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Assessing Preferences for Environmental Decisions with Long-Term Consequences

Principal Investigator Dr. L. Robin Keller
University of California, Irvine
350 Graduate School of Management
Irvine, CA 92697-3125
(949) 824-6348
FAX (949) 824-8469
LRKeller@uci.edu
Website: http://www.gsm.uci.edu/~keller/

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Part 1: Executive Summary, Report, References, Tables and Figures

Final Report by:

Dipayan Biswas (UC Irvine)

Thomas Eppel (UC Irvine)

Jeffery L. Guyse (California State Polytechnic University, Pomona)

Robin Keller (UC Irvine)

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Objectives of the Research Project: The main objectives of the study are: to expand previous research on discount rates for monetary consequences to non-monetary consequences (*e.g.*, environmental or mortality impacts); to conduct experimental studies to find out what factors have an impact on monetary and non-monetary preferences for temporal sequences; and to cross-validate and generalize the experimental results with information from professional analysts to guide development of procedures that will help policy makers in the determination of models for the temporal perceptions of different stakeholders in environmental decisions.

Summary of Findings and Accomplishments: An experimental study, reported in paper #1 on "Valuing Environmental Outcomes: Preferences For Constant or Improving Sequences," was designed and conducted to analyze individuals' preferences for sequences of outcomes over time related to air quality and near-shore ocean water quality. We were particularly interested in whether temporal preferences for monetary outcome streams differ from preferences for sequences of non-monetary outcomes. We compared our results for the environmental sequences with results on preferences for sequences of health and monetary outcomes (from the California graduate business student participants in this study and previous research conducted by Gretchen Chapman, George Loewenstein and others). Generally, participants gave significantly lower ratings to environmental and health sequences (with equal means) that worsened over time, relative to the ratings they gave to sequences that either remained the same or improved over time. This pattern is reversed when facing sequences of monetary payments. This preference structure held for both short (5-year) and long (50-year) time horizons, and was confirmed with choice data. In other words, the generally observed preference pattern implies negative discount rates for non-monetary but positive discount rates for monetary outcome sequences. A relationship between expectations and choices was also found. A model proposed by Loewenstein and Drazen Prelec for the valuation of sequences of outcomes was applied to the current data set and compared to the traditional discounting model. In all cases, the model that incorporated "Gestalt" features of the sequence (slope and uniformity) performed better than the net present value discounting model at predicting the mean ratings for the sequences in the different domains.

Thus we found that people have very different preferences for temporal sequences of environmental outcomes and income outcomes. This suggests that decisions involving monetary

and non-monetary outcomes should not be modeled by first pricing out all outcomes in money and then discounting the monetary stream backwards.

Another study (paper #2) was conducted to investigate whether or not the preference patterns observed in the air and water quality domains also exist in the "lives saved" and "lives lost" domains. Survey results on individuals' preferences for three-year temporal sequences of mortality numbers are presented and compared to results from previous research on preferences for sequences of monetary, health, and environmental outcomes. Three anomalies (Gain/Loss Asymmetry, Short/Long Asymmetry, and the Absolute Magnitude Effect) found in previous discounting research using pairwise matching questions suggested there might be preference differences when outcomes were framed as gains (lives saved) or losses (lives lost), when sequences begin now (short term) or in fifteen years (long term), or when the number of total lives involved over a three-year sequence was small (60) or large (36,000).

California college student participants accessed the survey via a website and responded to 8 scenarios by providing a preference rank order for the 5 options in each scenario, then provided demographic data. The first 4 scenarios involved 3-year sequences of numbers of lives lost each year. The scenarios varied by whether the sequences started now, or in 15 years from now, and in whether the total number of lives lost over the three years was 60 or 36,000. The 5 options in a scenario were different temporal patterns of the sequences (e.g., -20, -20, -20 is a constant number of 20 lives lost each year). Other patterns were steeply improving, moderately improving, moderately deteriorating and steeply deteriorating over time. The final 4 scenarios involved numbers of lives saved over time, and had the same structure as the first set of scenarios.

The standard discounting model would require a person to prefer to have all the lives saved occur in the first year of a sequence, and have no lives saved in the ensuing two years. (This assumes utility is linear in the number of lives lost). Similarly, in the case of lost lives, all the lives should be lost in the third year of the sequence. Such sequences are "steeply deteriorating over time." Only 25-33% of the subjects ranked such sequences first, when lost lives were involved. When lives were being saved, a larger percentage from 39-43%, but still less than 50%, ranked as first the sequence with all lives saved in the first year. So, fewer than half of the subjects conformed with the standard discounting model. Sizable numbers of subjects ranked first the constant sequence (32-43% in the lives lost scenarios and 25-29% in the lives saved scenarios). Improving sequences were ranked first by 19-24% in the lives lost cases and 23-29% in the lives saved cases.

We compare our results with prior results on income, health, and air and ocean water quality. Guyse, Keller and Eppel (paper #1) found people tended to prefer constant or moderately increasing sequences for their own health and for air and near-shore ocean water quality, but preferred steeply decreasing sequences for monetary income. In a study by Guyse ("Empirical Validity of Discounted Utility for Decisions Involving Sequences of Monetary Outcomes," working paper, California State Polytechnic University Pomona, 2002) with the same survey design as in this paper, sequences of monetary outcomes were examined. Compared with our mortality sequences data, significantly more people preferred a steeply or moderately decreasing monetary sequence. Also, significantly fewer people preferred the constant sequence of money outcomes than preferred the constant sequence of mortality outcomes. We also found a Gain/Loss effect similar to what Guyse found for monetary sequences: participants preferred to

spread the outcomes if they were lives lost, and consolidate them if they were lives saved. This preference for consolidation was stronger with a smaller magnitude of money or lives.

Based on these results, we conclude that temporal discounting models may be inappropriate for representing the value people place on mortality, health and environmental outcomes. Preferences for constant or improving sequences should be considered in policy making, rather than presuming all people have a preference for deteriorating sequences.

We also gathered information from professionals who work on environmental decisions with long-term consequences for paper #3. Four prominent practitioners were interviewed to discuss their practical experience with discounting and the evaluation of long-term consequences. The interviews were structured around a set of questions that ranged from general comments about the use of discounting to specific questions about what discount factors to use and whether such factors should be dependent on the specific nature of the consequences. While the results of these interviews cannot give us a widely representative view on the practice of discounting, they nevertheless reveal important insights. None of the respondents thought that discounting ought to drive the analysis of long-term consequences or could point to an application where discounting made a major difference. Everybody agreed that the complexity of consequences and the implications of various modeling assumptions (including discounting) should be clearly explained to everybody involved. Finally, the respondents warned of oversimplifying the richness of stakeholders' values by aggregating the streams of consequences into one number. Instead, the discussion and evaluation of long-term consequences should focus on a sub-aggregated level and should include extensive sensitivity analyses.

Paper #4 is on "Examining Predictive Accuracy Among Discounting Models." This follows up on our experimental work above and earlier experimental work by others that identify problems in consistency of preferences with any single discount rate. We ask the question: what discount rate should be used if you want to go ahead and use a discounting model? We present a methodology to analyze data from experimental surveys on intertemporal preferences. Focusing on the traditional exponential discounting model and the hyperbolic discounting model, we use different specifications to model some experimental data published by Richard Thaler. Standard measures of goodness of prediction are then applied to fitted data to select among alternative specifications. We first present our approach by applying it to simulated data. We then present a procedure for statistical estimation of the sample discount rate, testing four specifications. Such an approach could be used when temporal preference data has been collected from stakeholders and a discounting model needs to be fitted to the data.

Publications/Presentations:

Papers:

1. Guyse, Jeffery L., Keller, L. Robin, and Eppel, Thomas: "Valuing Environmental Outcomes: Preferences for Increasing or Constant Sequences," Organizational Behavior and Human Decision Processes, March 2002. Vol. 87, no. 2, pp. 253-277. (Available online at http://www.idealibrary.com/ on IDEAL, doi:10.1006/obhd.2001.2965. Also was working paper MBS 99-16 in Institute for Mathematical Behavioral Sciences Technical Report Series, August 1999 and recipient of finalist award in Decision Analysis

Society of INFORMS Student Paper Competition, awarded Fall 1999.)

