



Preferences for Sequences of Long-Term Environmental Consequences

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(UCI Institute for Mathematical Behavioral Sciences Working Paper #99-16)

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Summary

- Define Decision Problem
- Preference for Sequences of Outcomes
- Experimental Design
- Results of Experiment
- Application of Intertemporal Models
- Results of Model Fitting
- Future Research Directions

Environmental Decision Problems

- Regulation of Air Quality, Water Quality, Conservation of Forests, etc.
- Need to Identify the Most Efficient Use of Resources
- Enable Decision Maker to Support and Justify Decision



Key Problem Characteristics

- Multiple Attributes
 - such as Monetary Costs and and Nonmonetary Benefits
- Outcomes at Different Points in Time
 - Sometimes Generations Apart
- Possible Uncertainty of Outcomes
 - Advance of Technology

Decision Analysis

Techniques

Powerful Approach to Structure and Analyze Large-Scale Decision Problems

- **Multiple Attributes**
 - Tradeoffs Between Attributes
 - Weights in Multi-Attribute Utility Model
- **Outcomes at Different Points in Time**
 - Tradeoff Between Time and Outcome
 - Discounting or other models
- **Possible Uncertainty of Outcomes**
 - Probability Weighting Function

Focus of Research

How are individual society members trading off the level of the environmental attributes which have long-term consequences with time?

What preference patterns do we observe?

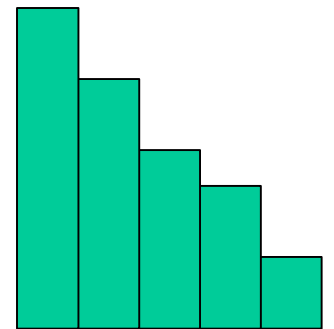
What type of decision model should we use in this situation?

Discounted Utility

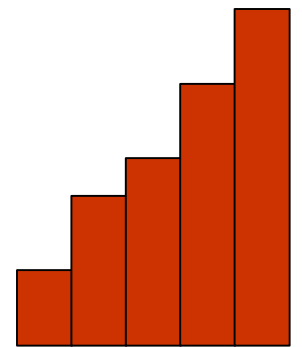
- Koopmans (1960)
 - Discounted Utility Theory
 - Axiomatic Framework for consumption bundles that are experienced over time.
 - $(x'_0, \dots, x'_T) \prec (x_0, \dots, x_T)$ iff
$$\sum_{\text{time } t=0 \text{ to } T} \delta^t u(x'_t) < \sum_{\text{time } t=0 \text{ to } T} \delta^t u(x_t)$$
 $u(c)$ is a concave ratio scaled utility function
 $0 < \delta = 1/(1+r) < 1$ is the constant discount factor for one period ($r =$ the discount rate)

Empirical Problems with Discounted Utility

DU implies **Positive Discount rate**
(prefer a sequence which declines)



Empirical Studies have shown that participants can display a **negative discount rate** (prefer increasing)



Income: Loewenstein and Sicherman (1991), Ross and Simonson (1991),
Loewenstein and Prelec (1992), Schmitt and Kemper (1996)

Health and Income: Chapman (1996)

Another Model

Loewenstein and Prelec (1993) propose a model to value sequences of outcomes that incorporates **the slope** and the **uniformity of the sequence**.

$$Value = \sum_{t=1}^n u_t + \mathbf{b} \sum_{t=1}^n d_t + \mathbf{s} \sum_{t=1}^n |d_t|$$

Research Question

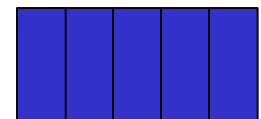
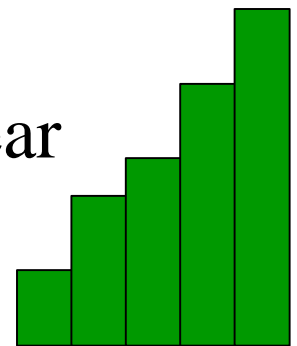
- What is the preference pattern in the environmental domain?
 - Look at Sequences
 - One time action (recycle one can, take the bus instead of driving one day) will have a negligible impact on long-term environmental levels
 - Similar to health and income streams
 - Empirically Health is discounted positively, income streams negatively. (Chapman, 1996; Loewenstein and Sicherman, 1991; Schmitt and Kemper, 1996)

Method

- Give survey to elicit preferences for sequences of environmental attributes
 - Air Quality, Water Quality, Along with Quality of Health and Income Streams
- Participants (48 UCI students)
 - Read excerpts from selected local newspaper articles on beach and air pollution as motivation.
 - Asked to choose, rate and give expectation for a set of graphs which depict air and water quality, as well as, health (Chapman 1996) and income from rental property (Loewenstein and Sicherman, 1991).

