—	#6 higher for risky payoffs
Order dependence	#7 depends on sequence of delay and risk discounting	—

Seven Observations: Experimental Evidence

Dimension	Observed risk tolerance	Observed patience
Delay dependence	#1 Abdellaoui et al. (MS 2011)	#2 Frederick et al. (JEL 2002), Epper et al. (JRU 2010)
Process dependence	#3 Gneezy and Potters (QJE 1997)	#4 Read and Roelofsma (OBHDP 2003)
Timing dependence	#5 Chew and Ho (JRU 1994)	—
Risk dependence	—	#6 Ahlbrecht and Weber (JITE 1997)
Order dependence	#7 Önculer and Onay (JBDM 2009)	—

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Seven Observations: Proposed Solutions

Dimension	Observed risk tolerance	Observed patience
Delay dependence	#1 increases with delay	#2 hyperbolic discounting models (Ainslie (AER P&P 1991), Loewenstein and Prelec (QJE 1992), Laibson (QJE 1997))
Process dependence	#3 higher for one-shot valuation	#4 higher for one-shot valuation
Timing dependence	#5 higher for late uncertainty resolution	–
Risk dependence	–	#6 higher for risky payoffs
Order dependence	#7 depends on sequence of delay and risk discounting	–

Seven Observations: Proposed Solutions

Dimension	Observed risk tolerance	Observed patience
Delay dependence	#1 increases with delay	#2 increases with delay
Process dependence	#3 higher for one-shot valuation	#4 higher for one-shot valuation
Timing dependence	#5 recursive preferences (Kreps and Porteus (Ecta 1978))	—
Risk dependence	—	#6 higher for risky payoffs
Order dependence	#7 depends on sequence of delay and risk discounting	—

Seven Observations: “Seven” different theories?

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Seven Observations: One unifying approach

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The Model

Two components:

1. **Belief:** constant per-period survival probability
2. **Atemporal risk preferences:** Rank-Dependent Utility (Quiggin, JEBO 1982; Yaari, Ecta 1979)

1. Belief Component: Constant Per-Period Surival Probability s

"A bird in the hand is worth two in the bush."

- **Prospect:** $P = (x_1, p_1; x_2, p_2; ...; x_m, p_m)$ with $\sum_{i=1}^{m} p_i = 1$ and $\forall i \; p_i > 0$
- **Adding a delay** t**:**
  - $P \rightarrow \tilde{P} = (x_1, p_1 s^t; x_2, p_2 s^t; ...; x_m, p_m s^t; \underline{x}, 1 - s^t)$ with $x_m > \underline{x}$
- **Example:**
  - $P = (\text{EUR } 10) \rightarrow \tilde{P} = (\text{EUR } 10, s^t; \text{EUR } 0, 1 - s^t)$

2. Preference Component: Atemporal Risk Preferences

Risk preference when the passage of time is immaterial $\Rightarrow$ *evidence from experiments and gambling market behavior*

Accommodate two well-established characteristic of atemporal risk preferences:
Allais (Ecta 1953) common ratio effect: Preference reversal when scaling down probabilities

ad 2: The Allais Common Ratio Effect in a Nutshell

Classic example (Kahneman and Tversky, Ecta 1979):

Pair	Alternative A		Alternative B
1	(3000)	$\succ$	$(4000, 0.8; 0, 0.2)$
2	$(3000, 0.25; 0, 0.75)$	$\prec$	$(4000, 0.2; 0, 0.8)$

- Note that
  - $(3000, 0.25; 0, 0.75) = \frac{1}{4}(3000) + \frac{3}{4}(0)$
  - $(4000, 0.2; 0, 0.8) = \frac{1}{4}(4000, 0.8; 0, 0.2) + \frac{3}{4}(0)$
- Expected utility's **independence axiom** says that (probabilistically) mixing $A1$ and $B1$ with a third prospect (here: 0) should not revert preferences
- The common ratio effect thus posits a violation of this axiom

