The Value of Life

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I. Introduction

What is the money value of a human life? This has been an interesting question for as long as we know. In the Law Code of Hammurabi, for instance, we read that "If a citizen has struck a citizen in a quarrel, and has inflicted on him a wound, [and] if he has died as a consequence ···, he shall swear [I struck him unwittingly], ··· and, if he was of citizen stock, he shall pay a half-mina of silver."(Thomas, lines 206–207). (A similar legal remedy – money damages – is suggested in some lines of *Exodus* (Chapter XXI, lines 28–30), but only in the special case of a fatal ox-goring, when the ox's propensity to gore is known to its owner. The similarity of these *Exodus* lines to lines 250–251 in Hammurabi's Code suggest that the biblical lines are a borrowing. The standard ancient Jewish remedy to accidental homicide was exile for the killer, not money paid by him to the clan or family of the victim.)

Islamic law clearly distinguished between intentional and accidental killing, and provides for the paying of *diyah* (blood-wit) in the case of accidental homicide. One source places the value of diyah at 30.63 kg of silver, or half that amount if the victim is a female, a Christian or a Jew (Niazi, 1985).

The Justinian Code provided for money payments to be made in cases of accidental killings of slaves (Kolbert, 1979). Early tribal customs in pre-Norman Britain put a compensatory price, or *wirgild* (man-price), on wrongful deaths. (Seebohm, 1972), and similar blood money compensation customs continued after 1066.

But sometime in medieval English law the maxim *actio personalis moritur cum persona* (a personal action dies with the person) became a legal principle along with the companion principle that the killing of a human is not grounds for damage actions (Smedley, 1960). According to Smedley these two principles may have evolved more by accident than by intelligence, but they were in place by the early seventeenth century (*Higgins v. Butcher*, Yel. 89, 80 Eng. Rep. 61 (1607)), and firmly in place by the early nineteenth century (*Baker v. Bolton* (1 Camp. 493, 170 Eng. Rep. 1033 (1808)). In *Baker*, Lord Ellenborough decided that "in civil court, the death of a human being could not be complained of as an injury."

The law of *Baker v. Bolton* was overturned by Lord Campbell's Act in 1846. Lord Campbell's act marked the beginning of the modern legal treatment of the value of life, at least in Anglo-American law. It provided an opportunity for the dependents of a deceased person to recover damages for the losses that they suffer, or, at any rate, for their money damages, such as lost wages the deceased would have provided them. The modern legal valuation of life is done in the United States in accordance with wrongful death statutes – descendants of Lord Campbell's Act, or in accordance with survival statutes, according to which the legal representative of the deceased can pursue the damages that the deceased himself suffered through his death, such as loss of income, pain and suffering before death, and, possibly, loss of enjoyment of life. Losses in many jurisdictions of the United States are combinations of, or hybrids of, wrongful death and survival laws. (For surveys, see, e.g., Prosser and Keeton (1984), Speiser, (1975), Brookshire, (1987).)

Although sometimes derided by economists as improper measures of how much a human values his own life (e.g., Mishan (1971, 1982)), the modern legal measures do have a certain logic to them, especially the measures incorporated in wrongful death statutes. Those statutes typically value a lost life as a lost net income stream, a stream that would have flowed (absent the death) to those who depended on the deceased. The survival statute provisions that enable dependents to receive money compensation for the deceased's pain and suffering are a little less logical, since, for example, they only compensate the deceased's pain and suffering (not the dependents'), but the compensation typically ends up in the hands of those dependents.

II. Two Standard Measures of Value of Life

There are two practical reasons to be interested in the money value of a human life, the first being legal actions. In the legal sphere, the standard measure of the value of a life is lifetime (net discounted) income. The deceased is viewed like a money-making piece of capital, and this measure of value is often called the *human capital* measure.

The second reason is the pervasive problem faced by government policy makers of choosing among alternatives – when those choices will result in lives being saved or lost. For instance: should we spend more on cancer research (or AIDS research) or not, should we rebuild a highway or not, should we spend 14 percent of GDP on medical care or not, should we build a long tunnel or not, should we force all building owners to remove asbestos or not, should we go to the moon or not? All these choices (and a myriad of others) have implications regarding saving (or spending) lives. Here academic economists usually dismiss the legal method for valuing lives, the human capital approach, because, it is claimed, typical people act as if they value their lives at much more than their lifetime (net discounted) incomes. That is, although I'll earn only $250,000 in my life (for instance), I would not accept a 10 percent risk of death if you paid me $25,000, and I certainly wouldn't walk the plank for $250,000.

The standard economic measure of value of life is the *willingness-to-pay* measure (Mishan, (1971), Mishan (1982)). This is attractive to economists because willingness to pay is how we measure the value a consumer places on the consumption of an apple, a car, or a house, and it seems natural to extend the method to willingness to pay for safety, or cure for disease, or perhaps, life itself. (Unfortunately, however, it is impossible to observe how much those souls not yet alive would be willing to pay to become alive. We can only observe how much those already alive are willing to pay to reduce the chance of death. This is an observational vacuum that may be related to various other philosophical puzzles surrounding this topic. See Broome, (1985)).

The willingness-to-pay approach essentially proceeds by posing the following question: Suppose a consumer has an opportunity to make his life safer, but at a cost. Assume he can reduce his probability of dying by ϵ if he buys some government program. What is the maximum, say C, he would pay for the extra survival probability? A consumer who mulls this over will decide on some C for the given ϵ. Then his valuation of ϵ is C, and no one would dispute the survival probability enhancement is worth C to him. But now assume 10,000 similar consumers answer the same question. If they act as a group to buy the program, they will reduce the expected number of deaths among them by 10,000 ϵ, and they will pay, in combination, a maximum of 10,000 C to do so. They will therefore, as a group, reveal their maximum willingness to pay an amount C/ϵ per expected death prevented. The willingness to pay "value of life" is then C/ϵ; that is, these consumers reveal that they are willing to pay this much per statistical life saved. And one consumer reveals his willingness to pay a maximum of C/ϵ per *probabilistic own life saved.*

III. Other Studies

There have been many studies which attempt to estimate C/ϵ. Excellent surveys can be found in Fisher et al. (1989), Jones-Lee (1989), Chapter 2, and Viscusi (1992), Chapters 3 & 4 among others. Jones-Lee categorizes the studies as revealed preference estimates (typically wage-risk differential studies) and questionnaire estimates; his compilations show striking variability in estimates of C/ϵ, but he concludes that a plausible value for a statistical life is, in 1987 money, at least £500,000 and possibly in excess of £1,000,000. A glance at his compilation of revealed preference estimates shows a range from a low (in 1987) of £130,000 and a high of £7,950,000, and a glance at his table of questionnaire estimates reveals an even broader range.

While Jones-Lee (1989) and others (e.g., Ted Miller (1990)) are comfortable with the estimated statistical values of lives, the possible importation of this statistical methodology into United States courtrooms under the name "hedonic damages" (see Stan Smith (1990)) has prompted some to raise warning flags. For instance, Dickens (1990) attacks the value of a statistical life methodology for several reasons, including the following: (i) various studies reject the behavior under uncertainty model that underlie the value of life literature, particularly in connection with low probability events. (See also Viscusi (1992)). (ii) Labor market imperfections, including unionization, clouds the wage differential studies, and (iii) the value of life studies are full of econometric problems, particularly omitted variable problems, that make their conclusions suspect. In fact Dickens claims that the clustering of value of life estimates that Jones-Lee (1989) and others find is as much a consequence of publishing bias as anything else — that is, if an economist's study finds a value of life in the plausible range of $1 to $2 million 1994 dollars, it's a successful study, but if it finds no positive value of life it doesn't get published!

