Evaluating Programs That Save Lives
(Maureen Cropper, University of Maryland and Resources for the Future, presiding)

Discounting Human Lives

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Over the last twenty years, economists have taken a strong interest in the evaluation of programs that save lives. The almost exclusive focus of their research, however, has been ascertaining individuals' willingness to pay for marginal reductions in annual mortality risk or, conversely, the compensation individuals would require to bear added risk (Jones-Lee, Mishan).

While it is critically important to understand the valuation of slight changes in mortality risk, it is not the only issue concerning life saving that merits attention. Frequently, for example, regulatory agencies are reluctant to assign dollar values to reduced mortality risks; instead, they evaluate life-saving programs solely on cost-effectiveness grounds; that is, they rank programs on a cost-per-life-saved (CPLS) basis. This raises a particularly thorny question, however, when different programs save lives at different times. For instance, imagine two regulatory programs that would cost society the same amount to undertake, one of which would save ten lives immediately, the other ten lives but only after fifty years (to make matters simple, assume the life-years saved are identical, too). Do both programs have the same CPLS? Or, should the lives saved by the latter program be given less weight (implying a higher CPLS) because they are more distant? A recent and heated dispute between the Office of Management and Budget and the Environmental Protection Agency revolved in large part around this seemingly arcane question.

The general issue in this debate, and the subject of this paper, is individuals' marginal rates of substitution between lives saved at different points in time. By interviewing random samples of individuals and confronting them with choices between hypothetical pairs of life-saving programs, we infer marginal rates of substitution for lives saved at different times. Among other things, we are interested in whether these rates differ for different horizons or are constant, whether they vary systematically with individuals' socioeconomic characteristics, and whether at least some individuals disregard altogether lives saved beyond some future date.

Estimating Marginal Rates of Substitution for Life Saving

To measure the number of lives saved in the future that are equivalent to saving one life today, we confronted people with questions such as the following:

Question 1

> Without new programs, 100 people will die this year from pollution and 200 people will die 50 years from now. The government has to choose between two programs that cost the same, but there is only enough money for one.
>
> Program A will save 100 lives now.
> Program B will save 200 lives 50 years from now.
>
> Which program would you choose?

Two points about the question deserve emphasis. First, it is deliberately abstract. What each program will accomplish is vague, except that it will reduce pollution and, thus, save lives. The purpose is to focus attention on the timing of lives saved, rather than on the cause of the deaths avoided. In pretests we found that references to real-world programs such as Superfund cleanups and nuclear waste disposal caused people to focus on these aspects of the question rather than on the number of lives saved and the time at which they were saved.

Second, the question asks the respondent to

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put himself in the role of a social decision maker, rather than asking him to make decisions from a more selfish viewpoint. The fact that the respondent may benefit from Program A but not from Program B (depending on his age) may, however, influence his responses. We return to this issue below.

In analyzing responses to our question, we assume that the respondent receives utility $U_A = aX$ from Program A and $U_B = bY$ from Program B, and chooses Program A if

$$(1) \quad aX > bY; \text{ which implies } b/a < X/Y;^1$$

where b/a is the fraction of a person saved today who is equivalent to saving one person at time T, or the marginal rate of substitution between lives saved today and time T.

We assume that there is a distribution of b/a values in the population, $F(b/a)$, and wish to estimate it. If b/a is a random variable, the probability that a randomly chosen person prefers Program A to Program B is

$$(2) \qquad P(b/a < X/Y) = F(X/Y).$$

A simple way to estimate the distribution of marginal rates of substitution is to face n_i people with a given ratio of X/Y, $(X/Y)_i$, and to record the number of persons in cell i who favor Program A. The proportion of persons in the cell who favor Program A, p_i, is an estimate of the value of the cdf at $(X/Y)_i$ $F[(X/Y)_i]$. A nonparametric estimate of the distribution of (b/a) is obtained by plotting p_i against $(X/Y)_i$ for various $(X/Y)_i$ ratios.

Testing Discounting Hypotheses

In addition to examining the distribution of marginal rates of substitution for a given horizon, we are interested in seeing how these change as the horizon changes. Because the number of persons who must be saved at T presumably increases with T, the distribution of b/a should shift to the left as T increases. One hypothesis we are interested in testing is whether the distribution shifts in a manner consistent with constant exponential discounting. If people discount future lives saved at a constant exponential rate, the marginal rate of substitution between lives saved now and at T may be written

$$(3) \qquad b/a = \exp(-\delta T);$$

hence, there is a one-to-one correspondence between the marginal rate of substitution b/a and the discount rate δ. The hypothesis that persons discount at a constant exponential rate can be tested by seeing whether the distribution of δ shifts with T.

