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MURDERING STATISTICAL LIVES . . . ?

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I. INTRODUCTION

The public appears to prefer saving known persons in present and serious peril over averting future dangers to persons yet unknown. The identifiable life--the coal miner trapped in a collapsed mine, the mountain climber stranded in a blizzard, a little girl in need of an operation--seem deserving of special priority over the statistical life--highway deaths, cancer deaths--occurring at some time in the future. But a question rarely asked is whether public emotions are aroused so much by the knowledge of a person's identity as by the knowledge that someone, whoever it may be, is in serious peril. Does not a ship lost at sea inspire the

[1]The author acknowledges the valuable comments made by Howard Kunreuther, Michiel Jones-Lee, Gavin Mooney, and James Vaupel on earlier drafts of this paper.

same response regardless of the existence of a passenger list? As Broome (1978) asks in his provocative article on this subject, "if a definite number of people are going to die, can it really make such a vast difference whether or not it is known for certain who they are?" (p.92).

Framing the issue in this way, the problem of allocating funds for the identifiable person in serious peril at the cost of saving statistical lives is but an extreme rendition of a more general, and possibly more important,[2] social dilemma concerning the distribution of the risk of early death over populations, none of which are so small that the victims are *ex ante* identifiable. Though the identity of the person, his name and his face, is undoubtedly a contributing factor to the disproportionate public response, the desire on the part of the public to spread or equalize the risk of early death among its members may be an equally important contributing factor. The problem, then, goes beyond the identifiable death and concerns the more general issue of allocating resources among statistical deaths, where placing priority on high-risk situations, thus promoting "risk equity," may be at the cost of "efficiency," or saving fewer lives in the total.[3]

[2]It is questionable whether society is, in fact, allocating more to save the identifiable life. According to Schwing (1979) the average cost per life year saved for kidney transplant, home dialysis, and highway rescue cars is $10,000, $50,000, and $40,000 respectively. These sums can be compared with the figure put on a statistical life by the U.S. government which ranges from $300,000 to $1 million.

[3]In this paper, I shall not be dealing with the problem of distributing risks in its entirety since I have chosen not to include one intriguing aspect, the catastrophic risk. Though the problem of placing priority on risks effecting many people at one time and in one place are in some ways similar, and in some ways importantly different, to the equity problem defined here, scope of this paper will be limited to the latter. For good discussions of the catastrophic event, see Lathrop (1981), Keeney (1980), and Bodily (1978). A related issue is the catastrophic loss to the *individual*. In this regard, one area of investigation concerns the decision processes of individuals for their protection against events which have a relatively small chance of occurrence, but that can result in severe personal losses. For instance, Kunreuther (1979) has looked into this question in the context of determining appropriate public policy with respect to subsidized insurance policies and disaster relief for individuals in areas of potential natural disaster. He has more recently expanded this work to include technological hazards (Kunreuther 1980).

To illustrate, consider the following problem:

> An oil-fired electricity-generating plant is being planned for construction. Though the plant will supply the electricity needs of a distant city, it is not without risks to the local population. The air of the region surrounding the plant will be polluted. In addition, the workers at the plant will be exposed to high safety risks. The per-capita risk from the air pollution is calculated to be smaller than that from the occupational hazards, but because the pollution affects a greater population, the life years lost are expected to be higher. The budget permits only one of two equally costly expenditures: scrubbers to clean up the air or a series of on-site improvements to reduce the occupational risks.

Keeney (1978) has stated the dilemma of deciding which population should receive priority as depending on whether "risk equity" is a desirable aspect of the public's value structure for evaluating risks. Borrowing his notation, the problem can more generally be stated as a choice of awarding priority between the following two risk profiles (assuming independent probabilities)

$$\left(\frac{1}{10}, \frac{1}{10}, 0, 0, 0, 0, 0, 0, 0, 0\right)$$

$$\left(\frac{1}{20}, \frac{1}{20}, \frac{1}{20}, \frac{1}{20}, 0, 0, 0, 0, 0, 0\right)$$

where in the first population of ten people, two are facing a 0.10 risk to their lives from some specified cause, and in the second population of ten people, four are facing a 0.05 risk to their lives again from a specified cause. The question is whether the policy maker does or should follow a strict efficiency strategy, in which case he would be indifferent between mitigating the risks from either cause, or whether equity considerations do or should play a role in his decisions, in which case he might prefer mitigating the higher risks facing fewer people.

Striving for efficiency, or attempting to spare as few lives in the total as possible has long been recognized as a desirable goal.[4] The question of how the government might reallocate resources in meeting this goal remains topical among policy analysts. In a recent survey of 57 lifesaving programs in the United States, Graham and Vaupel (1980) have revealed striking disparities across agencies and programs in the cost per life year saved. For example, a recent standard set by the Occupational Safety and Health Administration on the use of acrylonitrile is estimated to save a life at the cost of $11 million which can be compared, for example, to mandatory passive seat belts in automobiles which are estimated to save a life at the cost of $88. The question is how relevant are the *distribution* of the risks in making these shifts. This question of equity versus efficiency lies at the core of the preventive versus curative debate in the medical community.

A good example of this equity-efficiency dilemma in practice can be found in the area of radiation protection. The measure of radiation exposure is the person rem, or, more recently, the man-sievert[5], which is the exposure of one person to one rem (sievert), 100 people to 0.1 rems (sieverts) each or 10^6 people to 10^{-6} rems (sieverts) each, and so on.

[4] A plea for the rationale allocation of public money for government policies intended to save lives was made in 1963 by Carlson, who argued for economic efficiency in allocating the public pie among competing health and safety programs. He showed that a death on the highway could be prevented for a cost as low as $1,099; whereas, the U.S Air Force was spending on the B-58 capsule ejection system $9 million to prevent a death. Though Carlson was one of the first to argue for a fixed value on a life to promote allocative efficiency, he was not the first to propose a dollar value on a human life. Sir William Petty (1663) calculated "80 pounds sterling to be the value of each head of man, woman, and child, and of adult persons twice as much; from where we may learn to compute the loss we have sustained by the plague, by the slaughter of men in war, and by sending them abroad into the service of foreign princes," (p.136). It is impossible in any true sense to measure human life in terms of dollars and cents," (p.124). For a review of the more recent literature, see Linnerooth (1975, 1976), Acton (1976) and Mooney (1977).

[5] The man-sievert is equal to 100 person rems.

Since it is usually assumed (but by no means proven) that the probability of dying from a latent cancer is some linear function of exposure, the expected deaths from one person rem or one man-sievert is independent of how it is distributed, or independent of the size of the irradiated population. In a 1974 U.S Environmental Agency Report, Tompkins states the radiation protection dilemma as what population should get priority attention: the one with the highest per-capita exposure or the one with the largest person rems?

Since publication of this E.P.A. report, the concept of a cost to a person rem has received a great deal of attention. As pointed out by Jones-Lee (1980), the U.K. National Radiation Protection Board has argued for an increasing relationship between the cost of a man-sievert and the per-capita dose. By giving priority to the population with the highest per-capita exposure the NRPB has, in effect, made an implicit statement rejecting "deaths averted" as a policy goal. Preventing high risks to a few people is apparently more important than mitigating lower, more insignificant risks affecting many more people.

How justified are we in setting these sorts of differential safety priorities? Should public sentiment for the high-risk victim be permitted as a part of the rational calculus of allocative decisions? Or, as Raiffa suggests in the following statement made at a recent congressional hearing, should the policy maker be more cognizant of the efficiency principles involved?

> We must not pay attention to those voices that say one life is just as precious as 100 lives, or that no amount of money is as important as saving one life. Numbers do count. Such rhetoric leads to emotional, irrational inefficiencies and when life is at stake we should be extremely careful lest we fail to save lives

> that could have easily been saved with the same resources ... (as quoted by Lowrance 1980, p.6).

The problem can be generally phrased by asking how much the distribution of the numbers should count, how far can we justifiably deviate from an efficient strategy of minimizing the years lost to human lives?[6] Can we trade off *efficiency* in allocating our lifesaving budget for a gain, however defined, in the *equity* of the risk spread? Or by deviating from the most efficient solution, are we, as Raiffa once asked, murdering statistical lives...?[7]

I shall proceed by first examining the economist's perspective on the equity-efficiency problem within the context of the familiar Kaldor compensation rule for allocative decisions. The conclusion of this section, and the main point of my paper, is that this rule loses its appeal even to the most ardent supporters of market allocative mechanisms when applied to valuing the benefits of saving persons from high-risk situations. Some alternative ethical rules for resolving the equity-efficiency dilemma are presented in Section III. The conclusion of this paper is that the analyst, though he or she cannot resolve the ethical questions involved in allocating safety expenditures among populations with differing risk spreads, can play a useful role by explicating the tradeoffs and moral issues implicit in these difficult allocative decisions.