2. Jeffery L. Guyse and L. Robin Keller, "Valuing Lives Lost or Saved Over Time," working paper, California State University, Pomona and UC Irvine, 2002.
3. Thomas Eppel and L. Robin Keller, "Practitioners' Views on Discounting," Working Paper, Graduate School of Management, University of California, Irvine, 350 GSM, Irvine, CA 92697-3125, January 15, 2002.
4. L. Robin Keller and Elisabetta Strazzera, "Examining Predictive Accuracy Among Discounting Models," Journal of Risk and Uncertainty, Vol. 24:2, 143-160, 2002.

Presentations:

L. Robin Keller, "Preferences for Environmental Outcomes: Consistent with Discounting Models or Not?" presented at the EPA conference on "Economic Valuation of Mortality Risk Reduction: Assessing the State of the Art for Policy Applications," Silver Spring, MD, Nov. 6-7, 2001. See website link below for proceedings.

L. Robin Keller, "Preferences for Environmental Outcomes: Consistent with Discounting Models or Not?" presented at Stanford University, Decision Analysis Colloquium, Decision and Ethics Center, Department of Management Science and Engineering; April 12, 2001.

Jeffery L. Guyse and L. Robin Keller, "Valuing Lives Lost Over Time," presented at INFORMS International conference, Maui, June 2001, and Society for Medical Decision Making, San Diego, October 2001.

Guyse, Jeffery L., Keller, L. Robin, and Eppel, Thomas, "Modeling Environmental Decisions Over Time," Annual UCLA/UCI/USC Current Research in OR/OM Conference, University of California, Los Angeles, June 4, 1999.

Guyse, Jeffery L. and Keller, L. Robin: "Preference for Sequences of Long Term Environmental Consequences," presented by Keller and Eppel at Subjective Probability, Utility and Decision Making Conference, Mannheim, Germany, August 1999 and as a poster at the Los Angeles Judgment/ Decision Making meeting in November 1999. Presented by Guyse at the Institute for Operations Research and the Management Sciences (INFORMS) Conference in Philadelphia in November 1999 in session on Decision Analysis involving Outcomes Over Time and Environmental Risks organized by Keller; and at the Society for Risk Analysis conference in Atlanta, December 1999. Also presented by Guyse in campus seminars at Wharton, Tulane, Darden, Virginia Tech, Indiana State, and the California State Universities at Northridge, Long Beach, and Sacramento.

Eppel, Thomas, Guyse, Jeffery L., and Keller, L. Robin, "Assessing Preferences for Environmental Decisions with Long-Term Consequences," Society for Risk Analysis annual meeting, Phoenix. (December 1998).

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Relevant Web Sites:

L. Robin Keller's website: http://www.gsm.uci.edu/~keller/research_reports.htm, for detailed

final report.

EPA conference on "Economic Valuation of Mortality Risk Reduction: Assessing the State of the Art for Policy Applications," Silver Spring, MD, Nov. 6-7, 2001. Proceedings (written by EPA staff) are posted on the National Center for Environmental Economics' web site. http://yosemite.epa.gov/ee/epa/eerm.nsf/vwRepNumLookup/EE-0464?OpenDocument Follow the link to view Session IV, Risk Characteristics, containing Keller's talk.

Chapter 1

INTRODUCTION

With shrinking budgets and increased scrutiny of environmental regulations and policies, it has become very important that decisions regarding large-scale projects involving long-term consequences are made with utmost care and analytical support. An analytical approach should support the efficient employment of limited resources, and also provides justification and support for the decision-makers. The central issue in this decision-making exercise is an analysis of the tradeoff between the potential costs and benefits of a proposed policy. In general, tradeoffs between costs and benefits require difficult value judgments that express how much an individual or society as a whole should be willing to give up on one dimension (e.g., by allocating a particular amount of money to an environmental clean-up program) to gain some benefits on some other dimension (e.g., a cleaner and possibly safer environment). However such tradeoffs are difficult to analyze, especially when the potential benefits or risks involve impacts on health and environmental safety. One way to analyze such problems is through the use of multi-attribute decision analysis methods (Keeney and Raifa 1976; Corner and Kirkwood 1991). Multi-attribute decision analysis methods are well suited to portray the perspectives and preference tradeoffs of the different stakeholders in environmental decisions, including community members, firms, regulators, and decision makers (Keeney et al. 1990).

Moreover, the consequences (whether costs or benefits) of a particular program rarely happen at the same time. Instead, consequences occur at different points in time (sometimes decades apart) and possibly accrue over different time periods (sometimes

whole generations for health and safety impacts, sometimes several budget cycles for monetary expenditures). It is traditional to use a discounting factor to compute the net present monetary value for economic costs. However, it may not be appropriate to discount non-monetary health or environmental outcomes. Further, the preferences of stakeholders may not match the prescriptions of discounting models. So it is important to find out what types of decision models, using a traditional discounting approach or another approach, should be used in decisions with long-term consequences. Our primary focus here is to explore people's preferences over long-term environmental and health outcomes, and discuss implications for decision models and policymaking. .

Organization of the Report

This report is organized as follows. Chapter 2 outlines the experimental results on individuals' preferences for temporal sequences of environmental outcomes related to air quality and near-shore ocean water quality as compared with preferences for sequences of health and monetary outcomes. In Chapter 3, survey results on individuals' preferences for three-year temporal sequences of mortality numbers are presented and compared to results from previous research on preferences for sequences of monetary, health, and environmental outcomes. Chapter 4 examines experts' opinions on discounting. In Chapter 5, we present a methodology to analyze data from experimental surveys on intertemporal preferences, by modeling the experimental data published by Thaler (1981), by means of different specifications. Chapters 6, 7, and 8 present the references, tables and figures used in this report. Finally, appendices for Chapters 2, 3 and 4, are attached at the end.

Chapter 2

VALUING ENVIRONMENTAL OUTCOMES: PREFERENCES FOR CONSTANT OR IMPROVING SEQUENCES

In decisions involving the environmental domain, the outcomes and consequences are often on multiple dimensions (e.g., money and health). For example, decisions to clean up nuclear waste determine health and environmental consequences over many decades and require the allocation of funds over a long period of time. Hence in such evaluations, a coherent evaluation of such multi-dimensional, long-ranging and sequential consequences is important, if not necessary, for making sound decisions in this highly political context, where there are multiple stakeholders and tremendous public scrutiny. While decision analysis offers various techniques to model such situations, little empirical evidence exists in terms of how people actually evaluate such streams of consequences. This chapter reviews the existing research, including different intertemporal modeling techniques, and presents the results of an empirical study where respondents evaluated and chose from sequences of consequences that were systematically manipulated across different domains and time frames.[1]

The most commonly used approach for evaluating temporal streams of consequences on one particular dimension (e.g., money) is to apply a discount factor and calculate a net present value. The discount factor is often determined by a savings interest rate that money could earn if it were to be invested. For dimensions with non-

[1] The research in this chapter is reported in Jeffrey L. Guyse, L. Robin Keller, and Thomas Eppel (2002), "Valuing Environmental Outcomes: Preferences for Constant or Improving Sequences," *Organizational Behavior and Human Decision Processes*, 87 (2), 253-277.

monetary consequences, a common practice is to "price them out" by determining their monetary equivalent before applying the discounting technique. However, little is known about whether such an approach matches people's actual preferences. There are some indications from prior studies that monetary and non-monetary outcomes (such as health) may be treated differently.

Research on how people implicitly discount future monetary outcomes or consumer commodities received as single isolated outcomes found, in general, that if acquisition is delayed, then a premium (in the form of an increase in the amount of the good) must be paid to the person to offset the disutility caused by the delay (Ahlbrecht & Weber, 1997; Benzion, Rapoport & Yagil, 1989; Thaler, 1981). This is known as positive time discounting, since the discount rate is positive. In contrast, when Loewenstein and Sicherman (1991) investigated implicit discount rates that museum-attending adults used for sequences of wage profiles and income from rental investments, they found that participants' preferences tended to display negative time discounting, preferring increasing sequences rather than decreasing sequences with equal means.