Constant exponential discounting implies that the discount factor applied to a life saved at $T = 100$ to discount it to $T = 50$ is the same one applied to a life saved at $T = 50$ to discount it to the present ($T = 0$). The hypothesis that these two discount factors are equal has repeatedly been refuted in experiments involving the discounting of monetary payoffs (Horowitz, Lowenstein, Thaler, Winston and Woodbury). In terms of the present example, this literature has found that the discount factor used to discount lives from $T = 50$ to $T = 0$ is greater than the discount factor used to discount lives saved at $T = 100$ to $T = 50$, suggesting that the discount rate falls over time.

We examine the possibility that people discount lives saved at a nonconstant exponential rate by assuming that the discount rate δ declines linearly with time,

$$(4) \qquad \delta(t) = \alpha - \beta t, \quad \alpha, \beta > 0.$$

This implies that b/a is of the form

$$(5) \qquad b/a = \exp -\left[\int_0^T (\alpha - \beta t)\, dt\right] = \exp\left(-\alpha T + \frac{\beta T^2}{2}\right).$$

To capture heterogeneity in preferences, we assume that α is a random variable that is independently and identically normally distributed in the population with mean μ_α and variance σ_α^2; β, the slope of the discount rate function, is assumed identical for all persons. Given variation in T across respondents, μ_α, σ_α, and β can be estimated by maximum likelihood methods.

In addition to testing hypotheses about the discount rate, we wish to see how the mean of the discount rate function varies with respondent characteristics. Discount rates may increase with age if individuals consider benefits to themselves in choosing among life-saving programs. Individuals with small children may be more future-oriented (have lower discount rates) than

[1] We can allow for diminishing marginal utility of lives saved, i.e., $U_A = aX^n$ and $U_B = bY^n$; however, we cannot estimate n separately from b/a. Question 1 also prohibits estimating utility functions with an interaction term cXY. In written pretests of the questionnaire, however, we found that $c = 0$ and therefore abandoned more complicated questions (ones in which Program B saved lives today and at T) in favor of question 1.

those without, although people with children may consider it more important to protect their children when they are young than when they are old. Accordingly, we allow μ_α to depend on respondent characteristics.

Public Preferences for Saving Lives

The discounting results presented here are based on telephone surveys of households in Maryland, the District of Columbia, and northern Virginia conducted by the University of Maryland Survey Research Center.[2] In November 1990, approximately 1,000 Maryland households were asked questions similar to question 1. For half of the sample the time horizon for all questions was 25 years. For the other half, it was 100 years. A double-sampling strategy was used. Each respondent was asked which program he preferred, assuming that Program A saved X_1 lives and Program B Y_1 lives. Persons choosing Program A were randomly assigned a value of Y greater than Y_1 and asked to repeat their choices. For persons initially choosing Program B, the choice between the two programs was repeated with a randomly chosen value of Y less than Y_1. Respondents who selected the present-oriented program in both instances were asked the reason for their choice.

In March 1991, approximately 600 households in the Washington, D.C. area received questions similar to Question 1. A double-sampling strategy was again used. Each household was randomly assigned one of ten X/Y values and asked to choose between Program A and Program B, assuming Program B would occur in fifty years. The question was repeated, holding the X/Y ratio constant, with persons who chose Program A being confronted with a 25-year horizon and persons who chose Program B being confronted with a 100-year horizon.

Raw Data

Figure 1 shows the proportion of respondents in the Maryland Poll who favored saving lives in the present as a function of the ratio of lives saved in the present to lives saved in the future (X/Y). For each horizon, the proportion of those favoring the present-oriented program increases with X/Y. Furthermore, the proportion of those favoring the present-oriented program is higher, holding X/Y constant, the longer the horizon.[3]

Two features of the distributions are notable. First, when the number of lives saved at T is less than or equal to the number of lives saved today, about 10% of respondents still favor the future-oriented program: about 10% of our respondents have negative discount rates. At the other extreme, approximately 40% of the respondents choose the present-oriented program as X/Y approaches 0. There are two possibilities here. One is that while these invididuals may be willing to trade lives saved at T for lives saved in the present, they simply require more lives at T to switch to the future-oriented program than the maximum number in the survey.[4] The other possibility is that these individuals have lexicographic preferences: they would choose the present-oriented program no matter how many lives were saved in the future. One reason for this is the belief that technological improvements will enable future lives to be saved anyway—there is no need to make a trade-off.

To try to distinguish these responses, we asked persons who chose the present-oriented program (Program A) in both questions why they did so: 47% indicated that it was because "lives in the future will be saved some other way," suggesting that they would always choose to save lives today. We present results with and without these respondents, on the grounds that it is not meaningful to compute a marginal rate of substitution for persons unwilling to make trade-offs.