John Broome (1978, 1985) makes a number of profound philosophical criticisms of the willingness to pay model. The most telling is what I would call the Broome paradox (Broome, 1978): Suppose the government plans a project that will cost some money and also create a risk to some lives (for instance, a long tunnel). Assume there are 10,000 identical people whose lives are put at risk, and the project create an additional risk of death for these people of .0006. Assume that they would require at least $600 each to accept that additional risk of death. Then by reasoning like what's above (except here ϵ is a decrease in survival probability, and C is the minimum compensation required to make the consumers as well off) the value of a statistical life is $C/\epsilon = \$600 \div .0006$ or $1,000,000. Now assume that the government project would produce a net benefit to society of $10,000,000, aside from the cost of lost lives. Following Mishan (1971 & 1982), the usual economic cost benefit analysis compares society's $10,000,000 benefit to the expected cost of six lives @ $1,000,000 per life, or a life-cost of $6,000,000. Since benefits exceed costs the project is approved. But, argues Broome, what if we know which six were to die, what if we know their names? And what if we approached the six named people, and asked what amount of money they would require to compensate for the certainty of death? They would each answer with an extremely high figure (perhaps $\$ +\infty$), and if we then compared the life-cost to the $10,000,000 project benefit, the project would fail the cost benefit test by a spectacular margin. So Broome argues that the willingness-to-pay approach is logically unacceptable.

Naturally Broome's criticism of willingness-to-pay is not unanswered (see Buchanan and Faith (1979), Jones-Lee (1979), and Williams (1979)). The essence of the response is that these government projects are decided *ex ante*, before the fact, so the names of the six aren't known. And moreover, if Broome's logic were adopted, practically no government construction project would even go forward, nor for that matter would any private construction project be undertaken, nor would anyone drive a car, or a truck, or a tractor, or engage in any physical sport, or for that matter engage in almost any physical act. That is, if no one were to accept a positive increment in the probability of death in exchange for a modest money gain, the world as we know it would grind to a halt.

IV. Purpose of This Paper

Most of the criticism of the willingness-to-pay measures of the value of life have focused on the empirical studies. Economists have generally not attacked the theoretical foundation (with the notable exception of John Broome). The purpose of this paper is to attack that foundation, by exposing it, and by illustrating it with a plausible utility function, so as to reveal its weaknesses.

I use a simple two-period, two-state expected utility maximization model, similar to what has been used elsewhere. (See, e.g., Jones-Lee (1974) and many others.) The formal innovation here is to assume a simple log-utility function, and to analytically "solve" the model. Using the solved model, I define various alternative willingness-to-pay value of life measures. I show that "value of life" is not uniquely defined, and that, in fact, there are at least five ways to approach the willingness-to-pay value of life concept, all giving numbers that may differ by many orders of magnitude.

The model used here incorporates insurance (as does, e.g., Bailey (1978), Bergstrom (1978), Conley (1976), Cook & Graham (1977), Dehez & Dreze (1982), Jones-Lee (1980)) as well as bequest-motives (as does, e.g., Jones-Lee (1974), and many others). It incorporates precaution as a choice variable, which is somewhat unusual. It illustrates the Broome paradox.

The model has two parameters that are especially important. The first is a measure of the individual's concern for his dependents (or his beneficiaries); this is the *bequest parameter*, or what I call *altruism.* The second is a measure of the individual's *fear of death.* I show that no matter which willingness-to-pay measure of the value of life is used, value of life will depend crucially on these two parameters. The value of life measures are strongly negatively related to altruism, and strongly positively related to fear of death. I suggest that these associations between the value of life measure and altruism (usually considered a virtue), and fear of death (usually considered a vice), make the value of life measures suspect.

Finally, I propose a value of life measure that is a hybrid of the willingness-to-pay approach and of the human capital approach. My proposed measure is consistent, I think, with legal tradition, and yet incorporates some aspects of the willingess-to-pay model.

V. **The Model**

"Fear is the foundation of safety."

Tertullian: *Women's Dress,* c. 220.

This is a two-period model, with a "before" and an "after", or *ex ante* and *ex post.* The model is similar to the two-period models in Jones-Lee (1974 & 1976). A two-period model is clearly less realistic than a multi-period one, but the lack of realism is compensated for by tractability.

In the first period, an individual is contemplating his state in the second period. In that future period, he will be either alive or dead. If alive, his utility (as contemplated from the first period) will depend on the amount of money in his pocket. If dead, his utility (as contemplated from the first period) will depend on the amount of money in his estate, and on a constant factor that represents his "fear of death." This is, of course, utility as seen *ex ante,* for if he is dead *ex post,* he then has no utility (as far as we know).

Our individual is endowed with a given sum of money in period one. He may use it in three ways: (1) He may hold it to spend on consumption in period two, or to bequeath, as the case may be. The money he uses this way is called (disposable or spendable) income. (2) He may spend it in period one on precaution. By spending it on precaution, he increases the probability that he will be alive in period two. (3) He may spend it in period one on life insurance. By spending it on life insurance, he increases his bequest by the face value of whatever life insurance policy he buys.

I assume that the individual focuses on an expected utility function, and maximizes expected utility in the Von Neumann-Morgenstern sense. His maximization problem is to choose the sums of money used in the three ways detailed above, so as to achieve the highest *ex ante* expected utility.

For the model I use the following notation:

x	=	amount of money to be spent on consumption (or bequeathed if dead) in period 2
y	=	money spent on precaution in period 1
z	=	money spent to purchase life insurance in period 1
$\overline{x}$	=	$x + y + z$ = cash endowment
$p(y)$	=	probability of life in period 2
$1 - p(y)$	=	probability of death in period 2
$V(y, z)$	=	face value of life insurance policy
K	=	"fear of death."

Following the usual practice, I assume that there is an *ex ante* utility function contingent on life in period 2, and an *ex ante* utility function contingent on death in period 2. In general terms, they are as follows:

$$\begin{aligned} f(x) &= \text{utility if alive} \\ g(x+V) - K &= \text{utility if dead.} \end{aligned}$$

Note that f depends only on spendable income. Note also that the utility if dead is comprised of two factors, a function g that depends on the size of the estate $x + V$, and a constant K that reflects the individual's *ex ante* fear of death.

Utility for our subject is now:

$$u = \begin{cases} f(x) & \text{with probability} \quad p(y) \qquad \text{(if alive)} \\ g(x+V) - K & \text{with probability} \quad 1 - p(y) \quad \text{(if dead).} \end{cases}$$

The individual is assumed to choose x, y and z so as to maximize expected utility

$$Eu = p(y)\ f(x) + (1 - p(y))\ [g(x + V(y, z)) - K],$$

subject to the constraints

$$\overline{x} = x + y + z \text{ and } x, y \geq 0.$$

I don't require that z be nonnegative because its analytically simpler to allow individuals to buy negative quantities of life insurance (i.e., rather like annuities, translated into the structure of this model).

To solve the model, I make the following special assumptions:

Assumption 1 (Actuarially fair life insurance).

$$V = \frac{z}{1 - p(y)}.$$

That is, the premium for the life insurance policy z equals the expected payout, $V \cdot [1 - p(y)]$, and both individual and insurance company have full information. (See also Bailey (1978), among others.)