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[6] Though I have generally stated the maximizing dilemma in terms of lives saved, Zeckhauser and Shepard (1976) have proposed that the objective function be expressed in terms of quality-adjusted life years (QALY's) to account for differences in health status. The notion here is that cutting life expectancy for a group from, say, 80 years to 79 years, for *each* member of the group is quite a different thing from an equivalent shift in the life tables brought about by the deaths of healthy teenagers.

[7] This was expressed during personal communication.

II. THE ECONOMIST'S PERSPECTIVE

It is generally accepted among economists that the benefits of a public program are most appropriately measured in terms of the aggregate willingness to pay on the part of those benefiting from the program; similarly, the costs are most appropriately measured by the amount of money necessary to compensate the losers.[8] On the problem of determining how much a life-saving program is worth to a community, or alternatively, how much a community must be compensated for deaths that might be imposed by a government policy, the economist offers two pieces of advice: First, it is the individual's preference for his *own* life, not his economic worth to society, that is the paramount consideration. The "value of life" is, therefore, the value of a person's own life to himself, plus the value that his family, friends and society might add. But since this value is infinite in the sense that under most circumstances *no* amount of money can compensate a person for his certain death, the economist (notably, Mishan 1971b) offers a second piece of advice. The relevant concept is not life or death, but a (usually small) change in mortality risk, the value of which to most people is finite. It is not lives that are being valued, but rather the reduction or increase in the *risk* of death by some small amount over a large group of people.

As will be shown in this section, a person's willingness to pay to decrease his risk of death increases with the seriousness of the risk. For

[8]The most notable feature of this rule for allocating public funds is that it does not actually require the gainers to pay nor does it require that the losers be compensated. The rationale for adding up the costs and benefits in this manner is the familiar Kaldor compensation rule, requiring only an ability on the part of the beneficiaries to compensate any losers so that everyone *could* be made better off.

instance, a person will be willing to pay more to reduce his chances of dying from 0.9 to 0.8 than from 0.2 to 0.1.[9] Following the logic of the willingness-to-pay rule to its logical conclusions, society will give priority to individuals exposed to high risks at the cost of overall efficiency. By evaluating, not lives, but the risk of dying, the economist is inadvertently arguing against maximizing lives saved.

This device of commuting the cost of death to the cost of risk of death has been recently attacked by Broome (1978), who claims its illegitimacy lies in the fact that it capitalizes on the *ex ante* ignorance of the public as to the number and identity of the deaths.

> Each project which causes deaths and which is nevertheless accepted is accepted in the knowledge that, were it re-evaluated later, it would be rejected as infinitely wrong .... it does not seem correct to distinguish in value between the death of a known person and of an unknown person. (p.94)

By rejecting the practice of valuing projects *ex ante* to the fact of death, Broome appears to be arguing for an infinite cost on any program that imposes risks on the population, clearly an impractical way of conducting government's business. But this is not, in fact, the case Broome makes. He suggests that a life, even one in immediate peril, has a finite value, which is no different from the value of a statistical life (barring any interests on the part of family, friends or society), and for his reason the policy maker is not justified in deviating from the efficiency principle in allocating funds for lifesaving. I shall be making the argument in the next section that from a utilitarian perspective Broome's point, though

[9] Though an individual is probably willing to pay more to reduce his chances of dying from 0.1 to 0 than from 0.2 to 0.1 because of the reduction in his anxiety (Zeckhauser 1975).

apparently misunderstood, is essentially correct. There is a finite value in terms of utility on a life which is not reflected in the willingness-to-pay measure described above.

This divergence of willingness to pay for a commodity from the utility gained by the purchase of the commodity is well documented in the economic literature dealing with consumer surplus. But the point raised by Broome, on which I hope to shed more light here, is that the use of money for the valuation of risks on life can be thoroughly misleading, far more serious than the usual nuances of the consumer-surplus measure. The reason for this is quite simply that money, as the evaluator, has a value not independent of what it is valuing, i.e., barring a legacy value, money is worthless to the dying man. In contrast to Broome, however, I shall not totally reject the practice of valuing deaths *ex ante* to their occurrence, but shall show that this procedure is legitimate, even for the utilitarian, where the risks of death are small, but not legitimate, when the risks become large. Going beyond Broome, I shall argue that objections to the differential treatment of risk, where in the extreme the identifiable, immediate death is regarded as infinite and the statistical death as finite, are utilitarian in nature; the question of priorities for managing different risk spreads is an ethical question. But this is the subject of the next section.

In this section, I shall proceed by presenting a simple model of individual choice regarding payments for personal risk reductions. According to this model, personal preferences for risk reductions depend on the level of the risk and not only on the size of the reduction,[10] which justifies, in the Kaldor sense, deviations from a strict efficiency principle in

[10] This point has been made by Bergstrom (1974), Jones-Lee (1974), Howard (1979), as well as Linnerooth, et al. (1975).

allocating public money for risk mitigation activities. My purpose in the remainder of this section is to show that this model, though it has important descriptive appeal, may not be a desirable basis for prescriptive actions by public officials. For this purpose, I will briefly review the welfare basis of the willingness-to-pay concept, and I will reevaluate this welfare basis when the commodity under question is mortality risk.

A. A SIMPLE MODEL

Preferences with regard to risk of death can be viewed within the more general framework of decisions made under uncertainty, a framework which has long been dominated by the idea that a person's choices under uncertainty are made in such a way that he maximizes his expected utility.[11] Expected utility is usually formulated in terms of a probabilistic flow of goods or events affecting a person's well being. When the unfortunate event is death, we can conceptualize an expected lifetime utility, denoted Θ, which can be written:

$$\Theta = \sum_{i=1}^{n} p_i \mu_i^L \tag{1}$$

where p_i is the probability of surviving exactly i years ($i \leq n$) and μ_i^L is the utility of living in year i. The utility of living n years can be thought of as lifetime utility, noted henceforth as U^L, which should be distinguished

[11] Expected utility theory has been most extensively developed in the area of decision analysis (see Raiffa 1968) as a normative tool for the decision maker. In economics it has been adopted as a descriptive model of individual choice; its descriptive properties, however, have not gone without challenge. Recent works (Kahneman and Tversky 1974; Tversky 1975) show that there are certain attitudes which often lead to predictable violations of expected utility theory.

from *expected lifetime utility*, noted above as Θ. The gist of this formulation is simply that a person would be prepared in some sense to reduce his pleasures from life so that he might live a bit longer; or, alternatively, he would be willing to take on a risk to his life for some amount of compensation, monetary or other. There is a quality-quantity tradeoff.

For reasons stated above, the policy maker is most concerned with the tradeoff a person would voluntarily make between money and uncertain life years, the money-quantity tradeoff. Since it has proved difficult, if not impossible, to obtain direct empirical evidence on this tradeoff,[12] there have been several attempts to deduce it from some higher-level hypothesis for which supporting evidence exists. A tempting way to proceed is to equate the pleasures of living with the pleasures of consuming, $U^L = U(C)$, for which some empirical evidence exists.[13] But as I have pointed out elsewhere (Linnerooth 1979), implicit in this practice is the questionable assumption that a person views the loss of his livelihood as the loss of his life.

I shall proceed on the assumption that we live for more than bread alone, with full realization that if deprived of our bread, we cannot live. Not attempting a complicated description of reality, I shall consider the case of the "lone bachelor," whose utility for each year of life is some combination of his consumption and nonconsumption activities, where the latter can be thought of as the pleasures from working, from watching a sunset, or simply from being alive.[14] To put this notion into an

[12]For a review of the values derived from compensating wage differentials, see Smith (1979).
[13]See, for example, papers by Conley (1976) and Usher (1973).
[14]It might be argued that all activities are consumption, or require a monetary outlay, e.g., watching a sunset demands a price in terms of the opportunity cost of the time spent. Yet, it is important to realize that these activities can be overlapping with respect to time. A state of mind, for instance, can be regarded as a separate neutral activity which demands no

equation, let

$$\Theta = \sum_{i=1}^{n} p_i \mu_i^L (j_i, \boldsymbol{x}_i) \tag{2}$$

where j_i is the joy of living independent of consumption and $\boldsymbol{x}_i$ is the vector of consumption goods in period i. To simplify further, I will make three assumptions:

(1) The person possessing the above utility function knows for certain that he will survive n years if he survives the first period, and his probability of surviving this first period is P.

(2) He receives an equivalent amount of money or income (m), in each of the n years so that $u(\boldsymbol{x}) = \mu(m)$; and

(3) His lifetime utility function is separable and additive in j and $\mu(m)$.

This permits me to rewrite equation (2) as

$$\Theta = P[nj + n\mu(m)] \equiv P[J + U(M)] \tag{3}$$

We can thus think of the lifetime utility of a person living n years as $U^L = J + U(M)$.[15]

Two features of this model are worth emphasizing here:

price. This is the sheer joy of being alive.

[15]This lifetime utility function is not so dissimilar to the function proposed by Jones-Lee (1978), $U(w,t) = u(w) + l(t)$, where w is the present value of the person's wealth, including discounted future labor income, and t is the time of the person's death. Separability implies that the person has access to actuarially fair life insurance and annuity markets from which he covers his entire human capital.