Further evidence of lexicographic preferences is provided by the Washington Poll. As indicated in appendix D (available from authors), the proportion of persons favoring the present-oriented programs in that survey remained virtually constant at .44 as the number of lives saved fifty years hence was increased from 1,000 to 15,000. To probe the reasons for this we asked persons who continued to choose the present-oriented program with $T = 25$ why they did so. Thirty percent said that improvements in technology would make it possible to save future lives as well as current ones, implying that it was unnecessary to make a trade off between

[2] A detailed description of the sampling strategies and survey instruments is contained in the appendices, available from the authors upon request.

[3] Although the two distributions cross at $X/Y = 0.9$, the null hypothesis that they are identical can be rejected (at the .05 level) in favor of the alternative hypothesis that the distribution for $T = 100$ lies to the left of that for $T = 25$ using the Kolmogorov-Smirnoff test.

[4] When $T = 25$, the maximum $Y = 4{,}000$; when $T = 100$, the maximum $Y = 7{,}000$.

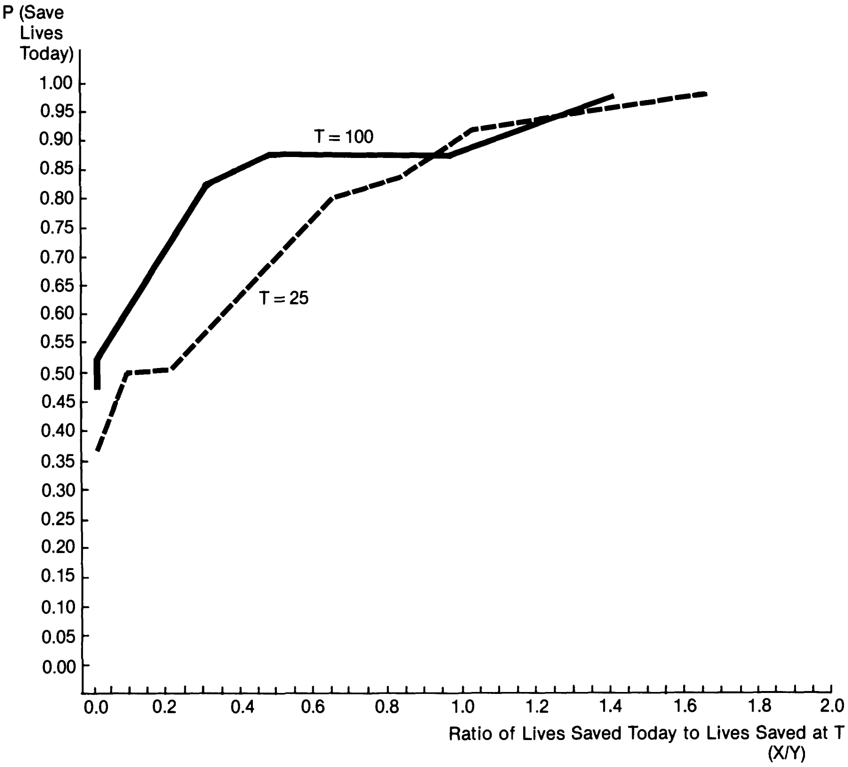

Figure 1. Ratio of lives saved

current and future lives saved. We report results with and without these responses.

Do People Discount at a Constant Exponential Rate?

Table 1 presents the discount rates implied by the Maryland and Washington Polls under the assumption that people discount future lives saved at a constant exponential rate. The mean and standard deviation of δ were estimated for each horizon, assuming that δ is normally distributed.

The results show clearly that the mean discount rate falls as the horizon increases: Based on all responses, the mean discount rate is approximately 8% for a 25-year horizon, 6% for a 50-year horizon, and 3% for a 100-year horizon. Tests of the equality of mean discount rates based on the assumption that δ is normally distributed allow us to reject the null hypothesis of constant exponential discounting.

We are also able to reject the hypothesis, proposed by Harvey, that people discount lives at a constant relative rate. According to Harvey's hypothesis, the factor applied to lives at T_2 to discount them back to T_1 is

$$b/a = (T_1/T_2)^r, \qquad (6)$$

implying that the discount factor used to discount lives saved from $T = 100$ to $T = 50$ will be identical to the discount factor used to discount lives saved from $T = 2$ to $T = 1$.

To see exactly how fast discount rates fall over time, we estimated the model of equations (4) and (5), in which the yearly discount rate falls linearly. The results of estimating this model for the Maryland and Washington polls are presented in table 2. Examining the models without covariates, the mean discount rate is 8.7% in year 0, 5.2% in year 50, and 1.7% in year 100. If persons who believe that future lives will be saved some other way are removed from the analysis, $\delta(0) = 7\%$, $\delta(50) = 3.5\%$, and $\delta(100) = 0\%$. We consider the implications of these results in the conclusions.

Heterogeneity in Discounting Behavior

Our emphasis thus far has been on mean discount rates. Table 2, however, shows that there is considerable heterogeneity in discount rates.