Assumption 2 (Bequest utility a scaled version of life utility).

$$g(\cdot) = Af(\cdot).$$

That is, the bequest motive utility is the if-alive utility, scaled up (or down). Using the same utility function makes the analysis much easier, and the assumption strikes me as rather plausible. If the individual in question has strong reasons to be concerned with bequests to his heirs, A might be larger than 1. If he simply wants to be sure that his dependents are no worse off financially if he dies than if he lives, he might have $A = 1$. If he has no dependents and no interest in a bequest, $A = 0$. If he is repelled by the thought of ungrateful, wretched children inheriting his money, A might be negative. A will be called *altruism* or the *bequest parameter.*

Assumption 3. (Log utility).

$$f(x) = \begin{cases} 0 & \text{for } 0 \le x \le 1 \\ ln\ x & \text{for } 1 < x \end{cases}$$

The assumption of logarithmic utility permits analytic solution of the model. The assumption that $f(x) = 0$ for x between 0 and 1 is made to avoid the negativity of the log function in the [0,1] interval. An alternative assumption would be to let $f(x) = ln\ (x+1)$, but this would make the formulas derived below slightly more complex. In the numerical examples presented, x will be far greater than 1 anyway.

VI. A Special Version of the Model

Assume for now that there is no insurance market $(z = 0)$ and there is no bequest motive. Expected utility is

$$\begin{aligned} Eu &= p(y)\ ln\ x + (1 - p(y))\ [-K] \\ &= p(y)\ [ln\ x + K] - K \end{aligned}$$

Suppose our individual has chosen x and y and is confronted with the following willingness-to-pay question: Consider a small increase in survival probability ϵ (sufficiently small that $p(y) + \epsilon < 1$). Suppose that ϵ would be provided through a government program external to your own precaution efforts, that is, y would not change, but the new enhanced survival probability would be $p(y) + \epsilon$. What is the maximum C that you would pay for ϵ, out of your spendable income? To solve for C, we set up the following equation:

$$Eu, \text{ without program} = Eu, \text{ with program}$$

Or:

$$p\ ln\ x + (1-p)\ [-K] = (p+\epsilon)\ ln\ (x - C) + (1 - p - \epsilon)\ [-K].$$

For C's that are small compared to x, $ln\ (x - C)$ is approximately equal to $ln\ x - \frac{C}{x}$. Using this approximation formula and rearranging terms leads directly to:

$$(1) \qquad \frac{C}{\epsilon} = \frac{x}{p+\epsilon}\,(ln\ x + K).$$

That is, the willingness-to-pay value of life is the product of income with the sum of life utility and fear of death, divided by the survival probability after the program is put in place. Note that high income implies high value of life, which obviously makes sense for a willingness-to-pay measure. Also, high fear of death implies high value of life, which makes sense. But value of life is inversely related to the after-program survival probability. If the survival probability is very low, this value of life measure is very high. The desperate person is more willing to pay for a small addition to survival probability. (This result is similar to Theorem 1 in (Weinstein, et al., 1980).)

VII. The More General Version of the Model

I now re-introduce the insurance market, and allow for a bequest motive. That is, z is unconstrained, and $A \geq 0$. Expected utility is

$$Eu = p(y)\ ln\ x + (1-p(y))\ [A\ ln\ (x + \frac{z}{1-p(y)}) - K].$$

This is maximized subject to $x + y + z = \overline{x}$ and $x, y \geq 0$.

First-order conditions for maximization lead to the following equations (assuming an interior maximum):

$$(2) \qquad \frac{z}{1-p} = (A-1)\ x.$$

$$(3) \qquad p'\ [K + (A-1) - A\ ln\ A - (A-1)\ ln\ x] = \frac{1}{x} = \lambda.$$

Here p' is the derivative of the $p(y)$ function, and λ is the Lagrange multiplier associated with the budget constraint. I will denote the variables that maximize expected utility as x^*, y^* and z^*.

Equation (2) has a simple interpretation, since $\frac{z}{1-p}$ is the face value of the insurance policy. It says the insurance policy is chosen proportional to disposable income x, and the proportionality constant is the bequest parameter A, minus 1. For instance, if A equals 2, the insurance policy face value equals income. If A is zero, the subject buys a negative insurance policy, that is, he trades his bequest for higher live-state income.

Next consider equation (3). The intuitive interpretation of p' is important. This is the marginal increase in survival probability resulting from a marginal increase in precaution expenditures y, for the utility maximizing individual who is choosing precaution, along with x and z. The inverse of p' is the marginal increase in precaution expenditure corresponding to a marginal increase in survival probability. That is, $1/p'$ *represents precisely the utility maximizing individual's marginally measured value of life*. That is, it is precisely analogous to the C/ϵ measure discussed above. (See also Bailey (1978), and others.)

In what follows, I let VOL stand for value of life, as measured in this willingness-to-pay (at the margin) sense. Hence, from (3)

(4) $$VOL = \frac{1}{p'} = x^* \; [K + (A-1) - A \; ln \; A - (A-1) \; ln \; x^*].$$

In the event that $A = 0$ (no bequest motive),

(5) $$VOL = x^* \; (ln \; x^* + K - 1).$$

In the event that $A = 0$ (no bequest motive), and no insurance market exists (so that z is constrained to be zero), first-order maximization conditions lead directly to

(6) $$VOL = \frac{x^*}{p} \; (ln \; x^* + K).$$

Note that equation (6) is the limiting version of equation (1). Also note the difference between equations (1) and (6), on the one hand, and equation (5) on the other. Equations (1) and (6) make VOL inversely related to survival probability, but (5) does not. That is, *the inclusion of insurance (in this case negative insurance) cuts the link between survival probability and the value of life.*

VIII. **Other Willingness-to-Pay Measures, and Some Parameter Magnitudes**

The next step in this analysis is to make a reasonable assumption about the magnitude of K. In what follows I shall do some calculations based on an assumed level for x^* of \$10,000. This is a plausible number, the same order of magnitude as annual income for a wage earner in the United States. To get a grip on K, assume the subject has some bequest motive ($A > 0$), and is asked the following Broome-type question: Given that you have chosen utility maximizing x^*, y^* and z^*, and given that $x^* = \$10,000$, what dead-state compensation would you require to be indifferent between the live state and the dead state? That is, what amount of many $\tilde{X}$, if added to your bequest, would cause you to walk the plank from life to death? Call $\tilde{X}$ the life-death-indifference measure. It is the solution to

$$(7) \qquad ln\ (x^*) = A\ ln\ (x^* + \frac{z^*}{1 - p(y^*)} + \tilde{X}) - K.$$

Because equation (2) allows us to substitute for the insurance policy face value, this simplifies to

$$(8) \qquad ln\ (Ax^* + \tilde{X}) = \frac{1}{A}\ [ln\ (x^*) + K].$$

Now, if the subject answers "I would require all corporate equity in the United States" (roughly, $\$5 \times 10^{12}$), if $x^* = 10,000$, and if, say, $A = 1$, equation (8) could be solved for $K = 20.03$.

(Of course, the hypothetical question has a big credibility problem – a subject is unlikely to believe that contracts granting his heirs title to all stock in the U.S. will be fulfilled. But the hypothetical is a hypothetical. If need be, a discounting assumption could be built in – for instance, the subject, if promised $\$5 \times 10^{14}$ might anticipate delivery of only $\$5 \times 10^{12}$. In which case, $K = 24.64$.)