-- Lifetime utility is finite, and

-- lifetime utility is not synonomous with the utility of lifetime income.

These propositions are illustrated in Figure 1, where, assuming diminishing marginal utility of money, the relationships among expected lifetime utility, survival probability and the utility of money are illustrated. I have arbitrarily set the utility of death at zero, represented by the heavy line marked $P=0$. If a person is at point A, with probability of surviving P_0 (or expected lifetime $P_0 n$) and with money income (or consumption) M_0, then the disutility of sudden death is not infinite, but $\overline{AC}$, which is *not* synonomous with the disutility of losing one's lifetime income, or $\overline{AD}$.

The astute reader might, however, question that the person is indeed alive at point E, where he has no money, or bread. If M is strictly interpreted as personal consumption, it is correct to equate $M=0$ with death, which would be illustrated by a discontinuity in the Θ function [$\Theta(x=0) = 0$]. Yet, it seems highly unlikely that an individual would view the loss of his money literally as starvation. Of course, it can be argued that some among us might commit suicide if we were reduced to bankruptcy. Some might even commit suicide at some income greater than zero.[16] Clearly, the location of the curves in Figure 1 is an empirical matter, but I believe that, as they are shown, they capture the essence of the situation for most individuals.

[16]Jim Vaupel has pointed out to me that a preference for death may not be equivalent to committing suicide because of the social stigmas attached, and that discussions with colleagues have revealed that some would, indeed, prefer not being alive to being alive with a low income.

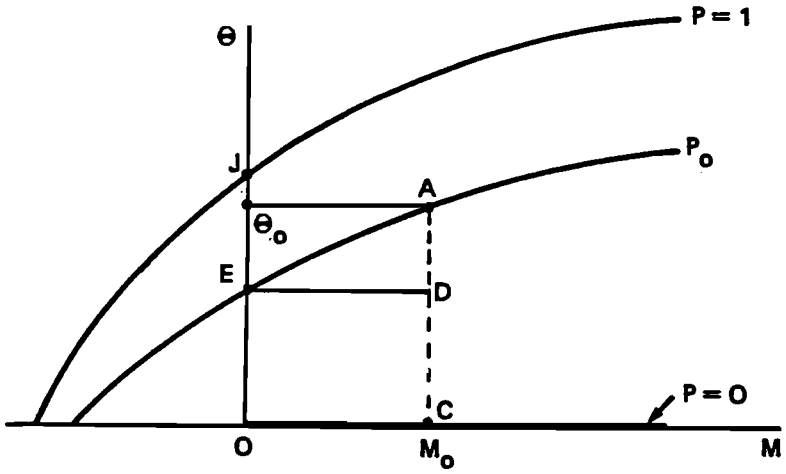

Figure 1: Lifetime Utility in Terms of
Money Income and Survival Probability

In sum, a reduction of income to zero is not necessarily viewed as a fate as bad as death; only where income is reduced to the point where the disutility of being alive but in debt is just offset by the joy of living, or $U(M)=-J$, is the individual indifferent between living and dying. And there may not be such a point, a case which will be argued in a later section.

From equation (3) it is a simple matter to express the tradeoff this representative person, as an expected utility maximizer, would willingly make between income and survival probability. For constant levels of expected utility, the marginal rate of substitution for M and P is

$$\frac{\partial M}{\partial P} = - \frac{J + U(M)}{P\lambda} \tag{4}$$

where λ denotes the marginal utility of income for each respective period.

This tradeoff is shown in Figure 2. The indifference curves represent a locus of points (P , M) such that expected utility remains constant. The slope of these curves, or the rate at which an individual is willing to trade a small amount of wealth for a small amount of safety, is often referred to as the "value of human life" appropriate for evaluating safety programs (see Bergstrom 1974, Jones-Lee 1974).

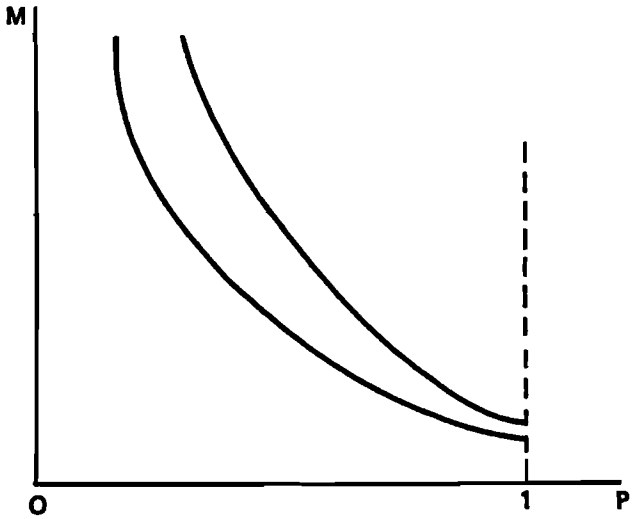

Figure 2: An Indifference Function Showing the Tradeoff of Money for Survival Probability

While the "lone bachelor" assumption has ruled out any motive on the part of the person to bequeath his wealth, inclusion of this motive would likely change the shape of the indifference curve, but the direction of the change is unclear.[17] On the one hand, a person might be less

[17]It is sometimes convenient to separate wealth into two components, consumption and bequests. However, it seems illogical to assume, as most writers on this subject, that bequests result in a posthumous utility. Bergstrom (in Hirschleifer, et al., 1974), for example, speaks of a bequest as a consumption stream which continues posthumously to those who are still alive. However, barring religious considerations, it is difficult to imagine a posthumous utility on the part of the dead person. Indeed, this same argument could be applied to any activity which resulted in posthumous benefits to others, e.g., spending time with one's children. It seems more reasonable to regard the bequest motive or providing for one's dependents as a separate lifetime activity, which can be included in consumption, resulting in utility (reduced anxiety about one's dependents) to the individual while he is alive.

willing to pay out large sums of money for his own survival since this reduces his legacy to his survivors; on the other hand, a person might pay out even larger sums to ensure that he is alive to care, in an emotional sense, for his family. Moreover, it is important to recognize that I have not considered the additional willingness to pay for a person's survival on the part of his family, his friends, and the rest of society. However, to the extent that a person internalizes the grief or economic hardship his death would cause others, these preferences would be double counted.[18] In addition, Arthur (1980), on the basis of results derived from an economic-demographic model, suggests that a value of life should take into a account the reproductive value of the individual as well as the expected social costs of his support. Because of the added burden of social-security, extending an individual's life can be a social liability.

Though the assumptions behind this derivation, most importantly the separable and additive utility function, the maximization of expected utility, and the case of the "lone bachelor", could be challenged, the most significant result, the nonlinearity of the indifference function, is probably independent of these assumptions. This nonlinearity explains the phenomenon that most persons would not accept any amount of money for the certain loss of their life[19] but commonly accept small risks on their lives for small amounts of compensation.

[18] A person's own feelings of self worth are founded to a large extent on his worth to his family, to his friends, and to his profession, so it is logical that his preferences for protecting his own life internalize the preferences of those close to him. To the extent that this is the case, a simple addition of willingness to pay on the part of all concerned with a person's survival would, at least partially, double-count the contributions.

[19] In fact, there is probably some risk less than certain death for which the person could not be compensated. This can be thought of as the maximum-acceptable risk (see Jones-Lee 1980a).

Now we have arrived at the heart of the matter. Because the tradeoff of money for survival chances is nonlinear, *the value of life or the priority given to life saving expenditures will logically depend, not only on the size of the risk reduction, but on the level of the risk.*[20] One life saved for sure from certain death is different from ten reductions in mortality from .3 to .2, which is in turn different from ten reductions in mortality from .2 to .1.

If we accept the Kaldor rule for decisions on resource allocation, this model of personal choice would justify, in contradiction to the strategy of maximizing lives saved, the differential allocation of public funds among competing programs in accordance to differences in the spread of the risks. This principle which gives priority to the high per-capita group at risk, depending on the relative differences in the risk and the slope of the indifference functions shown in Figure 2, might lead the engineer responsible for the safety of the electric power plant emphasize worker safety, saving fewer lives than had he instead installed scrubbers on the stacks at a near equivalent cost.

In sum, the economist does not recommend an efficient strategy where only expected lives lost or saved are of interest. As a case in point, Jones-Lee has recently argued for differential treatment of high-risk and low-risk populations exposed to radioactive material:

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[20] This point was made by Weinstein, Shepard and Pliskin (1975) who showed that the notion of a unique value per expected life saved is inconsistent with utility theory. The value varies depending on the *level* of the mortality probability being changed, and not just on the *increment*.