Table 1. Parameters of Discount Rate Distributions Assuming Constant Exponential Discounting

Model	Length of Horizon 25 years	50 years	100 years
δ Normally distributed (all respondents)			
Mean of δ	.086	.068	.034
	(19.0)	(11.4)	(21.5)
Standard deviation of δ	.083	.092	.026
	(15.3)	(6.51)	(13.7)
N	462	528	442
δ Normally distributed (some respondents deleted)			
Mean of δ	.065	.053	.027
	(16.1)	(9.01)	(19.9)
Standard deviation of δ	.070	.097	.022
	(16.1)	(5.78)	(14.1)
N	371	451	341

Source: Maryland poll (T = 25 and T = 100); Washington poll (T = 50).
Note: $|t$-statistics$|$ appear in parentheses.

Table 2. Estimates of Discount Rate Function $\delta(t) = \alpha - \beta t$, $\alpha = X'\gamma$

	All Respondents	Some Respondents Deleted
μ_α	0.087	0.070
	(21.0)	(18.6)
β	7.12E-4	6.82E-4
	(5.24)	(5.34)
σ_α	0.062	0.052
	(23.3)	(25.3)
N	904	712
γ_0	0.065	0.053
	(5.87)	(5.65)
Age (years)	7.17E-4	7.10E-4
	(3.86)	(4.60)
Male	−1.98E-4	−3.56E-3
	(0.03)	(0.77)
Children ≤ 18 at home	0.015	8.66E-3
	(2.56)	(1.71)
White	−0.029	−0.031
	(4.59)	(5.88)
College degree	2.01E-3	3.19E-3
	(0.34)	(0.61)
Married	5.88E-3	4.21E-3
	(1.05)	(0.85)
Income ≤ $30,000	−1.84E-3	5.00E-3
	(0.29)	(0.90)
β	6.72E-4	6.34E-4
	(4.68)	(4.86)
σ_α	0.061	0.050
	(22.3)	(24.1)
N	794	628

Source: Maryland poll.
Note: $|t$-statistics$|$ appear in parentheses.

The standard deviation of α, the intercept of discount rate function, is almost as large as the mean, indicating substantial heterogeneity in beliefs. The mean discount rate also varies substantially with respondent characteristics. In all cases the discount rate is higher for nonwhite respondents than for whites, and higher for older respondents than for younger ones. Respondents with children under the age of 18 also have higher discount rates than persons who do not.

Each of these results seems reasonable. That blacks have higher discount rates than whites has been found by other researchers (Leigh; Kurtz, Spiegelman, and West). We note that this result is robust to the inclusion of income in the discount function and interpret it as reflecting shorter planning horizons for blacks than for whites. If the likelihood of benefiting personally from a life-saving program influences responses, then it is reasonable that older persons would discount future lives saved more heavily than younger persons. This is also reasonable behavior for persons with children, assuming that they are more concerned with their children's welfare as children than as adults.

What is perhaps surprising is that income (income ≤ $30,000) and education (college degree) have no effect on the discount rate. Recall, however, that what is being discounted here are anonymous lives saved. There is no compelling reason why low-income persons, who have been found to discount monetary rewards more heavily than high-income persons (Hausman, Lawrance), should discount anonymous lives at a higher rate.

Conclusion

The results we have presented focus on choices between life-saving programs over long horizons: 25, 50, and 100 years. One of our most striking findings is that, over horizons as long as these, a significant share of respondents seems unwilling to choose any future-oriented program, primarily because they feel society will find a way to save people in the future anyway. Along with confidence in technological progress, respondents who wanted to save lives today cited uncertainty about the future as a reason for being present oriented.

Even if we eliminate respondents who feel that it is unnecessary to make a trade-off between lives saved today and in the future, discount rates for life saving seem high: Assuming constant exponential discounting, the mean discount rate is 6.5% for a 25-year horizon and 2.7% for a 100-year horizon. This finding also reflects the fact that people do not discount at a constant exponential rate, a finding consistent with results obtained by Thaler and others in the context of discounting monetary payoffs. If discount rates are computed under the assumption that they vary with time, the mean annual discount rate is 7% today and 0% in 100 years (after eliminating the "have-their-cake-and-eat-it-too" respondents).

For several reasons, our conclusions must be interpreted cautiously. First, our results were obtained during relatively brief telephone interviews, which may not be the best way to get people to think reflectively about difficult issues. Second, despite our probing in focus groups and pretests, we have not been able to explore in great detail why respondents answer the way they do.

In future work we intend to investigate this in more detail and also to explore people's discounting behavior over shorter horizons. In addition, we will examine individuals' preferences for saving persons of different ages, for example, 30-year-olds versus 60-year-olds. While such trade-offs are clearly difficult, public officials must make them all the time.

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