$\Rightarrow$ **Preferences are nonlinear in probabilities**

ad 2: Probability Weighting

- **Experiments:** Kahneman and Tversky (Ecta 1979), Fehr-Duda, Bruhin, Epper and Schubert (JRU 2010)
- **Insurance demand / deductible choice:**
  - Wakker, Thaler and Tversky (JRU 1997)
  - Sydnor (AEJ:Applied 2010)
  - Barsheyan, Molinari, O'Donohue and Teitelbaum (AER 2013)
- **Speculative markets:** Snowberg and Wolfers (JPE 2010)
- **Asset markets:** Dimmock, Kouwenberg, Mitchell and Peinenburg (RevFinancStud 2018)

2. Preference Component: Atemporal Risk Preferences

Rank-Dependent Utility (RDU):

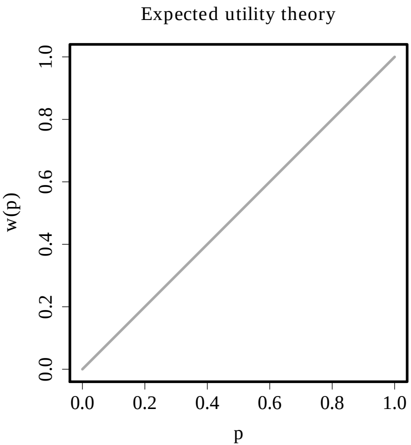
1. Nests expected utility theory
2. Retains asset integration, transitivity and first-order stochastic dominance
3. Marginal utility $\neq$ risk aversion
4. Incorporates first-order risk aversion everywhere (Segal and Spivak, JET 1990)

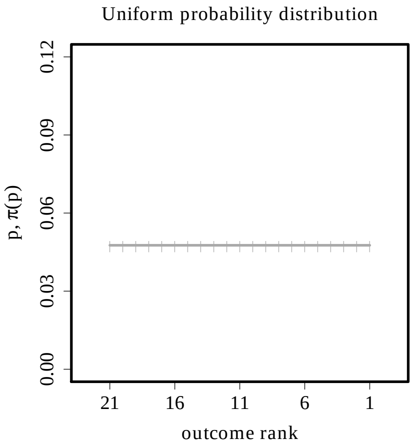
$$V(P) = \sum_{i=1}^{m} \pi_i u(x_i)$$

$$\pi_i = \begin{cases} w(p_1) & \text{for } i = 1 \\ w\left(\sum_{k=1}^{i} p_k\right) - w\left(\sum_{k=1}^{i-1} p_k\right) & \text{for } 1 < i \leq m \end{cases}$$

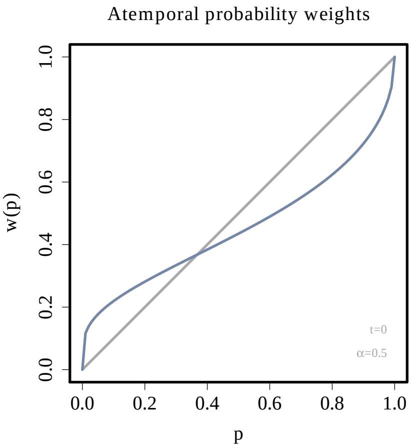
- **Probability weighting function:** w is
  - **subproportional**, i.e. $\frac{w(p)}{w(q)} > \frac{w(\lambda p)}{w(\lambda q)}$ for $1 \geq p > q > 0$ and $0 < \lambda < 1$
  - **regressive**, i.e. $w(p) > p$ for $p < p^* \in (0, 1)$ and $w(p) < p$ for $p > p^*$