If the subject is destitute (take $x^* = 1$ for simplicity), equation (8) can be reduced to

$$K = A \; ln \; (X + A) \cong A \; ln \; X. \tag{9}$$

The X in equation (9) is called the destitute-life-death-indifference measure. It is the answer to this hypothetical question: What amount of money X would make you indifferent between the live state and the dead state, if in the live state you had (essentially) no money? If $A = 1$ and $K = 20.03$, X would be $\$5.00 \times 10^8$.

Based on the above observations, it appears that $K = 20$ might be a reasonable assumption.

With assumed levels for x^*, K and A, it is easy to calculate VOL and the life-death indifference measures defined above. However to go further, it is necessary to assume some form for the survival probability function $p(\cdot)$. The simplest plausible function is incorporated in:

Assumption 4. (Survival probability).

$$p(y) = a - \frac{b}{1+y}, \text{ where } 0 < b \leq a \leq 1.$$

When plotted against y, this probability function has intercept $a - b$, and is asymptotic to a horizontal line at level a. The easiest version of this function, from a computational standpoint, is produced when $a = b = 1$, or when

$$p(y) = 1 - \frac{1}{1+y}.$$

The computationally easy probability function has the survival probability equal to zero if no precaution whatsoever is taken, and the survival probability rises asymptotically to 1 as infinite precaution is taken.

Based on all the observations above, I make the following assumptions about parameter values in the two sections that follow.

Assumption 5. (Parameter values).

(a) $K = 20$.

(b) $a = b = 1$.

IX. More Measures of Value of Life

To this point I have defined three values of life measures:

(i) $VOL = \frac{1}{p'}$, the marginal willingness-to-pay measure.

(ii) $\tilde{X}$, the life-death indifference measure, that makes the subject indifferent between living with x^*, and being dead with a bequest enhanced by $\tilde{X}$.

(iii) X, the destitute life-death indifference measure.

I shall define two more. Suppose an individual has chosen x^*, y^*, and z^* and is asked the following hypothetical question: What is the maximum you would pay, out of your spendable income x^*, to eliminate the chance of death? Call his answer $\hat{X}$. $\hat{X}$ is a non-marginal willingness-to-pay measure. The person who pays $\hat{X}$ removes the death probability $1-p$, and his willingness-to-pay-per-statistical-death-prevented is therefore $\hat{X}/(1-p)$. I call $\hat{X}/(1-p)$ the live-for-sure measure.

$\hat{X}$ is found by solving the equation

$$(10) \qquad p(y^*)\ ln\ (x^*) + (1 - p(y^*))\ \{A\ ln\ (Ax^*) - K\} = ln\ (x^* - \hat{X}).$$

An analogous die-for-sure measure can be defined as follows: Suppose an individual has chosen x^*, y^* and z^* and is asked this hypothetical question: What is the minimum you would demand, to be added to your spendable (and bequeathable) x^*, to eliminate the chance of life? Call the answer $\overline{X}$. The subject who accepts $\overline{X}$ removes the survival probability p, and his demand-per-statistical-life-lost is $\overline{X}/p$. I call $\overline{X}/p$ the die-for-sure measure.

$\overline{X}$ is found by solving the equation

$$(11) \qquad p(y^*)\ ln\ (x^*) + (1 - p(y^*))\ \{A\ ln\ (Ax^*) - K\} = A\ ln\ (Ax^* + \overline{X}) - K$$

X. Numbers

With all the apparatus in place, I can turn to calculations. Table 1 below shows calculated values for $y^*, z^*, V, p, \overline{x}$ and the five value of life measures. Table 1 is based on the parameter values assumed above ($K = 20,\ a = b = 1$). Note, however, that given x^*, A and K, the value of life measures VOL, life-death-indifference, and destitute life-death-indifference can all be calculated without using assumptions (4) and (5b).

Insert Table 1 Around Here

Table 1

Calculated Values-of-Life and Other Variables

$K = 20,\ a = b = 1,\ x^* = \$10,000$

$A = 0, 1, 2$ and 3

In sections I and II, the non-probability numbers are in $.

In section III, the numbers are utility units.

	A = 0	A = 1	A = 2	A = 3
I				
Precaution $= y^*$	530.13	446.21	321.54	52.24
Survival probability $= p$	.9981	.9978	.9969	.9812
Death probability $= 1 - p$	.0019	.0022	.0031	.0188
Insurance premium $= z^*$	-18.83	0	31.00	375.64
Insurance face value $= V$	-10,000	0	10,000	20,000
$x^* + y^* + z^* = \bar{x}$	10511.31	10446.21	10352.55	10427.88
II				
$VOL = \frac{1}{p'}$	282,103	200,000	104,034	2,835
Life-death-indifference $= \tilde{X}$	$+\infty$	4.852×10^{12}	2.183×10^{6}	-13,071
Destitute l.-d. indifference $= X$	$+\infty$	4.852×10^{8}	2.202×10^{4}	783
Live-for-sure $= \hat{X}/(1-p)$	284,216	195,594	92,676	-17,445
Die-for-sure $= \overline{X}/p$	$+\infty$	4.650×10^{12}	2.157×10^{6}	-13,135
III				
Utility, live state	9.2103	9.2103	9.2103	9.2103
Utility, dead state	-20	-10.7897	-0.1930	10.9269
Expected utility	9.1553	9.1656	9.1812	9.2426

How should Table 1 be interpreted? First, it illustrates the Broome paradox. At least in the cases where the bequest motive is small $(A = 0 \text{ or } 1)$, the measures that confront our individual with certainty of death (life-death-indifference, destitute-life-death-indifference, and die-for sure) are all exceedingly high, much higher than the VOL measure. Hence, government projects that would be undertaken ex ante, according to cost-benefit analysis using VOL, would most likely be decisively rejected if those who were about to die were identified.

Second, if $x^* = \$10,000$ is taken as a very rough proxy for a person's net lifetime income, and therefore the "value of life" as typically computed under law, that is, the human captial value of life, it shows that the standard economic willingness-to-pay value of life (i.e., VOL), seems to be about an order of magnitude greater than the legal or human capital value of life — unless A is large. This result seems consistent with previous theoretical results (e.g., Bailey (1978), and Bergstrom (1982)), and with the various empirical studies of willingness-to-pay (e.g., Jones-Lee (1989), Fisher et al. (1989)). But see below for large A.

Third, it shows that the live-for-sure measure is comparable to the VOL measure, and that both are far smaller than the certainty of death measures. That is, there is a basic asymmetry of behavior here: the subject will demand much more (per life lost) to accept a certainty of death, than he would pay (per death prevented) to achieve a certainty of life.

Fourth, the greater is the bequest or altruism parameter A, the less the value of life, by any measure. This is rather obvious, since the bequest motive lessens the sting of death, the $-K$ in the utility function. But what's more interesting, and very much in contrast to the standard theoretical and empirical results, is this: if A gets somewhat large $(A = 3)$, all the value of life measures fall below spendable income $x^* = \$10,000$, and several even become negative! (This result contrasts with Bailey (1978), who finds VOL exceeds income when actuarily fair life insurance is available.)