2.1 Temporal Preferences Differ for Health vs. Money

Individuals are likely to treat monetary income differently from non-monetary outcomes since they may imagine how the money will be saved or invested as they make their choices (among other reasons). For example, Rose and Weeks (1988) found that discount rates for health states isolated to one time period were quite high (more than 40% annually) and higher than for monetary outcomes. Chapman and Elstein (1995) also found that discount rates were generally higher (more present-oriented) for health than for money.

When looking at sequences of outcomes, Chapman (1996) extended Loewenstein and Sicherman's work (on preferences between sequences with different shapes but equal means) into the health domain. When the time horizon was long (60 years), she found that her undergraduate student participants displayed positive time discounting (decreasing sequences were preferred) for health outcomes in three consecutive experiments. In contrast, monetary outcomes over the same time horizon were discounted positively (decreasing sequences slightly preferred), not at all (increasing and decreasing equally preferred), and negatively (increasing sequences were preferred) in the same three experiments. Thus, in general, discount rates for health were positive and higher than for money in the 60 year time horizon, since implicit monetary discount rates were sometimes negative. When the time horizon was shorter (12 days or 1 year) though, all three experiments indicated that both income and health during a medical treatment were discounted negatively. Thus, the preference for increasing sequences was stronger in the short time horizon than it was in the long time horizon.

2.2 Discounting Model for Temporal Preferences for Sequences of Outcomes

Discounted utility theory would compute the net present value today of \$110 in t years by the formula: Net present value = $1/(1+r)^t$ (\$110). The annual discount rate r is positive in this standard discounting model since the discounting function, which is equal to $1/(1+r)$, must lie between zero and one (Fishburn & Rubenstein, 1982; Koopmans, 1960; Samuelson, 1937). Given a choice of how to allocate a fixed stream of income over time, a person following this standard discounting model would choose to receive all the income in period 1 and none later. Such a sequence is "steeply decreasing" when drawn graphically with time on the horizontal axis.

2.3 Experiment

An experimental design for sequences of income streams and qualities of health was adapted from Loewenstein and Sicherman (1991) and Chapman (1996), respectively. However, the current study changed the time horizons explored and added the additional environmental domains of air quality and near-shore ocean water quality. The research question addressed is whether or not participants will display differences in preferences for sequences of outcomes in the environmental, health, and monetary domains.

Figure 2.1 displays the seven graphical sequence shapes used in the survey. Note that each sequence has the same average outcome over all periods. The sequences differ in the pattern over time. We assume a person's utility is linear in the outcomes shown in the graphs.

The survey elicited three dependent measures, preference rating, preferred choice, and expectation. The ratings were done on a 0 ("extremely unfavorable") to 100 ("perfect") scale and placed on the appropriate line next to each graph. The participants were then asked to fill in the graph label (A through G) of the sequence that "was closest to your ideal" sequence, and this response was regarded as their preferred choice. Finally, expectation was measured by having the participants indicating the graph label (A through G) of the sequence which "regardless of your preference, is most likely to happen."

In the environmental sections, participants were asked to read selected excerpts from some local newspapers dealing with the on-going discussion of air and near-shore ocean water quality in the region. For example, an excerpt from the Los Angeles Times (March 1, 1999) described a recent study (Waxman, 1999) which dealt with the exposure

to hazardous air pollutants in Los Angeles. After reading the excerpts, the participants were then instructed to imagine that their local congressional representative had contacted them and asked them for their opinion on seven different air quality policies. These policies are to be carried out over a 5-year (or 50-year) period. To control for uncertainty, the participants were told that researchers believed that no technological advance would occur within the time period that could alter the policy once it was enacted. A "current level of the environmental attribute" line was added to the graphs, which was slightly below the average level over time for the considered policies. To ensure that the participants did not imagine seeing the sequence continuing beyond the time horizon given, thus possibly not having the same mean, they were also instructed that only one policy could be enacted and at the end of the time horizon, a new policy will be voted on and enacted, the current policy will have no influence on this future decision. They were then instructed that each of the seven policies has an equal average level of the environmental attribute over the time period, but the way this level is distributed differed between the policies. Also, a change in air quality means the same thing regardless of when it occurs. For example, a "much better" change in air quality near the beginning of the time horizon means the same thing as a "much better" change near the end of the time horizon. The same graphs were used for both the air and the near-shore ocean water quality sections.

2.4 Experiment Results

The survey elicited ratings (a continuous quantitative variable), choices of sequence closest to their ideal sequence (a dichotomous qualitative variable) and the selection of the sequence that they felt was most likely to occur (a dichotomous

qualitative variable) for the seven different sequences in the eight scenarios. Since there were 48 participants and four domains, there were 384 potential choices across all the scenarios in the two time horizons. When looking at the total number of choices that participants made, out of the 384 choices, there were only 20 instances (5.2%) in which the preferred choice was either the "hill" (Graph E of Figure 2.1) or the "valley" (Graph A) sequence. The remaining 94.8% of the choices were for one of the five monotonic sequences (steeply increasing, increasing, constant, decreasing, or steeply decreasing). For this reason, the "hill" and the "valley" graphs were not analyzed further. The analysis of ratings, choices, and expectations focused on the five other graphs. The standard discounting model requires the steeply decreasing sequence to be preferred, given that all sequences have equal average outcomes and utility is linear in the outcome.

Mean ratings were used as summary statistics for the strength of preference across the 48 participants for each of the five graph shapes. Ratings were good predictors of choice across participants according to a logistic regression model with ratings as a single independent variable (Wald = 270.79, p = 0.000). Figure 2.2 shows a graphical representation of these mean ratings. One will quickly notice that the environmental domains (air and near-shore ocean water) and the health domain have similar mean ratings per scenario, but the mean ratings in the monetary domain appear to be different. For environmental sequences, participants preferred the constant or improving sequences. For health, constant health over 50 years and moderately increasing over 5 years got the highest mean ratings. In contrast, for income the decreasing sequences were rated highest. Also there seems to be a distinct difference in the pattern of mean ratings between the two time horizons. In all four scenarios, increasing sequences were rated

higher (on average) in the 5-year time horizon than they were in the 50-year time horizon. Likewise, decreasing sequences received higher ratings on average in the 50-year time horizon than they did in the 5-year time horizon. Table 2.1 contans results on the frequency that each sequence shape was most preferred for each domain.

2.5 Discussion

The observed preferences for constant or improving sequences suggest that the standard approach of discounting financial outcomes which occur over time may be inappropriate for non-monetary outcomes such as health quality, air quality, or near-shore ocean water quality. Policy makers should carefully consider how to represent and verify outcomes over time when analytical procedures are being determined. Table 2.2 summarizes out results and previous findings on preferences for sequences.

2.6 Application of Alternative Intertemporal Preference Models

Loewenstein and Prelec (1993) proposed an alternative model for valuing outcomes over time which can capture preference for improving sequences and preferences for spread-out outcomes. Loewenstein and Prelec's model can predict preferences (expressed as high ratings) for increasing or decreasing sequences, as well as preferences for moderate slopes (since they are nearer to uniform). The traditional discounting model with a positive (non-zero) discount rate will predict preferences for steeply decreasing sequences. (If a negative discount rate is allowed, it will predict preferences for a steeply increasing sequence.) Fitting an intertemporal preference model to the mean judgments of a group would be appropriate in cases when it is important to characterize the opinions of a stakeholder group as a whole. An identical process would be followed to fit the models to individual participant's judgments.