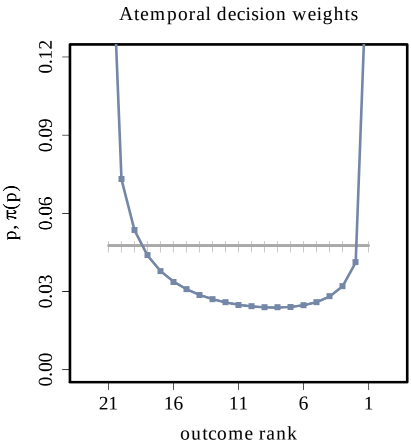
Illustration





Rank-Dependent Utility





Obtaining Predictions

- **Decision maker** evaluates prospects with RDU and weighting function w

$$\tilde{P} = \left(x_1, p_1 s^t; x_2, p_2 s^t; \ldots; x_m, p_m s^t; \underline{x}, 1 - s^t\right)$$

- **Observer** infers preferences using RDU with weighting function $\tilde{w}$ <!– and discount factor $\tilde{\rho}$ –>

$$P = \left(x_1, p_1; x_2, p_2; \ldots; x_m, p_m\right)$$

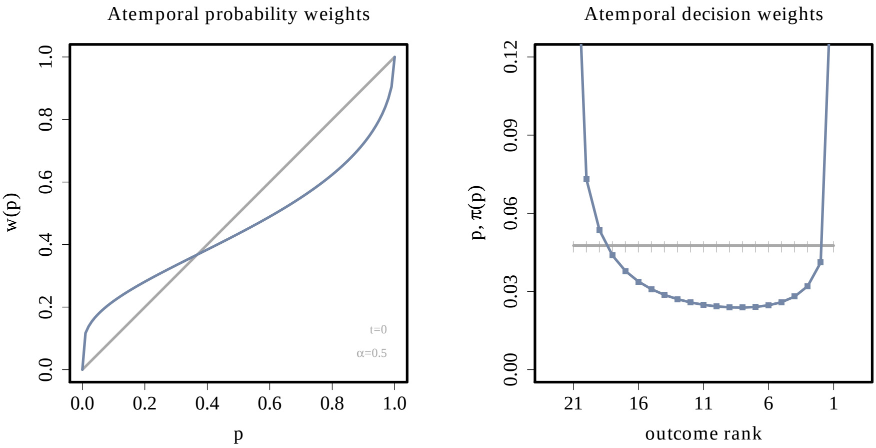
$\Rightarrow$ True and observed weights relate as follows: $\tilde{w}(p) = \frac{w(ps^t)}{w(s^t)}$

Prediction 1: Characteristics of Revealed Risk Preferences

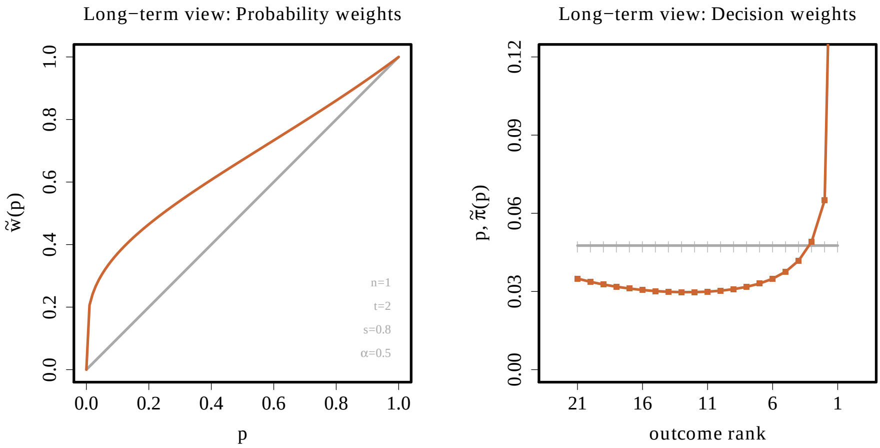
It follows directly from subproportionality of w and $s < 1$ that