Some observations about the negative measures are in order. The - \$13,071 for life-death-indifference, for instance, follows from equation (8), which, in this instance, gives:

$$(12) \qquad ln\ (10,000) = 3\ ln\ (10,000 + 20,000 + \tilde{X}) - 20.$$

The subject has purchased \$20,000 worth of life insurance, hence his utility in the live state, $ln\ (10,000) = 9.2103$, is less than his utility in the dead state (without $\tilde{X}$), or $3\ ln\ (30,000) - 20 = 10.9269$. Yet he is spending money on precaution $(y^* = 52.24)$, and the partial derivative of expected utility with respect to precaution is positive, because his precaution expenditure is linked to his life insurance premium. That is, in this model of perfect information, the life insurance company's oversight motivates an individual who is "better off dead" to stay alive, because he can buy a large life insurance policy at a modest price only if he exercises some precaution. Similar observations explains the other negative measures when $A = 3$.

Also note that "better off dead" in this context doesn't mean unhappy, suicidal, or depressed: in fact, as you go from $A = 0$ to $A = 3$, in Table 1, expected utility (the last line of part III) rises!

Now what is a reasonable level for A? Since the optimal insurance face value V equals $(A - 1) \times x^*$, we must have $A = 1 + V/x^*$. If we could observe our subject buying life insurance with face value twice his spendable income, we would infer $A = 3$. Obviously, it's a leap from the model (with only 1 future period, perfect information, etc.) to reality, but in the life insurance business one does observe people buying insurance with face value equal to several years' gross income. In fact, the 1993 *Statistical Abstract of the United States* shows, for the year 1991, average disposable income per household in the U.S. was \$44,700, while average life insurance in force per household was \$102,700. This gives a ratio of life insurance to income of 2.3. The problematical one-future period structure of the model aside, this kind of statistic does suggest that $A = 2$ or 3 might be reasonable values.

Fifth, and following from the above, the more life insurance a person buys, the less is his value of life by all the measures. This is not to say, of course, that the individual buying life insurance is less valuable to his beneficiaries, quite the contrary. It is simply a consequence of the willingness-to-pay approach, which places a low value on the life of the altruistic person, who might be more willing to sacrifice his own life for the benefit of, say, his children. In my view the negative relationship between concern for heirs and value of life is a strong reason to question the willingness-to-pay approach.

XI. **Fear of Death**

> "Cowards die many times before their deaths;
> The valiant never taste of death but once.
> Of all the wonders that I yet have heard,
> It seems to me most strange that man should fear;
> Seeing that death, a necessary end,
> Will come when it will come."
>
> Shakespeare: *Julius Caesar,* 1599.

The life values calculated in the last section are critically dependent on the fear of death parameter K; this is obvious since individuals who fear death more are more willing to pay to avoid it. I argued earlier that $K = 20$ is a plausible number. But what happens if K is less? In Table 2 below I show calculated values for $K = 10$, $K = 2$ and $K = 0$. As in Table 1, VOL, life-death-indifference and destitute life-death-indifference can be calculated directly from x^*, A and K, without knowledge of the survival probability function.

Insert Table 2 Around Here.

Table 2

Calculated Values-of-Life and Other Variables

$K = 10, 2, 0;\ a = b = 1,\ x* = \$10,000,\ A = 0, 1$

	K = 10		K = 2		K = 0	
	A = 0	A = 1	A = 0	A = 1	A = 0	A = 1
I						
Precaution = y^*	425.74	315.23	318.54	140.42	285.54	0[1]
Survival probability= p	.9977	.9968	.9968	.9929	.9965	0
Death probability $= 1 - p$	.0023	.0032	.0031	.0071	.0035	1
Insurance premium = z^*	-23.43	0	-31.30	0	-34.9	0
Insurance face value = V	-10,000	0	-10,000	0	-10,000	0
$x^* + y^* + z^* = \overline{x}$	10,402.30	10,315.28	10,287.24	10,140.42	10,250.64	10,000
II						
$VOL = \frac{1}{p'}$	182,103	100,000	102,103	20,000	82,103	1
Life-death-indifference = $\tilde{X}$	$+\infty$	2.203×10^8	$+\infty$	63,891	$+\infty$	0
Destitute l.-d. indifference = X	$+\infty$	2.203×10^4	$+\infty$	6.39	Any X	0
Live-for-sure $= \hat{X}/(1-p)$	187,844	98,435	110,160	19,859	90,639	0
Die-for-sure $= \overline{X}/p$	$+\infty$	2.1408×10^8	$+\infty$	63,301	$+\infty$	undefined[2]
III						
Utility, live state	9.2103	9.2103	9.2103	9.2103	9.2103	9.2103
Utility, dead state	-10	-0.7897	-2	7.2103	0	9.2103
Expected utility	9.1653	9.1787	9.1753	9.1962	9.1782	9.2103

1. By nonnegativity constraint.

2. $0 \div 0$.

The significance of Table 2 is that VOL and other willingness-to-pay measures for the value of life decline substantially as the fear of death parameter declines. Thus, for instance, if $A = 0$, VOL is around $282,000 when $K = 20$, $182,000 when $K = 10$; $102,000 when $K = 2$, and $82,000 when $K = 0$. The two life-death-indifference measures, and the die-for-sure measure, are all $+\infty$ when $A = 0$, unless $K = 0$, but for $A = 1$, they also show striking declines as K falls. The live-for-sure measure also drops sharply; for instance, if $A = 1$, live-for-sure is around $196,000 when $K = 20$; $98,000 when $K = 10$, $20,000 when $K = 2$, and $0 when $K = 0$.

All this confirms what may be obvious upon reflection: If the value of life is measured by willingness-to-pay to avoid death, then those who fear death most will have the most valuable lives.

Note that for any given x^*, and given A, equation (4) can be used to find a K sufficiently small that the VOL measure drops to almost zero. (Almost zero, since the non-negativity constraint for y, combined with the survival probability assumptions, force the minimum VOL to equal 1.)

Figure 1 below plots VOL against K, for three A values, and the assumed $x^* = \$10,000$. It illustrates the numbers presented in Tables 1 and 2. Note that for moderate A's (i.e., 2 or 3), and relatively small K's (i.e., 15 or less), VOL will often be modest (i.e., less than $100,000). Also note the negative relationship between VOL and the altruism parameter A, and the positive relationship between VOL and the fear of death parameter K.

Insert Figure 1 Around Here.

Both Figure 1 and Table 2 illustrates that, as a rule, willingness-to-pay measures of life value place high numbers on Shakespeare's cowards, and low numbers on the valiant. In my view this is another reason to question willingness-to-pay.

XII. Some Analytical Solutions

In this section I assume that $A = 1$. It follows from equation (2) that the utility-maximizing individual chooses no life insurance, and that expected utility is

$$Eu = p(y)\ ln\ x + (1 - p(y))\ \{ln\ x - K\}, \quad \text{or}$$

$$Eu = ln\ x - (1 - p(y))K. \tag{13}$$

Maximization of expected utility leads to equation (4), and with $A = 1$ this gives:

$$VOL = \frac{1}{p'} = x^* K. \tag{14}$$

Solving equations (8) and (9) when $A = 1$ gives two fairly neat equations for the life-death-indifference measure $\tilde{X}$ and the destitute-life-death-indifference measure X:

$$\tilde{X} = x^*(e^K - 1) = x^* X \tag{15}$$

$$X \ = \ e^K - 1. \tag{16}$$

It is also easy to solve for the live-for-sure measure $\hat{X}/(1-p)$ and the die-for-sure measure $\overline{X}/p$ using equations (10) and (11), plus $A = 1$ and equation (16) above. The results are as follows:

$$\frac{\hat{X}}{1-p} = x^* \left\{ \frac{e^K - (e^K)^p}{(1-p)e^K} \right\} \tag{17}$$

$$\frac{\overline{X}}{p} = x^* \left\{ \frac{(e^K)^p - 1}{p} \right\} \tag{18}$$

It should be noted that all the formulas in equations (13) through (18) above are independent of the functional form assumed for p, and therefore independent of Assumptions 4 and 5.