Loewenstein and Prelec's model for preferences over outcome sequences is:

$$Sequence \cdot Value = \sum_{t=1}^{n} u_t + \beta \sum_{t=1}^{n} d_t + \sigma \sum_{t=1}^{n} |d_t|, \tag{1}$$

where the parameter β signals whether an individual prefers sequences that increase (improve) over time ($\beta > 0$), or decrease (get worse) over time ($\beta < 0$). The parameter σ helps determine whether an individual prefers sequences that are relatively uniform, showing a small deviation from time unit to time unit ($\sigma < 0$) or prefers non-uniform sequences ($\sigma > 0$). For each period t, u_t is the utility of receiving the outcome in time t. The term d_t is the difference between the cumulated utility received up to time t and the cumulated utility that should have been received had the total utility been allocated in a constant sequence across the n periods. This term is formulated as follows:

$$d_t = \frac{t}{n} \sum_{i=1}^{n} u_i - \sum_{i=1}^{t} u_i. \tag{2}$$

Loewenstein and Prelec applied their model by first measuring the cumulative deviations of each sequence from the constant sequence. The utility of the outcome at time t was also recorded. The information was then inserted into the model (1) and predictions were recorded.

In the current study, the "Sequence Value" in Eq. (1) was used as a predictor of the mean rating for the different sequences in the eight scenarios (domains of air, water, health, and income by each time period, 5 and 50 years), where the only free parameters were β and σ. All of the sequences have the same mean and time frame (per scenario), therefore the total value (or utility) of each sequence will be equal, so the first term in (1) became a constant (the sum of the bars of the sequence which is equal to 60.5). The cumulative deviations of the two increasing, one constant, and two decreasing graphs

were recorded and used to determine the summations in the second and third terms in (1). Least-squares optimization was performed to come up with the parameters β and σ that fit the mean ratings data. Eight models were constructed, with different β and σ values for each of the eight scenarios.

2.7 Predictions of the Models

Loewenstein and Prelec applied their model in two different studies, each study had the participants rate sequences in a single scenario. The model was then fit to each individual. In the current study, the eight different scenarios were fit individually, but instead of fitting the model to each participant, the model was fit to the participants' mean rating data. Such an approach of fitting aggregate parameters might be used in decision making involving environmental outcomes, since consumer preferences must be met on an aggregate level. Figure 2.3 displays the partitioning of the (β, σ) parameter space. (The partitioning in this figure is similar to Loewenstein & Prelec's (1993) Figure 3, p. 99). The values of the (β, σ) pair determine the preference patterns. The large label (on top) in each section of Figure 2.3 represents the dominant feature of the sequence. For example, if an individual's (β, σ) pair fell into Area A, then that person would like sequences that both improved and that were uniform, but would find the improvement to be more important (higher weight) than the uniformity.

Figure 2.3 also plots the best fitting (β, σ) pairs for each sequence in the eight scenarios. These pairs, when used in Eq. (1), resulted in a predicted sequence value that minimized the sum of squared errors when compared with the actual mean values reported by the participants. These predicted values were then used as the independent variable in a regression to predict the actual mean ratings for the given scenario. A strong

significant relationship exists between the sequence value given by Eq. (1) and the mean ratings ($F_{1,38} = 604.08$, $p = 0.000$, $R^2 = 94.08\%$).

As can be seen from Figure 2.3, for the environment point (A-5, A-50, W-5 and W-50) and health domains (points H-5 and H-50), three out of six of the pairs lie in Area A. The remaining three pairs (A-50, W-50 and H-50) lie close to Area A, but closer to the β-axis, indicating a greater desire for uniformity than for improvement. This difference between the 5-year and the 50-year time horizons reveals that the participants (on average) put more weight on the increasing aspect than the uniformity in the short run, but a strong preference for uniformity in the long run. Looking back at the mean rating data in Figure 2.2, we can see that the constant sequence shape was rated highest (on average) for these three domains in the 50-year time horizon, while the moderately increasing sequence shape had the highest mean rating in the 5-year time horizon. This is also in accordance with Figure 2.3, which shows that the preference for increasing sequences is stronger in the short run than in the long run. In strong contrast, the best fitting (β, σ) pairs associated with the monetary sequences (I-5 and I-50) do not fall into the same areas as the other domains. The area that these pairs lie in shows a preference for sequences that both deteriorate and are uniform, but the deterioration of the sequence has a higher weight than the uniformity. The data point for the short run income parameter pair (I-5) lies to the left of the (I-50) point. This once again shows, that even in the monetary domain, increasing sequences received a higher weight in the short run than in the long run. It appears that for both the monetary and non-monetary domains, the mean rating data indicates a preference for more uniform over less uniform sequences, revealed by the best fitting $\sigma < 0$ in all cases. This goes against the traditional discounting

model, which would predict a preference for a sharply decreasing sequence (which is the least uniform along with the sharply increasing one).

To contrast the results given by Loewenstein and Prelec's model, the data were also fitted to the traditional discounting model. Least-squares optimization was performed to find the best fitting discount rate (r) that minimized the difference between the mean rating and the net present value of the sequence across all sequences per scenario. Eq. (3) displays the linear equation that was developed to best fit the data to the mean ratings.

$$Discounted \cdot Value = c + \alpha \sum_{t=1}^{n} \delta^t u_t \qquad (3)$$

where the parameters c and α scale the discounted utility into the 0 to 100 rating interval that the current data resides. The parameter δ is the net present value discount function equal to $(1+r)^{-1}$. The discounted values were used as the single independent variable in a regression to predict the mean ratings of the participants. A significant relationship exists between the discounted sequence value given by Eq. (3) and the mean ratings ($F_{1,38}$ = 93.29, p = 0.000, R^2 = 71.06%). Table 2.3 displays the results from the application of the traditional discounting model. As expected, the best-fitting discount rate associated with the environmental and the health domains is negative, and the discount rate associated with the monetary domain is positive. Looking at Table 2.3, it is easy to see that, although both models are good predictors of the mean ratings, the model developed by Loewenstein and Prelec fit the mean ratings data from the current study better than the traditional discounting model, even when allowing for negative discount rates. Comparing the Sum of Squared Errors (SSE) measure per scenario, the model developed by Loewenstein and Prelec produces a lower SSE in all cases, even in the monetary

domain. This is an indication that individuals use other features, besides the net present value of a sequence, when evaluating sequences of outcomes. Restricting the discount rate to be non-negative, as required in traditional discounting, would result in a worse fit ($F_{1,38} = 16.02$, $p = 0.000$, $R^2 = 29.66\%$).

2.8 Conclusion

Our experimental findings suggest that preferences for temporal sequences of consequences may show domain-specific effects, in particular that monetary streams of consequences may be treated very differently from environmental and health-related consequences. Generally, our participants a) prefer constant or increasing sequences of air quality and near-shore ocean water quality, and qualities of health but b) prefer decreasing sequences of income. They gave significantly lower ratings to environmental sequences (with equal means) that worsened over time, relative to the ratings they gave to sequences that either remained the same or improved over time. This pattern is reversed facing sequences of monetary outcomes. This preference structure held for both short (5-year) and long (50-year) time horizons, and was confirmed with the choice data. A positive relationship between the shape of the expectation of the most likely sequence and the shape of the ideal sequence was also found in the health domain, but not in the environmental or monetary domain.

Our findings have important implications for the application of traditional decision-analytic models to decisions involving sequences of environmental and monetary outcomes over time with effects on multiple stakeholders. For example, methods that "price-out" environmental consequences and discount their monetary equivalents may not reflect the true preferences of a stakeholder. Furthermore, even

using different discount rates for each attribute in a traditional discounting model may not be sufficient, since the standard model cannot represent preferences for "configural" aspects of consequence sequences (e.g., preference for uniformity of sequence patterns). We found that Loewenstein and Prelec's model of temporal preferences (which can incorporate such configural aspects) outperformed the traditional discounting model in representing the responses of our participants.