> While it has been established that the expected number of adverse health effects (e.g., fatal cancers) from one man-sievert is effectively *independent* of the size of the irradiated population, the National Radiation Protection Board has nonetheless argued for an increasing (and indeed convex) relationship between the cost of a man-sievert and the dose per capita (the latter being, of course, inversely proportional to the size of the irradiated population). The basis for this argument is namely that the cost (value) of the loss (saving) of one statistical life depends on the size of the population within which the life is lost or saved because population size determines the magnitude of the risk to which each person is exposed and individual compensating variations are non-linearly related to risk. From a purely qualitative point of view, then, the N.R.P.B. position is gratifyingly consistent with that for which I have argued (p.8)

B. THE WELFARE BASIS OF THE KALDOR COMPENSATION TEST

With the growing influence of economic logic in public policy analysis, it is crucial that the ethical basis of this logic be carefully examined. What was essentially a descriptive model of consumer choice, where it was shown that the consumer will pay less to reduce a low-level risk than to reduce by an equivalent amount a high-level risk, becomes a prescriptive model of public choice only if one is prepared to accept that survival probability can be treated as a commodity and that the Kaldor notion of social welfare, from which the willingness-to-pay (WTP) concept is derived, is a legitimate basis for public choice.

i. Why Willingness- to- Pay?

Though the willingness-to-pay (WTP) concept has gained general acceptance by economists, and to an important extent also by public policy analysts, its development in the literature is not without controversy.

What is referred to here as WTP was originally labeled by Hicks (1939) as the compensating variation (CV), or that sum of money received by or from the individual which, following a welfare change, leaves him at his original level of welfare. The CV is one of four measures of consumer surplus suggested by Hicks, of which one additional measure, the equivalent variation (EV), is of interest to this discussion. The EV is defined as that sum received by or from the individual which, had he denied the change in question, leaves him as well off as if he had the welfare change. The essential difference between the two concepts is that the CV has reference to a person's original level of welfare, whereas the EV has reference to his subsequent level. These two concepts, as will be discussed shortly, take on importantly distinct meanings when applied to the valuation of programs that save or risk lives.

The compensating variation is the concept closest to a willingness to pay measure. As mentioned above, the rationale for its use in making cost-benefit rankings rests on the acceptance of the Kaldor criterion, sometimes referred to as the Pareto criterion, which asks if the gainer's gain enough to compensate fully the losers.

If the costs and benefits of a decision consequence are measured in terms of the CV's, then the Kaldor or Pareto criterion may be stated as the excess of benefits over costs. Aside from the possibility of inequities in the distribution of the costs and benefits,[21] if the interpretation of the Pareto criterion is that the gainers gain more than the losers lose, then it

[21]The question of distribution is not the only unsettled matter in benefit-cost analysis. On the contrary, lively controversies remain over a number of other issues relevant to the evaluation of risk, including the problem of discounting future benefits and costs, quantifying these benefits in the absence of markets and expressing the relevant uncertainties.

has a certain appeal in that it indicates a net gain in aggregate social well being. However, this interpretation does not always hold true. A positive sum of benefits over costs calculated in this manner does not necessarily correspond to a positive net gain in aggregate utility or imply that the gainers have indeed gained more than the losers have lost. All that can be unambiguously stated is that a positive sum does suggest a welfare change within a Pareto context--which compares alternatives in terms of money rather than in terms of aggregate utility.

The question of interest is how far off is this measure, or under what conditions might the Pareto criterion correspond with a net aggregate utility change.[22] This problem has been investigated primarily in the context of a change in the price of one or more commodities. Without going into detail,[23] the general conclusions of these investigations can be summarized as follows:

(a) If there are no income effects, or if the marginal utility of money income is constant, the EV measures to a linear transformation the change in a person's utility resulting from an economic change;

(b) If the marginal utility of income is constant, the CV is equivalent to the EV.

Clearly, the marginal utility of income (λ) is the critical variable. Unfortunately, constancy of λ means both constancy with respect to changes in

[22]To answer this question, it is necessary to revert from the Hicksian concept of ordinal utility, on which the criterion is based, to the Marshallian concept of cardinal utility to the extent that diminishing marginal utility of income can be assumed and that interpersonal comparisons of utility can be made.

[23]The interested reader is referred to Currie, *et al.* (1971.

the person's income and changes in the prices of all goods under consideration, and as Samuelson (1942) has shown, constancy of both is impossible. A constant λ might, however, be approximated if changes in the price of the goods are small. This problem has led Mishan (1977) to conclude that

> ... so long as the economist plods doggedly along the route pioneered by Marshall, seeking all the time to convert dollar measures of consumer surplus into utility measures, and vice versa, by reference to λ, he is eventually impelled either to throw in the sponge or--what effectively comes to the same thing--to invoke the constancy of λ as a plausible assumption for negligible price changes that do not, in any case, matter and as a vain hope for large price changes that do matter (p.12).

ii. The Compensating Variation for Nonmarginal Changes in Mortality Risk

The intent of the foregoing discussion was to introduce or review for the reader the somewhat weak welfare basis of cost-benefit calculations. It was shown that only under restrictive circumstances do the benefits and costs calculated by recourse to the WTP rule correspond exactly to changes in utility. Of course, policy analysis is not an exact science, and the cost-benefit practitioner might be justified in straying from the utilitarian basis of cost-benefit judgments and (1) basing his policy judgements on the weaker Pareto criterion, or (2) assuming in certain circumstances that by summing the CVs one gets a close approximation to the change in aggregate utility. I shall argue here that only the former can serve to justify using WTP for valuing decreased mortality risk where serious threats to life are concerned.

Consider a small increase $(P_0 - P_1)$ in a person's mortality risk, say from the construction of an electric power plant near his home, represented in Figure 3 by a move from A to B. The amount of money required to compensate fully this person for the increased risk to his life, or the lump sum payment which returns him to his original level of expected lifetime utility (Θ_0) is noted on Figure 3 as M^c. This sum is the compensating variation. Mathematically, it can be written

$$M^c = CV_P = \int_{P_1}^{P_0} \left[\frac{dM}{dP}\right]_{\bar{\Theta}_0} dP \tag{5}$$

The question of interest to us here is how closely this concept corresponds to a person's welfare change, or to a change in his expected lifetime utility. In other words, how good is our concept of willingness-to-pay, or the CV, in measuring changes 'in utility due to changes in mortality risk?

To answer this question, I will proceed from the suppositions that expected lifetime utility depends upon beginning period survival probability, the joy of living, and the joy of consuming, or $\Theta = P\,[J + U(M)]$, from which the tradeoff between money and survival probability was written (see equation 4) as

$$\left[\frac{dM}{dP}\right]_{\bar{\Theta}} = -\frac{J + U(M)}{P\lambda}$$

By substituting into equation (5), the CV for a change in P becomes

$$CV_P = M^c = \int_{P_1}^{P_0} \left[\frac{1}{P}\right]\left[\frac{1}{\lambda}\right] \frac{d\Theta}{dP} dP \tag{6}$$

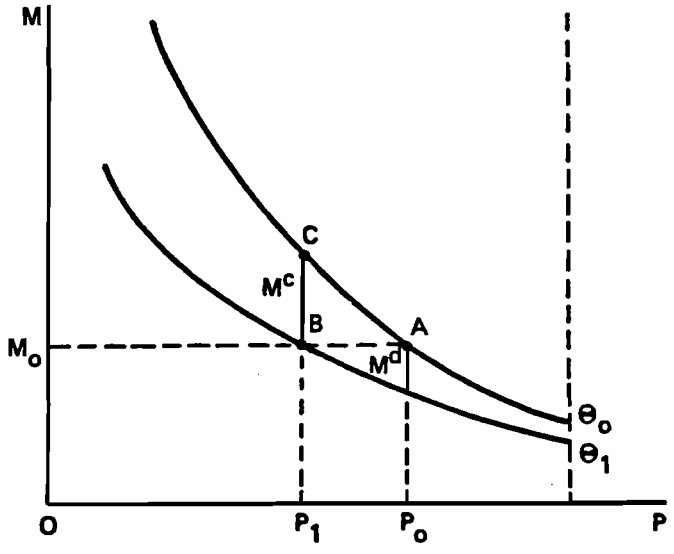

Figure 3: The *EV* and the *CV* for an Increase in Mortality Risk.

Figure 4 illustrates the relationship between the $CV(M^c)$ and welfare change ($\Delta\Theta$) for a change in $P(P_0 - P_1)$. Again consider a person at point A, with income M_o and survival probability P_o. If his chances of surviving are reduced to P_1, he moves from point A to point D. In order to be compensated for this move, he must be given the amount $M_1 - M_0$, which restores him to his original expected utility at point B. In this case,

$$M^c = \frac{\overline{AB}}{\overline{AP}}\Delta\Theta \quad .$$

From equation 6, it is seen that only if λ and P are constant (thus allowing the terms $\left[\frac{1}{P}\right]$ and $\left[\frac{1}{\lambda}\right]$ to be removed from the integral), does M^c reflect a change in expected utility, or $d\Theta$. Clearly, it is impossible for P to remain constant over a change in P. It is the term $\left[\frac{1}{P}\right]$ within the integral that accounts for the nonlinear relation between M^c and $\Delta\Theta$. And it is for this same reason that the curves in Figure 4 are not vertically parallel, which would equate M^c and M^d, allowing both to reflect

changes in Θ to a linear transformation. Because the curves are not parallel, the relationship between $\Delta\Theta$ and M^c will depend on the initial *level* of P. This can be seen from Figure 4, where for an equivalent reduction in mortality risk from P_1 to P_2, $\overline{DE} = \overline{AD}$, the compensating variation is shown to be greater ($M^{c'} > M^c$).