Equation (17) and (18), for live-for-sure and die-for-sure, are slightly complex, but can be approximated by much simpler formulas if p is very close to 1 or very close to 0. With respect to live-for-sure, or equation (17), the expression in braces approaches $ln\ (e^K) = K$ as p approaches 1, and the expression in braces approaches $(e^K - 1) \div e^K$ as p approaches 0. Hence we have:

$$(19) \qquad \frac{\hat{X}}{1-p} \cong \begin{cases} x^* K = VOL & \text{for } p \cong 1 \\ x^* \frac{X}{X+1} & \text{for } p \cong 0 \end{cases}$$

With respect to die-for-sure, or equation (18), the expression in braces approaches $e^K - 1 = X$ as p approaches 1, and approaches $ln\ (e^K) = K$ as p approaches 0. Hence, we have:

$$(20) \qquad \frac{\overline{X}}{p} \cong \begin{cases} x^* X = \tilde{X} & \text{for } p \cong 1 \\ x^* K = VOL & \text{for } p \cong 0 \end{cases}$$

These solutions are summarized in Table 3.

Table 3

Analytical Solutions for Values-of-Life

$A = 1$, Arbitrary K, x^* and p Function

Measure	Exact Solutions	Approximate Solutions
VOL	x^*K	
Life-death-indifference	$x^*(e^K - 1) = x^*X$	x^*e^K if $K >> 0$
Destitute-lid.-indifference	$X = e^K - 1$	e^K if $K >> 0$
Live-for-sure	$x^*\left\{\frac{e^K-(e^K)^p}{(1-p)e^K}\right\}$	$\begin{cases} x^*K \text{ if } p \cong 1 \\ x^* \text{ if } p \cong 0 \text{ and } K >> 0 \end{cases}$
Die-for-sure	$x^*\left\{\frac{(e^K)^p-1}{p}\right\}$	$\begin{cases} x^*X \quad \text{if} \quad p \cong 1 \\ x^*K \quad \text{if} \quad p \cong 0 \end{cases}$

Note: If $K = 3$, substituting e^K for $e^K - 1$ creates only a five percent error. As K rises, the error rapidly becomes negligible.

From Table 3, which depends on the $A = 1$ assumption, it would appear that there are three important magnitudes related to the value of life. They are, in ascending order, (1) x^*, (2) x^*K and (3) x^*e^K. Four of the five different measures of value of life reduce to one or more of these magnitudes.

I suggested above that x^*, spendable income, is the rough proxy in this model for human capital value of life. That is, it's the closest thing in the model to the net income measure typically used under law. Note that in Table 3 x^* is close to the live-for-sure measure if p is close to 0.

To get to the marginal value of life measure VOL, or the live-for-sure measure when p is close to 1, or the die-for-sure measure when p is close to zero, take x^* and scale it up by the fear of death parameter K. I argued above that a plausible K might be in the neighborhood of 20. But, of course, valuing life this way rewards the cowardly and penalizes the valiant.

To get to the life-death-indifference measure, or the die-for-sure measure when p is close to 1, take x^* and scale it up by e^K (a number that one would expect to vastly exceed K). These measures are the Broome-paradox-type measures, so high that, as most economists would argue, if the government adopted them, all programs that create small or even infinitesimal risks would grind to a halt.

The destitute-life-death-indifference measure is the only one of the five that, by construction, does not make the value of life proportional to income. It stands out of the sequence $x^* < x^*K < x^*e^K$, since $e^K - 1$ might well be either greater than or less than x^*K. One virtue of the measure is that it is independent of x^*, so those who are ethically opposed to making the value of life proportional to income might find it attractive. The vice is that it's a pure function of fear of death, rewarding the cowardly, and penalizing the brave.

XIII. Penultimate

"Timor mortis morte pejor." (The fear of death is worse than death.)

Latin motto.

In the preceding sections, I have defined five alternative willingness-to-pay measures of the value of life. Based on the examples calculated and shown in Tables 1 and 2 and in Figure 1, I argued that the five measures have minor and major disadvantages. In my view the major objections to the willingness-to-pay measures are, first, that they are inconsistent among themselves. That is, although the five meausres all formalize willingness-to-pay in one way or other, they produce vastly different numbers for the value of life, numbers which differ by many orders of magnitude.

Second, the willingess-to-pay measures assign lower life values to individuals who are more altruistic. That is, if you compare individuals with the same amounts of spendable increase, and the same utility functions except for the bequest parameter A, the individual with the higher A has the lower willingness-to-pay value of life. Scanning across the columns of Table 1 illustrate this vividly; for instance, for the marginal VOL measure, the value of life drops from roughly $282,000 to roughly $2,800 as A rises from 0 to 3. The drop takes place as expected utility is rising. The life-death-indifference measure drops from $+\$\infty$ to $-\$13,000$. The negative relation between willingness-to-pay value of life and A is very disturbing, since A is the one model parameter that is in a sense "virtuous." Most people think it's good for people to care about their heirs, e.g., their widowed spouses and orphaned children.

Third, the willingness-to-pay measures reward cowardice. That is, if you compare individuals who are otherwise identical, the individual who fears death more (i.e., has a higher K) has the higher willingness-to-pay value of life. Now I hesitate to endorse traditional celebrations of the heroic, but it certainly seems to be the case that western culture values courage above cowardice. It's hard to think of attractive characters in history or literature who are notable cowards. Even the cowardly lion in the Wizard of Oz gets courage in the end. To be a hero, one usually has to be brave. I cannot quite fathom why economists would want to institutionalize a methodology which is so keyed to fear (of death), and to see that methodology spread through government policy-making and through the courts. (Perhaps the only plausible rationale is in the quote that begins Section V.)

Economists normally defend the willingness-to-pay-to-reduce-risk measures by pointing at abundant empirical evidence of people paying to cut risk, or requiring compensation to accept risk (e.g., Jones-Lee (1989), Fisher et al. (1989), Viscusi (1992)). But perhaps no one has bothered to study the risk-seeking behaviors that are also common. Behaviors like skiing, whitewater canoeing and kayaking, sky-diving, motorcycle racing, bungee jumping, rock climbing, mountaineering, and spelunking all come to mind, not to mention warfare. (For instance, skiers and alpine climbers at Mont Blanc in France suffer more than two hundred fatalities per year!) Perhaps if the effort were expended, evidence would be amassed that "proves" people are willing to pay to increase risk of death.

It should be noted that there is no good biological reason to believe that fear of death is more fundamental than concern for survivors. Sociobiologists (See, e.g., Wilson (1975), Hirshleifer (1977)) have pointed out that reproductive success of a population might be enhanced by behaviors that are dangerous to one organism's (or one person's) life, but beneficial to his population, or his genotype. Altruism and risk taking may make evolutionary sense. Thus it is "natural" for a parent to risk her life or sacrifice that life for her children, if by so doing she increases their probability of survival. This suggests to me that altruism (a high A) and courage (a low K) may make good biological sense, although they would produce a low value of life by the standard economic measure.