Expected Results

- Since preferences involve consequences that individuals must “live with,”
 - Expect **negative time preference** for 50 year horizon for **environmental attributes**
 - Offset health impact in later years, better environment for children, etc.
 - Expect **constant ($r = 0$) preference** for 5 year horizon
 - No change in the short run

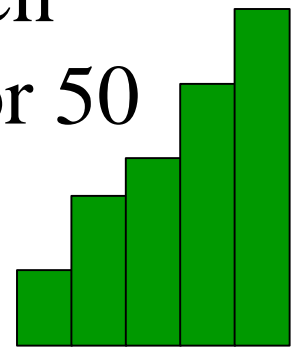


Results

- Between Domains
 - No difference in mean ratings between Air, Water and Health Quality
 - Income different from other three

Summary of Results

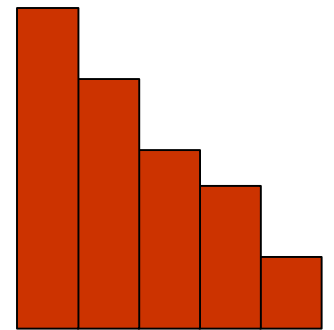
- There is a Statistical Difference between **Air, Water and Health Quality** over 5 or 50 year time horizons.
 - Increasing and Constant distributions are preferred to Decreasing distributions
 - Implicit discount rate is zero or negative
 - Contrast to Chapman (1996), preference for decreasing sequences of health.



Summary of Results

Domain difference between **Income** and three other cases

Decreasing sequences preferred for both 5 and 50 year time horizons for **income**



- Contrast to Loewenstein and Sicherman (1991)
 - Increasing sequences preferred
- Contrast to Chapman (1996)
 - Equal preference for increasing and decreasing over lifetime, and short term preference for increasing

Application of Value Models

- Fit the Means from the data elicited from the 48 participants to:
 - The traditional exponential discounting model
 - Find best-fitting (Least-Squares Optimization) implicit discount rate r .
 - Allow for $r \leq 0$. Compare to $r > 0$ (required by model).
 - Loewenstein and Prelec's (1993) value model
 - Find best-fitting (β, σ) pairs.

Discounted Utility

- Use a linear equation to best-fit the data to the traditional exponential discounting model.

$$Value = c + \mathbf{a} \sum_{t=1}^n \mathbf{d}^t u_t$$

Where c and α scale the discounted utility into the 0-100 rating interval that the current data resides. The discount factor $\delta = 1/(1+r)$. Assume linear in outcome levels.

Loewenstein and Prelec (1993)

$$Value = \sum_{t=1}^n u_t + \mathbf{b} \sum_{t=1}^n d_t + \mathbf{s} \sum_{t=1}^n |d_t|$$

Where $\beta > 0$ implies a preference for sequences that improve over time, and $\sigma < 0$ implies a preference for sequences that are more uniform.

The sequences used in the experiment all had equal means, so the first term was constant across all sequences (60.5).

Summary of Results

- In all cases, even when allowing r to be negative, the model proposed by Loewenstein and Prelec outperforms (has a smaller SSE)

the traditional exponential discounting model.

Research Directions

- Is the difference due to the nature of the good?
- Do the anomalies that exist in the monetary domain also exist in the environmental domain?
 - Short-Long Term Asymmetry
 - Absolute Magnitude Effect
 - Gain-Loss Asymmetry

Application of Possible Generalizations

- If this difference is due to the nature of the good, then applications outside of the environmental domains may exist
 - Products with relatively short product lives
 - Service and delivery times
 - Positive consumer services
 - Entertainment, dining, etc.