- $\tilde{w}$ is a proper, subproportional probability weighting function
- $\tilde{w}$ is more elevated
  - the longer the time delay t
  - the higher the survival risk $1 - s$, and
  - the stronger the degree of subproportionality of w

Atemporal Risk Preferences

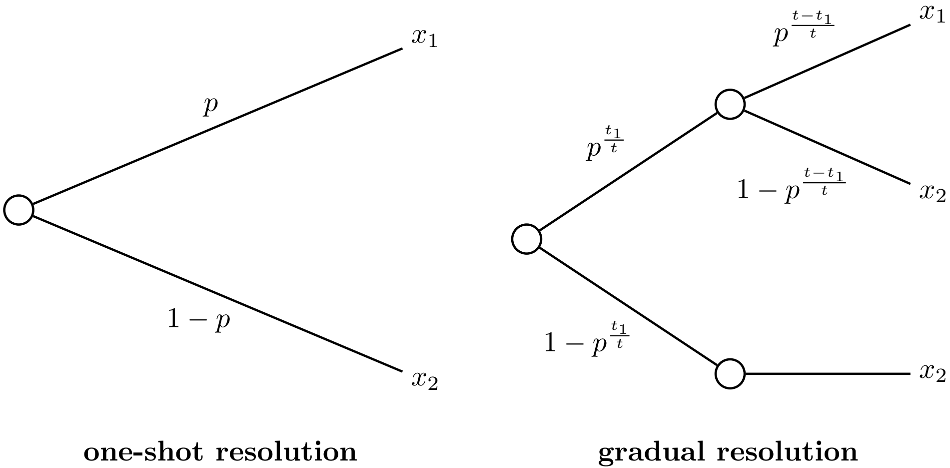


Delaying Resolution of Uncertainty



Prediction 2: Preference for One-Shot Resolution of Uncertainty

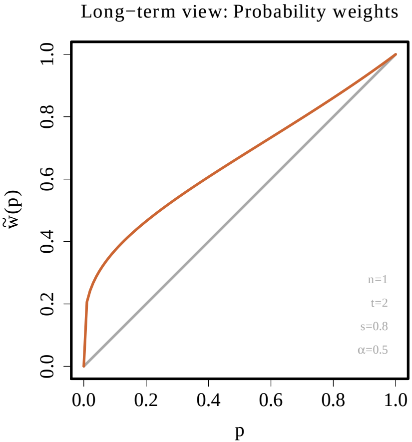
Prospect risk p may resolve in *one shot* or *gradually over time*

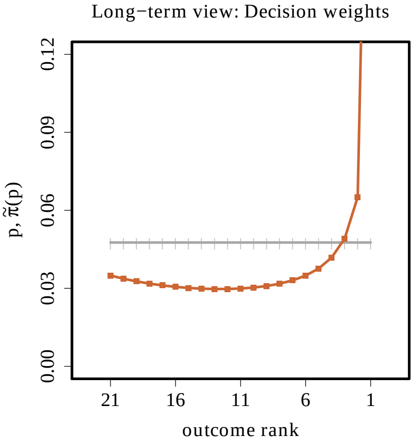


Prediction 2: Preference for One-Shot Resolution of Uncertainty

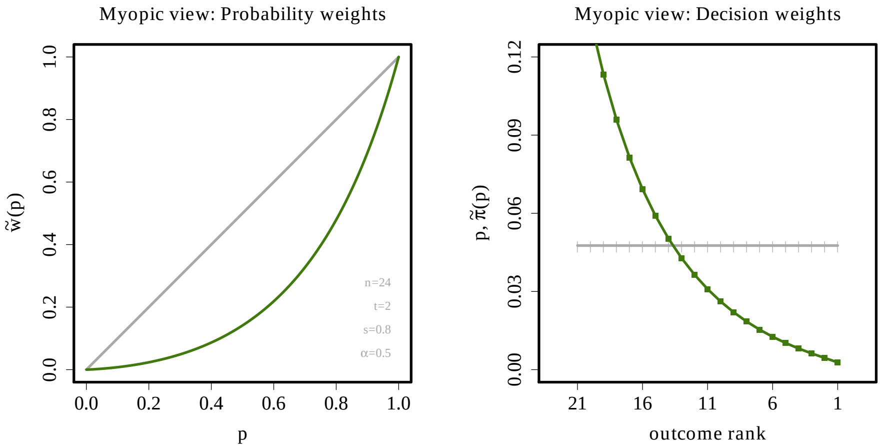
- If w is subproportional then $w(q)w(r) < w(qr) \Rightarrow$ reduction by probability calculus fails
- As a consequence, risk tolerance is higher for one-shot resolution of uncertainty than for sequential resolution of uncertainty