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Chapter 3

Valuing Lives Lost or Saved over Time

In this chapter, survey results on individuals' preferences for three-year temporal sequences of mortality outcomes are presented and compared to results from previous research (see chapter 2) on preferences for sequences of monetary, health, and environmental outcomes[1]. Three anomalies (Gain/Loss Asymmetry, Short/Long Asymmetry, and the Absolute Magnitude Effect) found in previous discounting research using pairwise matching questions suggested there might be preference differences when outcomes were framed as gains (lives saved) or losses (lives lost), when sequences begin now (short term) or in fifteen years (long term), or when the number of total lives involved over a three-year sequence was small (60) or large (36,000). The standard discounting model would require a person to prefer to have all the lives saved occur in the first year of a sequence, and have no lives saved in the ensuing two years. Similarly, in the case of lost lives, all the lives should be lost in the third year of the sequence. Such sequences are "steeply deteriorating over time." Only 25-33% of the subjects ranked such sequences first, when lost lives were involved. When lives were being saved, a larger percentage from 39-43%, but still less than 50%, ranked as first the sequence with all lives saved in the first year. So, fewer than half of the subjects conformed with the standard discounting model. Sizable numbers of subjects ranked first the constant sequence (32-43% in the lives lost scenarios and 25-29% in the lives saved scenarios).

[1] The material in this chapter was presented at the INFORMS Conference in Maui, in June 2001, and at the Society for Medical Decision Making Conference in San Diego in October 200. The authors are Jeffrey L. Guyse and L. Robin Keller.

Similarly, improving sequences were ranked first by 19-24% in the lives lost cases and 23-29% in the lives saved cases.

We compare our results with prior results on income, health, and air and ocean water quality. Guyse, Keller and Eppel (2002) found people tended to prefer constant or moderately increasing sequences for their own health and for air and near-shore ocean water quality, but preferred steeply decreasing sequences for monetary income. In a study by Guyse (2002) with the same survey design as in this paper, sequences of monetary outcomes were examined. He found a Gain/Loss effect: participants preferred to spread the outcomes if they were losses, and consolidate them if they were gains. This preference for consolidation was stronger with a smaller magnitude of money.

Based on these results, we conclude that temporal discounting models may be inappropriate for representing the value people place on mortality, health and environmental outcomes. Preferences for constant or improving sequences should be considered in policy making, rather than presuming all people have a preference for deteriorating sequences.

3.1 Procedures For Eliciting Intertemporal Preferences

Pairwise Matching Elicitation Procedure: One type of question that has been used to investigate intertemporal choice asks an individual to make a matching judgment (either a quantity of money or a time of acquisition or payment) in which the individual would be indifferent between a pair of options. For example, "how much money ($x) would you need to receive now (time t = 0) to be indifferent to receiving $60 two years from now (at time t = 2)?" or "for how many years of remaining life in good health would you be indifferent to 40 years of remaining life, all in poor health?" We shall call

this technique pairwise matching, since it involves matching of quantity vs. timing pairs. It is particularly useful when the aim is to determine a discount rate, since the question contains the minimal information required to precisely calculate the discount rate. Thaler (1981) used this matching procedure to assess experimental participants' interest rates for mandatory amounts. (In chapter 5, we use Thaler's data to examine discounting models). When McNeil et al. (1978) asked lung cancer patients to value the survival profiles associated with surgery or radiotherapy, individuals varied greatly in their implicit discount rates on their future years of life. A modification of a pairwise matching elicitation procedure involves inferring a single discount rate to best fit a set of judgments. Viscusi, Hakes, and Carlin (1997) used a regression approach to discover implicit discount rates for years of remaining life in the range from 3.3% to 12.4% when facing mortality risks (such as heart disease, cancer, various accidents, etc.). They found the discount rate that best predicted a group's perceived risk ratings for different mortality risks. Moore and Viscusi (1988) and Viscusi and Moore (1989) also estimated implicit discount rates for job fatality risks.

Relative Valuation of Sequences Elicitation Procedure: Another type of question that makes the time factor explicit presents a sequence of outcomes over time. This type of question matches the natural decision environment, where multiple time periods are involved. This separate stream of research has focused on preferences over different sequences, in which the participants rank or rate different sequences of the outcomes that usually have the same means; see Loewenstein and Prelec (1993) for an overview.

The equivalence of the two elicitation methods has been assumed when testing the traditional discounting model. However, the conclusions from the two streams are

somewhat different depending on the elicitation method used. The studies that have used pairwise matching to investigate the deviations from the normative discounting model have revealed a set of systematic violations of one or more of the axioms of discounted utility. The main systematic violations can be expressed in three anomalies. They are: (1) Gain/Loss Asymmetry; (2) Short/Long Term Asymmetry; and (3) The Absolute Magnitude Effect (see Loewenstein and Prelec, 1992 and Loewenstein and Thaler, 1989, for complete reviews). These anomalies are discussed more formally in the next section.

3.2 Descriptions Of Anomalies In Intertemporal Choice

Gain/Loss Asymmetry: A person's reference level may affect whether an outcome is seen as a gain or a loss. Prospect theory (Kahneman and Tversky, 1979) is arguably the most successful theoretical attempt to explain such reference point effects. The theory depicts a value function that is concave in the domain of gains and convex in the domain of losses. In risky contexts this value function, in conjunction with a probability weighting function, leads to predominantly risk averse preferences in the domain of gains, and risk proneness in losses.

Loewenstein (1988) introduced the reference point concept into temporal decision making. Even in situations where decisions are made under certainty, such as a certain loss or a certain gain, the domain of the outcome (either loss or gain) can have an influence on the implicit discount rate of individuals. In general, losses are discounted at a lower rate than gains. Formally the anomaly is, using the notation (x, t) to denote getting amount x at time t, $\sim_p$ to mean preference indifference and $<_p$ to denote preference order:

$$\text{If } (x', t') \sim_p (x, t), \text{ then } (-x', t') <_p (-x, t) \text{ for } 0 < x < x' \text{ and } t < t'. \qquad (1)$$

Short/Long Term Asymmetry: The stationarity axiom[2] of discounted utility theory ensures *dynamic consistency*, that is, changing the timing of a decision will not have an impact on preference. Suppose an individual is indifferent between adding x' units to consumption in time t and $x''>x$ units at a later time t', given a constant level (x) in all other time periods. Using the traditional discounting function $(1+r)^{-1}$, where r is the constant discount rate, implies:

$$(1+r)^{-t}[u_x(x + x')] + (1+r)^{-t'}[u_x(x)] = (1+r)^{-t}[u_x(x)] + (1+r)^{-t'}[u_x(x + x'')] \tag{2}$$

dividing through by $(1+r)^{-t}$ yields,

$$[u_x(x + x')] - [u_x(x)] = [u_x(x + x'') - u_x(x)]\ \frac{(1+r)^{-t'}}{(1+r)^{-t}} \tag{3}$$

Since $0 < (1+r)^{-t} < 1\ \forall\ t = 0$ to T (Koopmans, 1960), then $\frac{(1+r)^{-t'}}{(1+r)^{-t}} = (1+r)^{-(t'-t)}$ in Eq. 3 above. Therefore the preference between the two consumption streams depends only on the absolute time interval separating them, or $(t - t')$ in the above example. So, in terms of rank orders that our participants will be providing, there should be the same rank order for sequences occurring in years 0-2 and for the same sequences shifted 15 years later into the future. Dynamic consistency is normatively appealing, since classic "money pump" style arguments can be presented that would violate rationality if preferences were not stationary. Thaler (1981) found that implicit annual monetary discount rates of experimental participants declined as the time period involved increased. In general, discount rates decrease as a function of the time delay when the elicitation procedure is pairwise matching. Only Guyse (2001) has experimentally

[2] Stationarity expresses the idea that the passage of time does not have an effect on preferences. The axiom is: *For some x_1 and all sequences ${}_2x$ and ${}_2x'$ (from time unit 2 to infinity), $U(x_1, {}_2x) \geq U(x_1, {}_2x')$ iff $U({}_2x) \geq U({}_2x')$.* Koopmans (1960).

investigated Short/Long Term Asymmetry directly using the relative valuation of sequences elicitation procedure. The stream of sequences evaluation research *has* used different time periods, a short time period (from 12 days to 5 years) and a long time period (lifetime from 50 to 60 years), but prior designs did not allow direct testing of dynamic consistency. Significantly higher ratings for increasing sequences in the short time period than in the long time period (Guyse, Keller, and Eppel, 2002) were revealed though. Chapman's (1996) experiment 2 also found that the preference for an increasing sequence was more dominant in the short time period than in the long time period. But because of the experimental design used in these studies, the stationarity axiom was not explicitly tested.