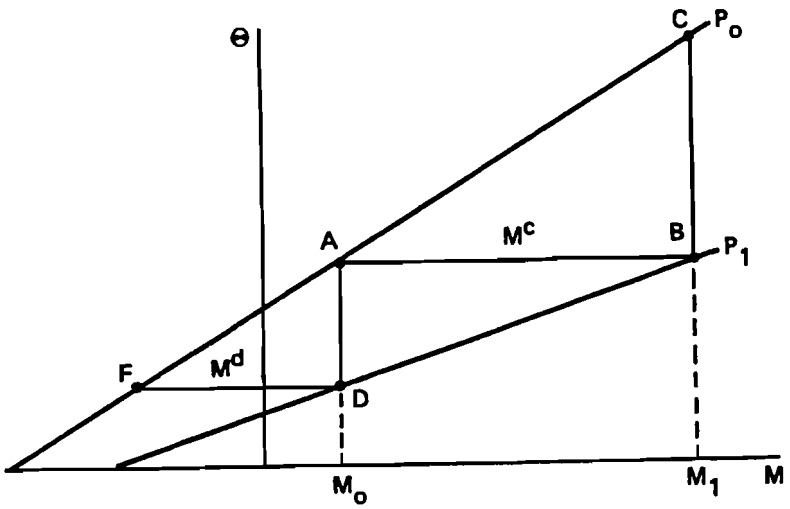

Figure 4: The *EV* and *CV* for a Change in P Assuming Constant Marginal Utility of Income

Broome (1978) has also noted this problem with relying on the *CV* to measure a change in utility. Choosing one particular path of change, $P = P_1$, he suggests that the *CV* (or M^c in Figures 3 and 4) be multiplied by the marginal utility of money averaged over values of money holdings between M_1 and M_0, when the probability of survival is P_1. Though not entirely clear from his discussion, Broome's mathematics reveal that he is interpreting the marginal utility of money, not as λ, but as the marginal lifetime utility of money, $d\Theta/dM = P\lambda$, which I will denote Υ. The fact that Broome measures the *CV* with P held at P_1, is significant.[24] This is

the most usual interpretation of the compensating variation, and can be written

$$M^c = CV_P = \frac{1}{P_1}\frac{1}{\lambda}\int_{P_1}^{P_0}\frac{\partial\Theta}{\partial P}dP \tag{7}$$

so that $\Delta\Theta \approx M^c(P_1\lambda) = M^c\,\Upsilon$. The proportional sign $\approx$ can be interpreted here as equivalent up to a linear transformation. Thus, as Broome rightly states, "... if M_j^c is to measure *j's* increase in utility, it must first be multiplied (weighted) by an appropriate average of *j's* marginal utility of money (p.98)".

It is not immediately intuitive from this quote that Broome is not referring to the more usual interpretation of marginal utility of money λ, but to Υ, where λ is weighted by P. Accordingly, one must ask, what is the extra value of an additional dollar to an individual, which yields a value of λ, and then ask what is the probability of the person surviving to enjoy this extra dollar. The marginal lifetime utility of money, or Υ, is the product of the two. Though it is common knowledge that if WTP is to reflect a utility change, λ must be constant, it is not common knowledge that WTP for an increase in survival chances will reflect the utility gain only if Υ is constant. Clearly, $\Upsilon = P\lambda$ cannot remain constant over changes in P.

[24] To measure this quantity with P fixed at P_1 invokes an important assumption concerning the *path* of the change and the corresponding compensation. A person when asked for that amount he considers as adequate compensation for an increased risk of death will respond as though he is facing that risk. By definition, the CV takes this particular path of adjustment. Alternatively, if one incrementally increased the probability of death and compensated according to these small increments, in the limit this compensation would take the form (for constant λ): $M^c = -\lambda^{-1}\,U^L\,[\ln P_0 - \ln P_1]$. This compensation, or the shadow price of mortality risk changes, will reflect nonequivalent changes in utility depending on the path of the change.

How can we interpret diminishing marginal lifetime utility of money? As a person's survival chances decrease, the value of his money decreases since he might not be around to enjoy it (recall that I have ruled out any bequest motive). So we are measuring the value of a commodity (survival probability) with a measure (money) the value of which is not independent of what it is measuring. In the economist's terminology, *money and survival probability are complementary goods.*[25]

As shown in Figure 5, the seriousness of this bias of money as the numeraire increases as the probability of survival decreases. As P decreases, money becomes decreasingly valuable, reflected by the slope of $\Theta(M,P)$; the ratio $M^c / \Delta\Theta$ increases for equivalent changes in P. In the extreme, when $P = 0$, money has no value whatsoever to the individual, and M^c is infinite, noted on Figure 5 as the "money-is-worthless" trap. This explains why a person must be compensated an infinite amount to accept death, though his utility loss from dying as defined in this paper, is finite.

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[25]Having shown that the evaluation of mortality risk introduces a new complication into consumer-surplus calculations, it might be of interest to ask how the introduction of uncertain lifespan affects the evaluation of more orthodox goods. For this purpose, assume that an individual allocates his budget over X_m goods where the $X^{m^{th}}$ good is the numeraire, or money M. Expected lifetime utility can therefore thus be written $\Theta = PU(J, X_1, \ldots, X_{m-1}, M)$. Proceeding as above (and assuming no cross partials), the CV for a change in X_i can be derived as

$$CV_{X_i} = \frac{1}{P}\int_{X^0}^{X^1} \frac{1}{\lambda}\frac{\partial\Theta}{\partial X_i}dX_i$$

which is surprisingly similar to the CV for a change in mortality risk as expressed in equation (6). Again, if the CV is to reflect a change in utility, it must be adjusted for both diminishing marginal utility of income (λ) *and* for the person's probability of survival. Depending on the basis for making public policy, this result could have important implications for policies affecting older populations.

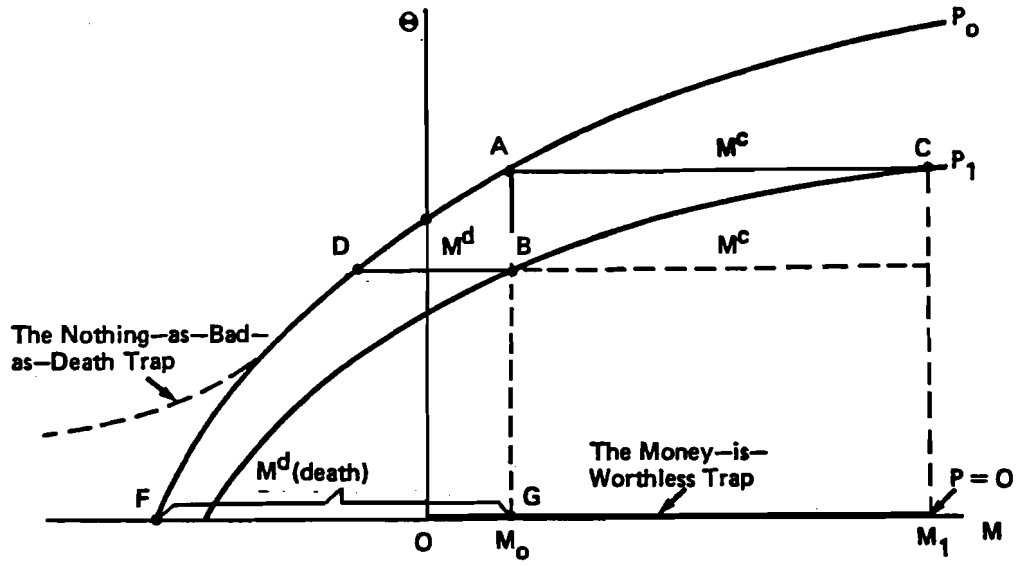

Figure 5: The *EV* and the *CV* Illustrated.

It might be argued at this point that the introduction of a bequest motive would have a devastating effect on the logic of this argument. Indeed, Jones-Lee (1978) leveled such an attack on a similar (but not entirely correct) logic pursued by Broome:

> ... given that an individual is (a) able to make bequests and (b) concerned with the welfare of his surviving dependents, the marginal utility of 'money' (i.e., wealth) will most certainly not be zero.... It is one thing to construct paradoxes for extreme cases in which purely selfish individuals without concern for dependents (or at least without the means of expressing such concern through life insurance markets) are to die immediately (or during a forthcoming period) but quite another matter to achieve the same sense of moral outrage with examples drawn from the real world.... (p.255).