One-shot Resolution of Uncertainty in the Future





Sequential Resolution of Uncertainty in the Future



Outline

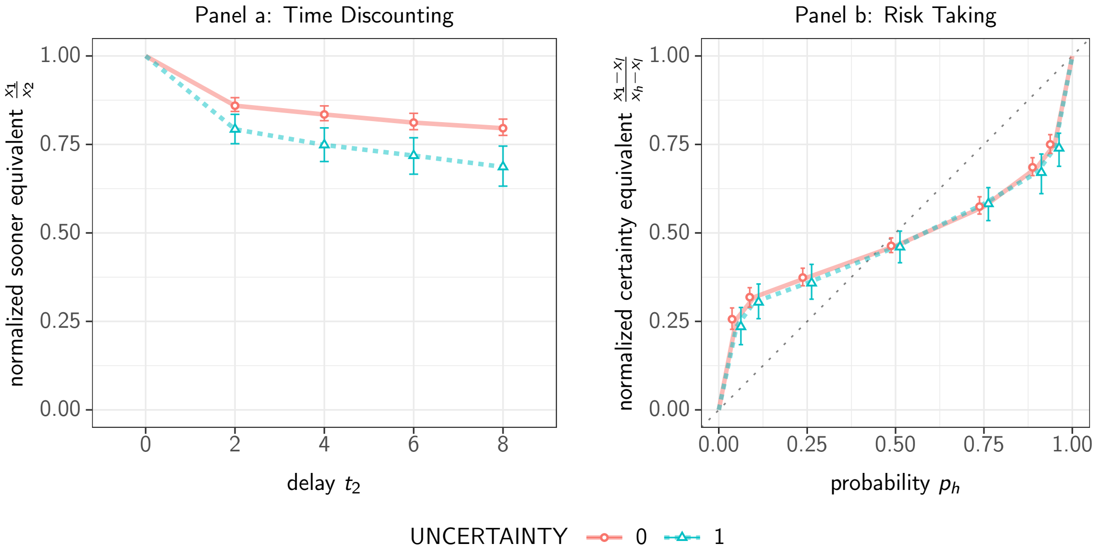
Data

- Time and risk preferences of 282 individuals recruited from the Swiss German speaking population
- Elicitation of sooner/certainty equivalents using varying outcomes, delays and probabilities
- **Survey question:**
  - *"Which of the following factors influenced your choices between sooner and later payments?"*
    1. For some reason it may be impossible for me to obtain the money.
    2. It is possible that the money will not be delivered.
    3. The survey organizers are not trustworthy.
    4. Other factors that cannot be influenced.
  - Reponses categories: *"clearly yes"*, *"rather yes"*, *"do not know"*, *"rather not"*, *"not at all"*

Measures

- **Perception:** Binary variable UNCERTAINTY
  - 1 if response was "*clearly yes*" or "*rather yes*"
  - 0 otherwise
- **Time preferences:** Normalized sooner equivalent $\frac{x_1}{x_2}$
- **Risk preferences:** Normalized certainty equivalent $\frac{x_1 - x_l}{x_h - x_l}$

Perception of Future Uncertainty



Estimated Survival Probabilities