All this leads in the following direction:

A reasonable measure of the value of life should depend on income, or x^* in the model. It seems to me that this is the most compelling conclusion of the willingness-to-pay approach. It is also the basis of the legal approach to the value of life, that is, the human-capital approach. And in the legal approach it has a history, literally thousands of years long. (Oddly though, the advocates of hedonic damages in wrongful death cases intentionally leave income out, although willingness-to-pay models say it is central. See Smith (1990).)

A reasonable measure of the value of life should depend positively on altruism, or A in the model. This is not just a moral position, because A captures some of the important externalities in life-death questions. If everyone were totally indifferent to everyone else, A in the model would always be zero. Our subject individual has a greater A the greater is his concern for his heirs. The value of that person to the rest of society is therefore crucially dependent on A. (See Needleman (1976) for a serious treatment of the externalities question.)

Finally, a reasonable measure of the value of life should not be as dependent on the fear of death, K in the model, as the willingness-to-pay measure. It's hard for me to see a central legitimate role for K for several reasons. First is the measurement problem. Unlike, say, x^*, K is not directly observable. If it is inferred from answers to Broome-paradox-type questions, it is problematical. One should be suspicion of answers to questions like "How much would you need to be paid to walk the plank," since these questions are basically outrageous. Second, it places too much importance on utility in the dead state, a utility which exists ex ante but doesn't exist ex post. To paraphrase a Greek philosopher, death is nothing to be feared, because when we fear it we're alive, and when we're dead we don't fear it anymore. Perhaps one should not base an important measure on such paradoxical fear. Third, it assigns high value to the lives of cowards and low values to the lives of the brave, contrary to the beliefs that most people usually express.

XIV. **Wrongful Death Damages Revisited**

Consider the following rearranged version of equation (4), with a new term C implicitly defined:

$$(21) \qquad VOL = Ax^* + x^*[K - 1 - A \ln A - (A-1) \ln x^*] = Ax^* + Cx^*.$$

Note that the sign of the term C is ambiguous. A priori, for an "average" person, there is no strong reason to believe that this term would be very much greater than zero. On the other hand, for an "average" person who cares about his family, the parameter A should be positive, and Ax^* should be a large positive number.

To get an idea about the likely magnitude of C, refer to Figure 2, which plots some C contours in the A-K plane. Note that there are lots of plausible (A, K) combinations that produce C's close to zero; and certainly many very plausible (A, K) combinations that give C's less than 10.

Insert Figure 2 Around Here.

Next, consider a typical wrongful death action in the United States. Suppose Eve leaves a husband and three children, suppose that she was employed outside the home, suppose she had an average life insurance policy, and suppose that, like a typical wife and mother, she provided valuable unremunerated services to her family. Then her widower and orphans would probably be able to recover for damages in a lawsuit (provided they could establish liability), and the damages they would receive in a majority of American courts would be:

- (i) loss of net earnings;
- (ii) loss of household services, guidance and companionship, consortium;
- (iii) pain and suffering prior to death.

In addition, she would collect on her life insurance policy:

- (iv) insurance.

Now to translate these items (with caveats because of the roughness of the model) into close model equivalents, we have:

(i) x^*.
(ii) Not separate or explicit in model – part of x^*.
(iii) Somehow related to K.
(iv) $V = (A-1)\ x^*$.

Note that under the collateral source rule, the loss of net earnings part of damages (i.e., x^*) would not be mitigated by insurance proceeds (i.e., $(A-1)x^*$), so from parts (i) and (iv), and ignoring (ii) and (iii), the widower and orphans would receive $x^* + (A-1)x^* = Ax^*$.

Set element (ii) of damages aside since it's either wholly out of the model, or ought to be considered part of x^*, and all that remains is element (iii), pain and suffering. Now for simplicity assume the death itself is quick and painless, but that decedent may have suffered via contemplation of imminent death. If a jury decides that decedent was unaware (e.g., unconscious) of her imminent death, then compensatory damages for pain and suffering, flowing to the estate and then to widower and orphans, would be zero. Hence, the widower and orphans would receive Ax^*.

On the other hand, if a jury decides that decedent was aware and conscious and looked imminent death in the face, they could award damages for pain and suffering. The amount they would award would be chosen by them, and they would have wide latitude in the choice. The amount they award could, in theory, correspond to an answer to a Broome-type question, or in our model to the life-death-indifference measure or the die-for-sure-measure. (Jurors would typically adjust the award according to the length of time, the decedent contemplated death. This adjustment may not be a linear, or even a monotonic function of the length of time. Thus, contemplating death for 75 years probably warrants an adjustment factor of near 0, contemplating death for 75 days probably warrants an adjustment of around 1, and contemplating death for 75 microseconds probably warrants an adjustment factor near 0.) The adjustment aside, however, with the pain and suffering award for contemplation of death, widower and orphans should now receive $Ax^* + (\tilde{X}$, or X, or $\overline{X}/p)$, if compensatory damages are set right to make plaintiff whole. (Under the special assumption that $A = 1$, and based on Table 3, the terms in parentheses would roughly range between x^*K and x^*e^K. Note that under our assumptions of $x^* = \$10,000$ and $K = 20$, the latter number is $\$5 \times 10^{12}$, the value of all U.S. corporate equity.) But what do juries decide?

A rough guide to recent wrongful death settlements and awards in U.S. courts can be found in Munger (1993). Munger lists 198 wrongful death cases. The mean settlement or award was $1.3 million, *including* pecuniary damages (i.e., net earnings, or x^* in the model). Unfortunately, Munger doesn't generally separate pecuniary damages from pain and suffering damages, but he does provide enough information in most cases to enable a reader to inter whether the death was quick or slow; the slow deaths obviously provide a greater potential for contemplation of death, as well as actual pain. Based on Munger's case list, however, there is *no correlation* between the size of the award and whether the death is quick or slow. That is juries (and attorneys negotiating settlements) seem to place little value on the pure fear-of-death element of damages. In other words, they act as if K is much smaller than 20, or as if the term C in equation (21) is relatively modest.

In sum, in our hypothetical wrongful death case, compensation (inclusive of life insurance proceeds) flowing to hypothetical survivors is (in model notation):

$(A-1)x^*$ from insurance, plus

x^* as pecuniary damages, plus

Cx^* for fear of death pain and suffering,

for a total of $Ax^* + Cx^*$.

Based on assumptions and observations about the model made above, and based observations about the usual legal rules and legal outcomes, and subject to revision to accommodate a more realistic n period model, I would propose the following value of life function:

$$\text{Value of Life, All Considered} = Ax^* + Cx^* \qquad (22)$$

And I would suggest that C is a small number, about the same size as A.