Absolute Magnitude Effect: Empirical research has shown that individuals may display a different implicit discount rate for small outcomes than for large outcomes. In general, decision makers show a larger subjective temporal discount rate for small magnitudes than for large magnitudes, that is, large monetary amounts suffer less proportional discounting than do smaller ones (Benzion *et al.,* 1989; Chapman and Elstein, 1995; Kirby and Marakovic, 1996; Loewenstein and Prelec, 1992; Thaler, 1981). For example, Thaler (1981) reported that participants in an experiment who were on average indifferent between receiving $15 now and $60 in one year ($r = 300\%$) were also indifferent between the larger magnitudes of $3000 now and $4000 in a year with a lower discount rate ($r = 33\%$).

Preference for Spreading Outcomes Over Time: Empirical research has shown that sometimes individuals prefer more moderate to more extreme sequences with equal

means. In general, people may prefer to spread outcomes over time, than to concentrate them (Chapman, 1996; Guyse, Keller, and Eppel, 2002; Loewenstein and Prelec, 1993).

3.3 Current Research

The research question addressed is whether or not the anomalies of discounted utility theory found previously in pairwise matching judgments with primarily monetary outcomes will surface in some form with mortality outcomes and this more natural elicitation technique. First, we will examine whether preference orders match those required by the traditional discounting model. Second, we will investigate whether there are differences between gains and losses, short or long-term time horizons, and small or large magnitudes.

3.4 Methods

Participants. The participants were 75 undergraduate students at California State Polytechnic University, Pomona who volunteered to participate in the study. Their ages ranged from 19 to 46, with a mean of about 24. The subjects were about evenly split between males and females, with 53.4% being male. They were given the choice to be compensated with extra credit points or $5 for participation in the experiment. All chose course credit.

Procedure. Participants were asked to complete a questionnaire that they accessed via the World Wide Web, which consisted of two parts. In the first part, each set contained five sequences (triples of numbers of lives, with the same total over the three years) that differed only in the distribution of the outcomes over the time horizon. An example task is presented below:

Please rank order (according to personal preference) these sequences on different ways that 60 lives could be **saved** for sure over **the next 3 years.**

This Year	Next Year	2 Years from Now	Rank (fill in the blank) 1=best, 5=worst
0	0	60	_____
10	20	30	_____
20	20	20	_____
30	20	10	_____
60	0	0	_____

The Gain/Loss effect was investigated by multiplying all outcomes by negative one and changing the instructions to read "lives lost" instead of "saved."

Please rank order (according to personal preference) these sequences on different ways that 60 lives could be **lost** for sure over **the next 3 years.**

This Year	Next Year	2 Years from Now	Rank (fill in the blank) 1=best, 5=worst
0	0	-60	_____
-10	-20	-30	_____
-20	-20	-20	_____
-30	-20	-10	_____
-60	0	0	_____

Given the sequence set above, the Short/Long Term effect was investigated by adding a constant 15 years to all outcome timings and changing the wording, such as to "Please rank order (according to personal preference) these sequences on different ways that **60 lives** could be **lost** for sure for 3 consecutive years, **starting 15 years from now.**" In addition, the rankings' "fill in the blank lines" were moved to the left of the consequence matrix to help the participants realize the difference in time horizons. The Absolute Magnitude Effect was investigated by multiplying all the outcomes in the matrix above by 6000. So the design incorporated a 2 (Short/Long) X 2 (Small/Large Magnitude) X 2 (Gain/Loss) factorial design, creating eight possible combinations. These eight

combinations were randomized in the survey construction, then each participant received the same order. The ordering resulted randomly in the first four scenarios being on lives lost and the second four on lives saved.

3.5 Results and Analysis

Table 3.1 contains the percentage of participants who ranked each sequence first. In each case, the majority did not rank the steeply decreasing sequence (SD) first. Only 25-33% of the subjects ranked such sequences first, when lost lives were involved. When lives were being saved, a larger percentage from 39-43%, but still less than 50%, ranked as first the sequence with all lives saved in the first year. So, fewer than half of the subjects conformed with the standard discounting model. Sizable numbers of subjects ranked first the constant sequence (32-43% in the lives lost scenarios and 25-29% in the lives saved scenarios). Similarly, improving sequences were ranked first by 19-24% in the lives lost cases and 23-29% in the lives saved cases.

Gain/Loss Effect Results: For the sequences in our survey, no matter what single positive discount rate is used within a scenario, the model requires the SD>D>C>I>SI order. But, the discounted values would be closer together if there is less discounting. (In fact, with a zero discount rate, the values (using the normative model) would be identical, e.g. 60+0+0 lives = 20+20+20 lives = 0+ 0+ 60 lives.) So, under gain/loss asymmetry, the values a person places on the different loss sequences would be closer together and this might lead to it being more likely that (due to random error or a preference for spreading the outcomes) it would not follow the model's recommended order. So in general, there should be more ranking the Sharply Decreasing sequence shape first in the domain of gains than in the domain of losses. Figure 3.1 and Table 3.1

present the results. Looking at Figure 3.1 we see that, this is indeed the case, only 30% in the lives lost cases ranked the SD sequence first, down from 38% in the lives saved cases. Further, the data graphed in Figure 3.1 also reveals that more participants preferred to spread the outcomes if they were losses, by ranking the constant sequence first among the 5 sequences. In contrast, they preferred to consolidate the outcomes with the SD sequence, if they were gains.

Small/Large Magnitude Effect: Figure 3.2 and Table 3.2 show the results for the different magnitudes of lives, the ranking of sequences should be the same across both magnitudes, As can be seen, the steeply decreasing and constant sequences were most popular under both magnitudes.

Short/Long Term Effect: The ranking of the five possible sequence shapes for three-year sequences beginning now should be preserved for the corresponding three-year sequence starting in fifteen years. Figure 3.3 and Table 3.3 display the results for now (years 0-2) and later (years 15-17). As can be seen, the percentages ranking each sequence first remain nearly the same across the two time periods. Again, the steeply decreasing and the constant sequence shapes were most popular.

3.6 Comparison with Results on Monetary Sequences

Guyse (2002) conducted a parallel experiment with the mortality outcomes replaced by money ($60 replaced 60 lives, etc.). The results for money differed from the results for lives, as can be seen in Figure 3.4.

3.7 Written Statements on Process

Participants gave written descriptions of their decision process. Both declining slopes and equal spreads were most often mentioned.

3.8 Discussion and Conclusion

While the general pattern of responses was relatively the same across scenarios, some differences were found due to the factors varied. The strongest factor is the Gain/Loss Effect - people tended to have two popular sequence shapes for temporal sequences involving either lives saved or lives lost. The traditional discounting model prescribes one popular shape, a steeply decreasing sequence. Although popular, it always had fewer than 50% of the study participants ranking it as most preferred. Another popular shape is the "Constant" shape, with the same outcome in each time period. Such a shape spreads the outcomes evenly over time.

These results on mortality outcomes can be compared with prior results on income, health, and air and ocean water quality. For example, Guyse, Keller and Eppel (2002) found people tended to prefer constant or moderately increasing sequences for their own health and for air and near-shore ocean water quality, but preferred steeply decreasing sequences for monetary income. In a study by Guyse (2002) with the same survey design as in this paper, sequences of monetary outcomes were examined. He found a Gain/Loss effect: participants preferred to spread the outcomes if they were losses, and consolidate them if they were gains. This preference for consolidation was stronger with a smaller magnitude of money. See Figure 3.4 for a comparison of the mean ranks for the five sequences for Guyse's participants ranking monetary sequences and our participants ranking mortality sequences

Based on these results, we conclude that temporal discounting models may be inappropriate for representing the value people place on mortality, health and environmental outcomes. Preferences for constant or improving sequences should be

considered in policy making, rather than presuming all people have a preference for deteriorating sequences.