While this critique by Jones-Lee is surely correct, I think its importance to the arguments in the paper is only a matter of degree. Though the motive on the part of a person to leave a legacy to his survivors is in some cases undoubtedly strong, it is not clear if this bequest motive would dominate the motive on the part of a person to live, especially

where a person views his responsibilities to his family more in terms of emotional support than financial support. Of course, the importance of a bequest motive to a person's safety decisions is an empirical matter, and it would be expected that the bequest motive would be stronger in the decisions of elderly persons.[26]

iii. Roses for Rainy Day

It should now be clear that money, in terms of compensation, cannot measure the utility losses from dangers imposed on human lives for two reasons: (1) the marginal utility of money cannot be assumed constant, and (2) the marginal lifetime utility of money decreases as one's chances for survival grow slimmer. To illustrate this point, Broome makes the following analogy:

> ... imagine trying to perform a compensation test with roses as medium instead of money. People cannot be compensated with roses for any major loss. Therefore, according to this method, rather a lot of projects would have an infinite cost. Nevertheless many of them could still be improvements (as we might be able to find out by recalculating their values in terms of money). The point is that roses are an inadequate measure for big costs and benefits. Money is a more powerful measuring instrument, but even the measuring rod of money is not long enough to encompass life and death. I hope this analogy will serve as a reminder that I have made no fancy claim that the value of life is infinite, but simply pointed out a difficulty in measuring it in monetary terms. Let us suppose that no finite number of roses could compensate a person for enduring a day of rain; no one would deduce that a day's fine weather is infinitely valuable.

[26] There is a good discussion of this point in Jones-Lee (1976).

But compensation for a rainy day with roses is *not* entirely analogous to compensation for a chance of death with money. It misses the point that money (or wealth) and survival probability are complementary goods. *Whereas the value of money depends on whether one lives to enjoy it, the value of roses does not depend on whether it is raining.* This analogy thus fails to show the complementary relationship between the commodity and the measuring device. It appears from Broome's analogy that the difficulty lies only with diminishing marginal utility of roses, (and analogously only with λ) which, the economist would counter, could be remedied if we allowed exchanges. But in the case of compensating for a possible death, barring indulgences, *no possibilities* exist to exchange money for something of more use in the contemplated state of the (next) world.[27]

Attempting a revision of this analogy, to make it more analogous, imagine a rare rose that depends on sun for its very survival. The harder it rains, the shorter is its life. On a drizzly day, it may survive a few hours, but hardly long enough to be exchanged for another commodity. But when it pours, the rare rose survives only a few seconds. It might prove difficult, depending on a person's love of the rose, to compensate him for a drizzly day, but one can appreciate the added difficulty in compensating him for a cloud burst.

[27]Jones-Lee, in his critique of Broome, recognizes the error Broome makes in ignoring the exchange value of roses. However, Jones-Lee fails to recognize that, though Broome's analogy is misleading, Broome's point that money cannot compensate the dying bachelor's utility loss is essentially correct.

iv. The Equivalent Variation for Changes in Mortality Risk

So far, a person's loss from a program decreasing his prospects for survival has been valued by the compensation which, coming after the change, would restore him to his initial wellbeing--called the compensating variation. Recognizing the problems described above in using this concept as a measure of welfare, Broome has suggested that one might rely, instead, on the equivalent variation, or that amount of money which the person would be willing to pay to avoid the risk, shown in Figure 5 as M^d. The key difference is that the latter reflects a person's perceived change in welfare coming ***ex ante*** to the change, itself. And, because it comes ***ex ante*** to the change, it circumvents the problem described above from the diminishing value of money.

It can be recalled that the compensating variation, to reflect a change in utility, must be weighted by the ***ex post*** survival probability and the marginal utility of money, or $\Delta\Theta = P_1 \lambda M^c$. Noting where death is the outcome, it is problematic to multiply an infinite compensation by a zero probability, Broome suggests that the appropriate way around is to measure, instead, the equivalent variation, or M^d:

> For a person whom the project proposes to kill, M^d is (minus) the amount of money which, taken away from him, will leave him just the same welfare as if he were dead. The idea is conceptually staggering, but some people might claim to make sense of it, and they might suppose M^d to be finite (p.99)

Is M^d finite? And, if so, does it provide a superior measure of welfare change to M^c? I will show here that M^d (for $P=0$) is finite only under certain conditions, but does provide a closer measure of utility change than does M^c. To see this, we can begin by writing the EV as

$$EV_P = M^d = \int_{\Theta_1}^{\Theta_0} \frac{\partial M}{\partial \Theta} d\Theta \tag{8}$$

which from equation (3) can be rewritten as

$$M^d = \frac{1}{P_0} \int_{\Theta_1}^{\Theta_0} \frac{1}{\lambda} d\Theta \tag{9}$$

If it could be assumed that λ remains constant over the range of changes in Θ, then M^d would express changes in expected lifetime utility unique to a linear transformation. The important variable here, as with any discussion of consumer surplus, is the marginal utility of money, or λ.[28]

Turning to the question of whether M^d is finite when evaluating a person's certain death, the answer can be seen to depend on λ. Looking at Figure 6, the equivalent variation M^d for a change in survival probability from P_0 to P_1 is labeled M_0^d, and interpreted as that amount of money which can be taken away from this particular person leaving him at the same level of utility (Θ_1) as would a reduction in his survival probability from P_0 to P_1. If he contemplates, instead, a reduction in his survival probability, not to P_1, but to zero, the question becomes how much money would he be willing to give up to avoid this unpleasant fate. Is it

[28] What is the relationship between the EV and the CV? Looking at Figure 3, the two would be equivalent if the indifference curves were vertically parallel, requiring a constant marginal rate of substitution between P and M, or

$$\frac{d(\partial M / \partial P)}{dM} = 0$$

It is common knowledge among consumer-surplus specialists that a constant marginal utility of money will ensure this condition. However, one must be careful here. It is not appropriate here to interpret this condition to mean constant λ; rather, it must be interpreted as constancy of the marginal *lifetime* utility of money, or Υ, since

$$V = \frac{\partial \Theta}{\partial M} = P\lambda$$

this condition cannot hold over changes in P. Thus, in this case, a constant λ is not sufficient for equivalency of the CV and the EV.

finite?

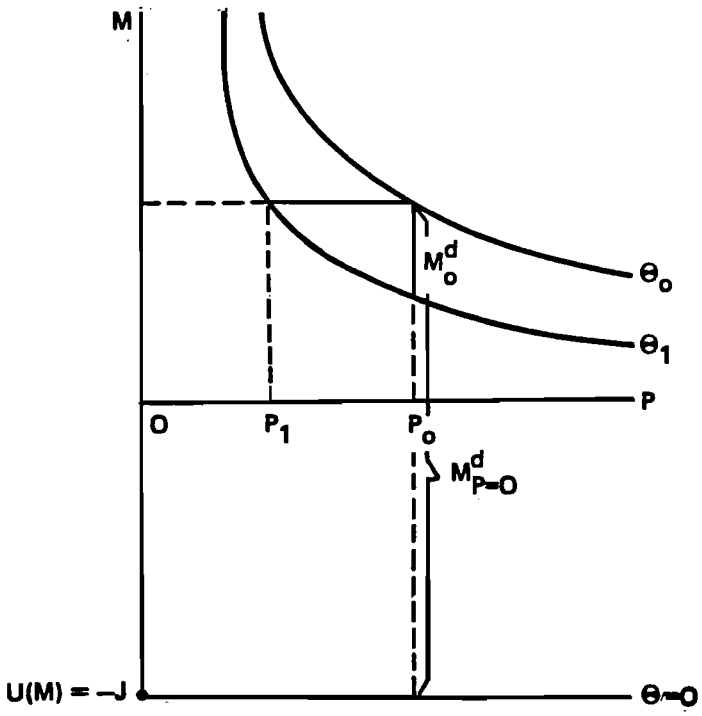

Figure 6: The Behavior of M^d as P Approaches Zero.

The answer depends on whether a financial state, or a level of debt, is reached where the individual is indifferent between life and death. At this point, and only at this point, does the indifference map shown in Figure 6 intersect the M-axis, a necessary condition for a finite M^d. From my model, where $\Theta=P[J+U(M)]$, this point is interpreted as $U(M)=-J$, at which point $\Theta=0$. But this condition may never be reached. There are two possible interpretations of $U(M)$. A person may perceive a level of debt at which his life would no longer be worth living or alternatively, a person may perceive life to be worth living no matter how bad the circumstances ($\lambda>0$ for $M<0$). In Figure 5, this is labeled as the "Nothing-As-Bad-As-Death" trap, since if λ goes to zero, there will be no finite value for M^d.

C. SOME REFLECTIONS

Consumer sovereignty prescribes that society recognize the right of the individual to spend his fortune as he chooses in the expectation of his soon approaching death, even though the social opportunity cost of his doing so might be high. A person with terminal cancer may choose to spend a large sum on a cure with little chance of success. Though the dollar is of little value to the person who does not expect to be around to enjoy it, in society's view it is a dollar that is not spent on the school system, on providing housing for the poor, *or on providing greater chances of keeping someone alive elsewhere*.