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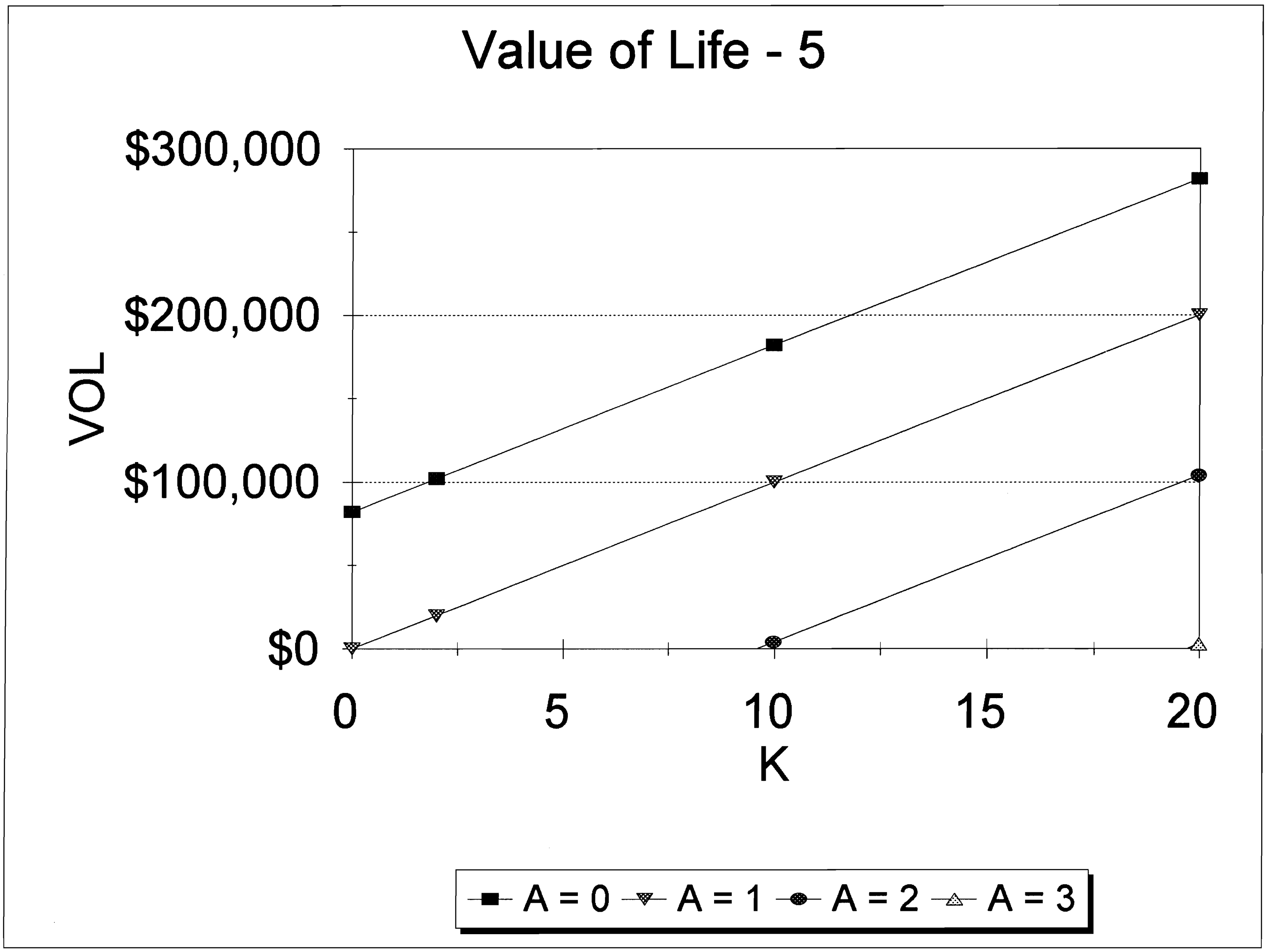
Value of Life - 5
$300,000
$200,000
$100,000
$0
VOL
0
5
10
15
20
K
A = 0
A = 1
A = 2
A = 3

Figure 1

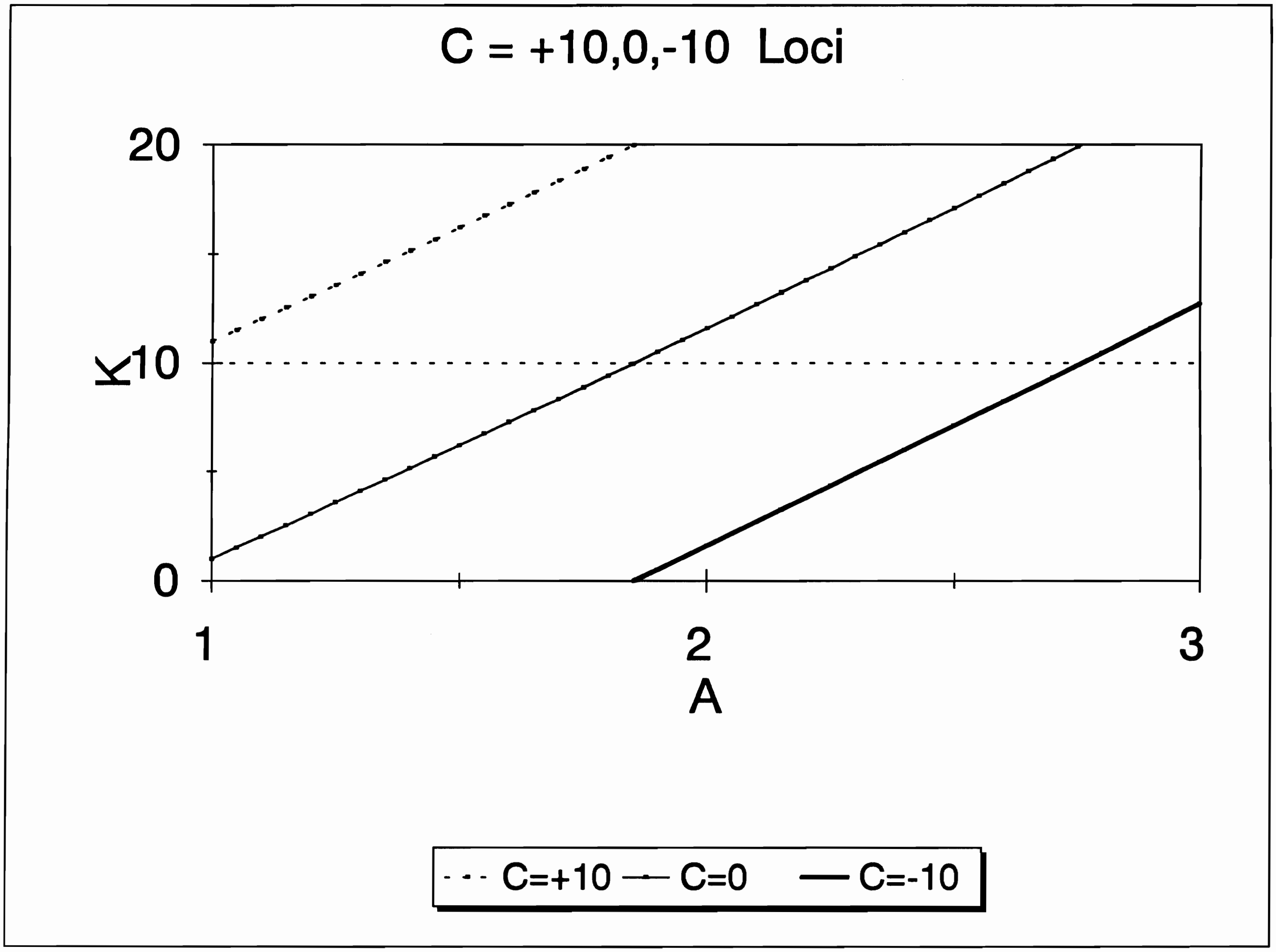

Figure 2