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Chapter 4

Practitioners' Views on Discounting

4.1 Abstract

Four practitioners were interviewed to discuss their practical experience with discounting and the evaluation of long-term consequences.[1] The interviews were structured around a set of questions that ranged from general comments about the use of discounting to specific questions about what discount factors to use and whether such factors should be dependent on the specific nature of the consequences. While the results of these interviews cannot give us a representative view on the practice of discounting, they nevertheless reveal important insights. None of the respondents thought that discounting ought to drive the analysis of long-term consequences or could point to an application where discounting made a major difference. Everybody agreed that the complexity of consequences and the implication of various modeling assumptions (including discounting) should be clearly explained to everybody involved. Finally, the respondents warned of oversimplifying the richness of stakeholders' values by aggregating the streams of consequences into one number. Instead, the discussion and evaluation of long-term consequences should focus on a sub-aggregated level and should include extensive sensitivity analyses.

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4.2 Introduction

As outlined in chapter 2, many decisions, especially those in the environmental domain, affect streams of consequences on multiple dimensions. For non-monetary consequences, decision analysts often "price them out" by determining their monetary equivalents before applying the discounting technique. However, little empirical evidence exists about whether or not such an approach matches peoples' preferences. Even less is known about how practitioners handle such situations.

The purpose of this study was to gather information from professionals who have been involved in decisions with long-term consequences, either directly as decision makers or indirectly as consultants, advisors, or interested stakeholders. This survey is not meant to be a rigorous "field experiment" with strict controls. Instead, we wanted the respondents to react to a few questions that are based on our reading of the literature and experimental results. We also invited the respondents to provide us with free-form answers and feedback that would help policy and decision makers to learn from their experience and advice.

4.3 Method

In the spring of 2000, we contacted four practitioners who have been involved in numerous projects dealing with decision problems with long-term consequences. Most of their work has been in the environmental arena. These four practitioners (in the following referred to as "respondents") include an internationally known decision analyst, an equally well-known risk analyst, a senior official at the California Department of Health Services, and a senior project manager at a national laboratory. Respondents were

contacted and asked whether they would be willing to participate in a relatively unstructured interview that would ask them about their experiences and advice in terms of how to deal with long-term consequences in general, and how to deal with various forms of discounting in particular. Each one of the respondents agreed to be interviewed. As a basis for these interviews we developed a questionnaire that guided the actual conversation. The questionnaire included the following questions:

1) Do you think that, in general, discounting provides a reasonable strategy to deal with future consequences and should be used when making decisions today?

2) Assuming that a discounting technique is used, what do you think is the appropriate discount factor?

3) Do you think that the discounting model (e.g., discounting rate) should be different for different domains (e.g., monetary consequences, environmental consequences, health and safety consequences, etc.)?

4) In principle, should future consequences in the following domain be discounted?

- Monetary Consequences
- Environmental Consequences
- Health and Safety Consequences

5) Do you agree with the common practice of "pricing out" non-monetary consequences to provide a dollar-equivalent of environmental, health and safety, and other consequences?

6) Do you agree with the common practice of "pricing out" non-monetary consequences and then to discount the dollar equivalent of combined monetary and non-monetary consequences of environmental policies?

7) Do you agree with the suggestion that "configural" aspects of consequences over time (e.g., the fact that environmental consequences improve or deteriorate over time) should be taken into account when evaluating long-term consequences?

8) Could you briefly describe an example (or examples) of projects that you were involved in or are familiar with where a discounting technique has been used and whether that use of discounting has been successful?

9) Could you briefly describe an example (or examples) of projects that you were involved in or are familiar with where, in your opinion, a discounting technique should have been used but was not?

These questions were meant to provide some consistency and commonality of topics across the four interviews. However it might be emphasized that these interviews were primarily conducted to have informal conversations about the respondents' experiences with evaluating long-term consequences and with discounting. Thus, these conversations should not be regarded as a formal, scientific survey with a representative sample of practitioners. Rather the interviews and their results are meant to provide the reader with a first-hand look at the practice of discounting.

4.4 Results

We structure the reporting of the results of the interviews along the questions that made up the questionnaire. Complete, edited transcripts of the interviews are given in Appendix 4.

1) Do you think that, in general, discounting provides a reasonable strategy to deal with future consequences and should be used when making decisions today?

The respondents' answers to this general question fall into two broad categories. The first set of responses (given by respondents 1 and 4) emphasize that discounting is a derivative concept, but that the more fundamental principle is one of time preference: "valuing outcomes now vs. later in the context of decisions we are making now" (Respondent 4). Respondent 1 also believes that, in general, "a good thing sooner is better and a bad thing sooner is worse" and stated that "a mechanism that logically and systematically deals with that basic preference is discounting."

The other two respondents were somewhat more critical about a "mechanical" application of discounting techniques to model time preferences. For example, Respondent 2 said: "Based on my experience, my objection to discounting is that it is sort of done as a technical thing where the importance of the assumptions is buried." Similarly, Respondent 3 raised the issue that whether or not consequences should be discounted probably depends on the nature of the consequences (a theme that was picked up in subsequent questions). For example, he thinks that discounting "is probably appropriate with consequences that are financial or with consequences that are translated readily into financial impacts" but wasn't so sure whether discounting would make sense for ecological impacts. This special nature of monetary consequences was echoed by

Respondent 1 who emphasized that money (and maybe some other consequences) has the very unique property of "growing" into something more with little effort since there is a mechanism in place (compound interest) that will lead to such growth.

2) Assuming that a discounting technique is used, what do you think is the appropriate discount factor?

On a fundamental level, Respondent #4 warned about a possible fallacy, namely that "people think that the discount rate is somehow an objective thing that comes out of the market or is enshrined in government regulations or something like that and we ought to use it for everything or for everything within some class of activities." Respondent 2 suggested to use the interest rate in non-inflationary times, but cautioned that a justification of the use of interest rates might run into problems since they might be different depending on the particular nature of a decision domain. Respondent 3 raised the possibility of using a discount factor "that represents the judgment or the value of decision makers or other stakeholders."

Respondent 1 discussed in great detail the context-dependency of discount rates. In particular, he differentiated between discount rates in the public domain and those for personal decision problems. More significantly, however, he described a scenario where an assessment of a discount factor might very well turn into a more general discussion about the specific nature of the decision problem and its structure. He emphasized the "proxy" nature of the description of consequences (in particular money), where the underlying reality is more concerned with different decision opportunities that might arise in the future. So, the more fundamental problem might be how to systematically think about and assess the value of future decision opportunities rather than the specific

discount factor for the consequences that enable these opportunities. In addition, Respondent 4 raised the issue that discounting future consequences, in particular for public decision situations, need to somehow deal with an assessment of how societies are going to evolve and what values they might hold in the future.

3) Do you think that the discounting model (e.g., discounting rate) should be different for different domains (e.g., monetary consequences, environmental consequences, health and safety consequences, etc.)?

4) In principle, should future consequences in the following domain be discounted?

- *Monetary Consequences*
- *Environmental Consequences*
- *Health and Safety Consequences*

Everybody agreed that discount factors are context-dependent and should therefore be assessed on a case-by-case basis. Everybody also agreed that monetary consequences are special since one can have them compound over time, which would create "a good basis for using discounting as a way of valuing that cash payment in the future" (Respondent 4). Respondent 1 discussed the fact that trade-offs among different objectives might very well change over the lifetime of a decision situation which would lead to using different discount rates in analyzing these different value-relevant streams of consequences.

Finally, Respondent 2 raised the issue that some people might have ethical concerns when it comes to discounting consequences in the health domain. In particular, he offered the possibility of someone saying that "I'm not going to discount lives because

that is repugnant to me." This respondent again reiterated the necessity to present and discuss all elements of a decision model, including discounting and specific discount rates. In his opinion, consequences "ought to be represented in a transparent way with and without discounting so that people understand the consequences and are forced to think about them."

5) Do you agree with the common practice of "pricing out" non-monetary consequences to provide a dollar-equivalent of environmental, health and safety, and other consequences?