Where the private value of a dollar seriously understates the social value, is society justified in valuing public programs in reference to the former? In the author's opinion, the WTP rule loses its appeal in this case since the judgment of the people concerned is based, in part, on their slim chances of survival.[29] However, there may be other attractive reasons for coming to the rescue of persons in serious peril, which will be taken up in the next section.

Before proceeding, however, it must be emphasized that the equity issue discussed here is qualitatively different when lifetaking, as opposed to lifesaving, is of concern. Appealing to the Pareto criterion when a redistribution of utility *from* the dying man *to* society is involved is morally different from appealing to the rule where the redistribution is *from* society *to* the individual in peril. Rescuing a person from certain or

[29]According to Gould and Thaler (1980), the willingness to pay by a group with a low survival probability *might* be ignored (or rather, discounted) for this reason.

near certain death invokes an ethical judgment distinct from that of condemning a person to certain or near-certain death.[30] As Blumstein (1976) has noted, this dichotomy is apparent in the reluctance of the Supreme Court to condone capital punishment--which has imposed a duty of individualized decision-making in capital cases. Yet, the Court has interpreted the constitution as *not* guaranteeing government support to a hemophiliac who faces the finality of death without this support. "Of course, there is a fantastic overlay of symbolic issues in the death penalty controversy, creating significant external costs to our self-image as a humanitarian society, committed to preservation--not destruction--of human life." (Blumstein 1976, p.266). As with any redistributive question where property rights are involved, taking away a person's chances of survival is a separate matter from increasing these chances.

III. THE UTILITARIAN AND RAWLSIAN PERSPECTIVES

The intent of the last section was to dissuade the reader from accepting uncritically the Pareto principle where the saving of the high-risk person is concerned.[31] This principle is based upon the notion that personal life extension is a commodity and should be valued in terms of what the person, including his family and friends, is willing to pay for it. It has been shown that this principle would, at least under some assump-

[30] We give a firing squad one blank cartridge so that every member can pretend that he did not take a life.

[31] Of course, the question of an ethical stance can be viewed as a question of the appropriate societal objective function. Going somewhat beyond the ethical discussion here, Lowrance (1980) presents a number of possible objectives that society might adopt when choosing which risks to reduce.

tions, afford priority to the high-risk case.

A second argument for maximizing lives saved is based upon the concept of a collective or social preference for spreading risks, or for helping those in particular danger. Keeney (1978) proposed a criterion of *risk equity* as being one desirable aspect of the public's value structure for evaluating risks. According to Keeney, if individuals are at risk due to a common activity or situation, it seems intuitively fairer if the risks are in some sense balanced among all the individuals concerned. Recalling the example of the electric power plant, Keeney's intuition would favor reducing the higher risks to the group of workers over reducing the pollution risks affecting a larger group.[32] This recommendation is not based on a willingness to pay notion on the part of those concerned, but rather on a desire on the part of society to spread the risk burden.

In this section, I will examine this question of social preference from the point of view of the Utilitarian and the Rawlsian. I have chosen these two alternative ethical perspectives because they offer intriguing contrasts and similarities to the Pareto principle. Without being comprehensive, the aim of this section is simply to give the reader the flavor of two alternative ethical perspectives.[33]

[32]Just as placing priority on the high-risk case does not maximize lives saved, Keeney demonstrates that adherence to his concept of equity implies acceptance of a risk-prone utility function over number of fatalities, also not maximizing lives saved.

[33]In addition, one might consider, the elitist system of Nietzche, the more class conscious Marxian View, or the more egalitarian perspective of Kant.

A. THE UTILITARIAN VIEW

The utilitarian ethical view, as expressed by Bentham (1978), John Mill (1863), and others, requires "the greatest good for the greatest number." This ethical system can be translated into a utility concept, where the social objective is to maximize the sum of the cardinal utilities. The measurement problems involved in assessing interpersonal differences in utility are well documented and preclude strictly pragmatic applications of the ethic.

Yet some insights can be gained by applying the principle of aggregate utility maximization on the assumption that cardinal utilities can be approximated. This procedure has a special appeal when applied to the problem of safety allocation, where the policy outcome can be expressed in terms of life and death. A simple and appealing way to proceed is to suppose that each person in society, regardless of who he or she is, enjoys the pleasures of life to the same extent as any other person in the society. Recalling the utility function described in the last section, $\mu_i^L = n_i(j_i + \mu_i(m_i))$, where the lifetime utility of individual i is a sum of his joy of living (j_i) and his joy of consuming ($\mu_i(m_i)$) summed over his n years of life, this assumption would assign equivalent j's and μ's to each person. Thus, lifetime utilities differ only to the extent of varying money holdings and lifespans. If we assume further that each person is endowed with the same level of yearly income, and if j_i and $\mu_i(m_i)$ are independent of the year in which they occur, then the utilitarian view translates into the strategy: maximize total life years. This is one version of the efficiency strategy, which in contrast to Keeney's risk-equity concept,

requires the decision maker to proceed on the basis of a risk-neutral social utility function over the number of life years lost. If this is not the case, it should be recognized that the utilitarian would give preference to the lives of the wealthier people if they are, as this utility function suggests, in some sense "happier."

From the model in this paper, it can be easily shown (see Appendix) that the utilitarian value of life is a simple extrapolation from a person's willingness to pay for a reduction in his mortality risk at that point where the person considers his chances of surviving the period without the risk to be close to one, or

$$d\Theta = \left[\lambda \frac{\partial M}{\partial P}\right] dP \quad \text{for} \quad P \approx 1 \ .$$

This equation has empirical significance, since if we can approximate a value for λ (marginal utility of money), we can assign a money value to risk changes over the entire range, $0 \leq P \leq 1$, from the slope of the indifference function at $P \approx 1$. Seen in this light, it becomes clear that Broome's rejection of the use of the WTP measure for valuing changes in survival chances, where he accepts the utilitarian life value implied by use of the equivalent variation, is contradictory (see Appendix).

The most striking implication of the utilitarian approach, narrowly interpreted, is that no special regard is attributed the distribution of risks in society; the relevant policy-variable is the ***number*** of people (or people years) who are in danger or who will be endangered.[34] The low-risk

[34]A perhaps disturbing implication of this approach is the symmetry of the life lost and the life saved. A strict interpretation of the utilitarian view suggests that, if the case arises, one person should be "sacrificed" for the rescue of two persons.

population breathing the polluted air from the power plant would receive priority, in view of the greater number of expected deaths, over the higher risk group of workers who will be exposed to occupational risks.

This conclusion is, of course, derived from the model presented here and deserves qualification. The distribution of the risks may be relevant to the utilitarian once interdependent utilities are introduced into the model. If Mr. X does care if a person or a group of people is facing a serious risk, then he has a positive utility gain if measures are taken to mitigate this risk. This interdependency utility may be founded on two distinctly different premises: First, Mr. X may stand in special relation to this person (or group) due to present or potential love, friendship, or financial considerations. Second, his positive feelings toward taking extra measures to help those in a life-threatening situation may be based upon more abstract concepts of justice and fairness as suggested, for example, by Keeney's social utility function discussed earlier.

However, this second rationale for doing more to aid those facing higher risks must be ruled out for the utilitarian since, by definition, it deviates from his concept of social utility. The first argument or what Fried has called the personalist argument deserves, however, some mention. The personalist argument, according to Fried, holds that some preference for known over statistical lives is justified since it is with identifiable people that we enter into relations of love and friendship, while to the abstract statistical lives we stand in relations defined by justice and fairness. On the question of turning away the person in immediate peril, the personalist would have this to say:

> We will refuse to recognize an individuality that is there for us to recognize, and we will do it moreover in a context where that other person's life might be at stake. It is this that seems a horrible thing to do, horrible to contemplate and horrible to experience ... in many of our dealings--as taxpayers, as voters, as public servants, as entrepreneurs--we can look at our fellow men only as abstractions, as statistical persons. But often too we encounter people as actual persons, and there it seems we have the occasion, the opportunity to show our deeper humanity. (Fried, p.1430).

Though this argument has great intuitive appeal, Fried recognizes that there are objections which may leave little of it standing. The categorization of immediate and present peril may not encompass all those situations where one stands in a special, emotional relation to the victims. Yet, a more serious objection concerns the distinction between persons known at the time of the decision and those statistical lives who will be known at a later time. On the question, for example of using a limited supply of serum for vaccinating (preventive) or for curing those with a fatal disease, those later victims will be as clearly identified as those present patients, and we will stand in exactly the same relation to the later victims as we stand to those current ones. Whether one accepts or rejects the personalist argument as relevant to the utilitarian, the important point is that from the utilitarian's perspective, in contrast to the welfare economist's, the differential treatment of risk populations cannot be justified by reference to an individual's *own* preferences for reducing high risks to himself, but can only be justified by reference to a desire on the part of others to respond disproportionately toward the more threatening situation.

One rather appealing principle that supports the utilitarian ethic has been put forth by Harsanyi (1977), and perhaps deserves mention.