6) Do you agree with the common practice of "pricing out" non-monetary consequences and then to discount the dollar equivalent of combined monetary and non-monetary consequences of environmental policies?

Both respondents 1 and 4 recognized that the most important aspect behind these questions is the notion of making tradeoffs and agreed that "pricing out" is a reasonable strategy to express such tradeoffs. Both, however, also raised some specific issues and misunderstandings behind pricing out. Some of these concerns were echoed by the other respondents as well. Respondent 4, for example, said that "basically what we're looking at is making tradeoffs in consequences from decisions across time. ... My concern and problem with a lot of this is that it starts to be mechanical, people feel that their ability to make input into the decision is taken away from them rather than being added to. I think what we're aiming for in all of this is trying to be logically consistent about what we want. And discounting can help you do that."

Related to the concern by Respondent 4, namely that pricing out as a mechanism to make tradeoffs can lead to "substantial problems with equity where consequences

occur to different people." Respondent 2 pointed out that "decision analysis is different from the classic utilitarian cost-benefit analysis in that it is supposed to be done for each stakeholder and that you can keep the color of money separate. You can figure out who's bearing the cost and who's getting the benefit. And that, I think, is something that is very important to do, and of course it is very divisive when you start saying there are losers and gainers. So, decision analysis can be done in a way that doesn't obfuscate some of the political problems."

Respondent 3 had some very general concerns about our ability to build models that truly reflect people's values and tradeoffs, including tradeoffs over time. This respondent believes "in providing some limited guidance in terms of making decisions" but doesn't think that one "should just price out and then accept that as a fixed value for decision making." He then said: "My concern is about our inability to really develop an approach that can accurately represent the value of non-monetary characteristics. First, we might have the tools, but we might not have the time or take the time to do it right. And secondly, I think people just aren't used to thinking in those kinds of terms. So, it is not clear, even if you're asking the right questions, whether their answers are totally representative of what they think or what their values are."

7) Do you agree with the suggestion that "configural" aspects of consequences over time (e.g., the fact that environmental consequences improve or deteriorate over time) should be taken into account when evaluating long-term consequences?

Respondents in general agreed that specific aspects of the evolution of consequences over time ought to be taken into account in their evaluation. There seem to be two rationales behind that. First, even for monetary consequences, where there seems

to be the least amount of disagreement about discounting and discount factors, the specific pattern of these consequences in and by themselves could be something that a decision maker cares about. For example, Respondent 3 mentioned that "it is typically more advantageous to have a smooth, relatively unchanging cost profile than one that has lots of ups and downs and you can have the same net present value for both." On further probing, this respondent acknowledged that budgets (in particular in the political arena) are easier to handle that way but also said that the smoothness of a cost profile "is probably a more general value-bearer in terms of minimizing variance."

Respondent 2 raised the issue that specific patterns in consequences over time could be valuable indicators of possible inequities of the distribution of the costs and benefits of consequences. Finally, Respondent 1 discussed in some detail the notion that the evaluation of specific patterns of consequences on one dimension often uncovers some hidden additional value-relevant dimensions for which the original dimension might have served as a proxy. So, for example, the pattern of profits over time might not be just value-relevant in terms of assessing the financial well-being of a company, but might also indicate how well the business is run and what kind of opportunities or problems the company might face at any particular position in the sequence of profit figures.

8) Could you briefly describe an example (or examples) of projects that you were involved in or are familiar with where a discounting technique has been used and whether that use of discounting has been successful?

9) Could you briefly describe an example (or examples) of projects that you were involved in or are familiar with where, in your opinion, a discounting technique should have been used but was not?

One surprising result of the conversations with these eminent practitioners is the fact that discounting has rarely played a central role in the kind of decision problems they were working on. While all respondents were involved in decision problems with long-term consequences, none of them was really determined by the specific discount factor or whether or not discounting was used at all. As Respondent 3 puts it: "We did the analyses, we did discount, but that wasn't the basis of any decisions." Furthermore, Respondent 1 complained that he couldn't even remember a project "where one of the variables has been the discount rate for money that I could wiggle." This need for making discounting and the specific choice of a discount factor part of a comprehensive series of sensitivity analyses was also mentioned by Respondent 4.

However, these comments should not be misinterpreted to say that one can ignore the time aspect of consequences. To the contrary, all respondents emphasized the importance of using the discussion about discounting as a "catalyst" to encourage decision makers and other involved stakeholder groups to gain some deeper understanding of the complexity of the consequences of decisions. Respondent 1, in particular, raised some interesting topics that such a discussion could lead to. For example, he thinks that it might be much more important to somehow account for the changing structure of decision situations and opportunities that might arise in the future rather than just discounting a stream of profits. Again, such profit numbers might merely serve as proxies for the ability of a company to effectively react to market problems and

opportunities, which might have a much more profound impact on how one ought to evaluate today's decision alternatives than just looking at discounted streams of profits.

Respondent 2 criticized the narrow scope of these questions since discounting is a "technoid" way to summarize a stream of consequences into one number. The real issue, according to this respondent, is to make sure that people are "paying attention to the fact that there is a stream problem" to begin with. This line of reasoning was also apparent in the answers by Respondent 3 who said: "It is important to understand explicitly and see explicitly both near-term and long-term consequences and not try to aggregate those into a single number."

4.5 Summary and Discussion

As mentioned before, this study should not be seen as an attempt to gain a representative view about the practice of discounting. However, we attempted to use our conversations with these four practitioners to use specific empirical and theoretical results that are often discussed in the "standard" discounting literature as a stimulus to have an open discussion about how the evaluation of long-term consequences is done in practice.

With these caveats in mind, we will now summarize some of the more salient and sometimes surprising issues that came up in our discussions. Certainly, one of the surprising results is the fact that none of our respondents could point to an application where discounting was really the determining factor of the analysis. While discounting might be required (either from a technical point of view or based on regulatory requirements), it rarely drives the analysis. However, the discussion of discounting issues often leads to more general discussions about the structure of the decision problem

(including how this structure might evolve in the future), the specific nature of the value-relevant dimensions (including the discovery of hidden objectives), and possible inequities in the distribution of costs and benefits over different stakeholder groups (now and in the future).

Another reasonably general theme in the conversations was the context-dependent nature of discounting and discount factors. Almost all respondents mentioned the unique aspect of monetary consequences that allows them to "grow" over time due to the existence of a market mechanism that leads to this compounding of consequences. However, it is far less obvious how one ought to discount non-monetary consequences, even though everybody agreed that, with the necessary tradeoffs, such consequences could be "priced out" and therefore translated into monetary equivalents. Such an attempt to summarize a stream of consequences across dimensions and across time periods into a single number is generally viewed as an inadequate solution to represent the complexity of a decision problem and of the values held by various stakeholder groups.

Finally, and somewhat related to the issues just raised, various responses in one way or another spoke to the importance of a clear and transparent discussion of the specific nature of the consequences and of the implications made by various attempts (including discounting) to analyze and evaluate these consequences. Every respondent warned about the possibility of short-changing the complexity and richness of a decision situation by following a "technoid" desire to summarize the value of each decision alternative by one number, which might be the result of a technically correct process, but a process that fails to represent the true values of various stakeholder groups nonetheless. Respondent 4, in particular, spoke about the difficulty of building a united front among

decision analysts, risk analysts, and economists because of the perception that "much of what we do gets seen by other people as a mechanical process, which takes away power rather than adding power, especially in group situations or political situations." In a similar vein, Respondent 2 objected to blindly following discounting because "it is sort of done as a technical thing where the importance of the assumptions made are buried."

On the other hand, these criticisms can lead to important improvements in the practice of evaluating long-term consequences. Certainly, recommendations as to what course of action to follow should not be based solely on an overly aggregated and discounted measure of value. Instead, the discussion of the consequences of the various decision alternatives:

- Should occur one or two levels below a complete aggregation,
- Should involve a comprehensive series of sensitivity analyses, and
- Should ultimately lead to a careful exploration and assessment of all assumptions (including discounting) that go into the analysis and modeling effort.