According to Harsanyi the ethic used for distributing resources should be impartial in the sense of reflecting the preferences of a person who is impartially situated, or a person who does not know his position in the decision at hand. Referring to the power plant example, the impartially situated person has a higher chance of being killed from the pollution (since he has a higher probability of being in this large group where expected deaths are higher) than from the occupational risk. Thus, for selfish reasons he should adopt the utilitarian stance.

A decision-theoretic approach to valuing a year of life formulated by Weinstein, ***et al.*** (1975) adopts this Harsanyian view. The authors suggest that the relevant time to value a program, such as a dialysis center, is before the victims become victims, that is, ***ex ante*** to the fact of identifiable persons in need.

> ... the situation would be quite different if we asked each individual ***in advance*** (to his illness) to decide whether it was worth it to him to have dialysis available. Since this is the relevant question, it is on this basis that decisions between dialysis and other forms of care should be made. (p.19).

B. RAWL'S THEORY OF JUSTICE

According to Rawl's (1971) ideal contractualism, principles of justice are seen as agreements that would be made by rational deliberates seeking to pursue their interests behind a "veil of ignorance," or without knowledge of their place in society (natural abilities, class, and so on). He maintains that persons in the initial situation would choose two principles to guide social decisions: "the first requires equality in the assignment of

basic rights and duties, while the second holds that social and economic inequalities, for example, inequality of wealth and authority, are just only if they result in compensating benefits for everyone, and in particular for the least advantaged members of society" (pp. 14, 15).

From this second principle, Rawls derives his criterion of social justice, the so-called "difference principle,", suggesting that basic institutions ought to maximize the life prospects of the worst-off person in society, sometimes called a "maximin" strategy. Inequalities are tolerated only if they serve the purpose of increasing the size of the pie to everyone's advantage.

Rawls' theory, which he refers to as justice as fairness, is an alternative to the classical utilitarian thought discussed above. A principle which may require lesser life prospects for some simply for the sake of a greater sum of advantages for others, Rawls argues, would not arise from the original agreement. A rational man would not accept a basic structure merely because it maximized the algebraic sum of advantages in the society (Rawls, p.14). The question between utilitarianism and justice as fairness comes down then to the question whether the disadvantages imposed on a few can be outweighed by a greater sum of advantages enjoyed by others; or whether, as Rawls argues, moral justice permits only those economic and social inequalities which are in each and every person's interests.

With this necessarily rough description of Rawls' theory of justice, let me turn to the problem involving the unequal distribution of risks from the construction of the electric power plant.[35] Assuming the plant has

[35]Rawls' first principle of justice, which must be fulfilled before equity of the costs and bene-

been built, should the risks to the workers or the risks to the general population be mitigated when *both* cannot be mitigated? Assuming that the population cannot be fully compensated for the risks already imposed on them, the choice of which risk-mitigation measure to adopt is a question of how society can best advance toward the social ideal. Assume for the sake of argument that the two populations suffering from unequal risks of air pollution and occupational hazard are equal in every other respect. Applying Rawls' maximin rule to this decision would suggest that priority be given to improving the circumstances of the most disadvantaged, or the workers. Rawls concedes that a maximin procedure is not always the most rational one for choices under uncertainty, but it would be chosen, he maintains, when certain conditions exist: when knowledge of the probabilities of various outcomes is limited, when the prospects of gain are not terribly enticing, and when the possibility of losing is intolerable (pp.153-155).

Thus in the Rawlsian perspective, not unlike Keeney's, how the risks are distributed is of critical importance. But does it make a difference if the risks are distributed across populations as in the above example, or, alternatively, if they are distributed over time? Returning to the topical problem of prevention versus treatment as two routes for increasing lifespan, I would interpret the Rawlsian difference principle as giving priority to those most acutely in need. It would favor *ex post* medical rescue over *ex ante* preventive measures. However, this interpretation is debatable since the original contractors would, as the Harsanyian view

fits are considered, requires that everyone involved have equal opportunity with respect to the social institution charged with making this decision. In addition, there must be appropriate safeguards for assuring this equality during the course of the decision.

suggests, see themselves as having a low probability of needing acute medical aid but a high probability of benefiting from preventive measures.

As a final thought on this subject, we can ask if the contract parties might choose to give safety lexical priority, or regard life as a right with unqualified priority over other wants, as a social primary good on a par with civil liberties.[36] Just as Green (1976) argues that access to health care is a citizens right, could we not reason that every member of society has a right to life. Are not such guarantees already present in the U.S constitution, for example, as stated in section one of the fourteenth amendment: "No state ... shall ... deprive any person of life, liberty, or property without due process of law ..."

The only answer to the question of giving lexical priority to life is that it simply is not possible. As Arrow (1963) points out, a strict maximin solution to the problem of health services could lead to the choice of medical procedures so costly as to reduce society to a level of subsistence. At any rate, according to Blumstein (1976) the court would be unlikely to expand the government's responsibility to include the maintenance and sustenance of life:

> Such expansive readings of the concepts of "life" and "deprivation" under the fourteenth amendment would transform the nature of government's role in the life-saving area, thrusting on the state the "role of a giver of life itself." The Court appears unwilling to read into the Constitution such positivistic notions, and that analytical approach would be out of step with recent

[36] It is not, however, the case that Rawls gives civil liberties ***unqualified*** priority over other wants. For this reason, enjoyment of equal health opportunities or an equally safe environment could be argued to rank with "liberty" among the social priorities established by the theory of justice.

decisions. (p.247).

Notwithstanding its impracticality, there appears to be an important myth that life is "priceless." This is the argument considered by Schelling (1968), Zeckhauser (1976), and most recently Calabresi and Bolbit (1978), that in giving preference to the identifiable person in immediate peril society can maintain this myth. This is often referred to as the symbolic value argument, and is summed up in the following quote from Zeckhauser (1975):

> When risks of lives are involved, an important valued belief is that society will not give up a life to save dollars, even a great many dollars. Rarely is this belief, widely held albeit mistaken, put on a clear test. When it is, it may be desirable for society to spend an inordinate amount on each of a few lives to preserve a comforting myth (pp. 447-448).

Fried, who generally argues for the maximizing lives saved, calls this argument "either confused, wrong, or morally repugnant" (p.1425). Since the funds for preserving this myth must come from somewhere, and possibly from another life-saving activity, the myth has a cost in terms of human life. "But surely it is odd, to say the least, to symbolize our concern for human life by actually doing less than we might to save life" (p.1425).

IV. CONCLUDING REMARKS

Whether to deviate from a strict policy of allocating public funds to save as many lives or life years as possible where the alternative is to favor those persons facing high risks, is a difficult moral judgment. I have argued in this paper that the efficiency-equity tradeoff implied by this choice should not be resolved by recourse to the economist's model of consumer choice without a critical examination of the underlying ethical principles. Where the decision involves persons facing high risks to their lives the Kaldor principle, on which the economist's calculations of the value of "rescue" might be based, may seriously overstate the utility gain of this rescue. Placing priority on the high-risk population by virtue of the Kaldor principle cannot be rationalized by arguments of a net utility gain among those receiving the life-saving benefits and those paying the costs. Accepting the consumer-choice model for resolution of the equity-efficiency issue, therefore, rests upon little more than dogmatic adherence to the Kaldor principle.[37]

Where life and death are possible consequences of a government's actions, the numbers *do* count. Providing the policy maker with information concerning the number of lives involved or the number of life years endangered by a contemplated action is undoubtedly worthwhile. In evaluating these consequences, in the opinion of the author, both efficiency and equity are relevant policy goals, and an approximation of wil-

[37] It might be objected here that the Kaldor principle is not intended to resolve questions of equity. But this notion of equity involves distributional disparities between those paying the costs and those receiving the benefits and not, as is the issue here, among several alternative programs receiving funding. For the latter, the Kaldor principle is claimed to have relevance.

lingness to pay (or necessary compensation) on the part of the population at risk is useful data.[38]

However, in this paper I have rejected the notion of individual preference for personal risk reduction as the final word on this issue, at least where *lifesaving* is the topic of concern. I have examined two alternative ethical systems. The utilitarian, if the utility of a year of life is assumed to be the same for everybody, would recommend maximizing lives or life years saved, where no distinction is made between the saving and the taking of a human life. A Rawlsian, on the other hand, would come to the aid of those in the most need placing high priority on the equality of the risk spread.

If, in the case of lifesaving, we count the costs incurred by deviating from the utilitarian's maximizing strategy in terms of lives lost, and give these lives names and faces, this strategy of minimizing human death appears to be the only humanitarian principle on which to base public choices. The nonutilitarian, the argument might go, must recognize that he is a murderer of statistical lives. But are we framing the issue appropriately? Who among us could justify, for instance, purchasing a television set with the knowledge that somewhere a life could be saved with this money? Could we not use "lives" as a numeraire for calculating

[38]Still, the analyst must be cautious lest he misuse this information. I have argued elsewhere (Linnerooth 1978) that risk is a multidimensional concept including situational factors (who and how are the people affected?) and psychological factors (how do those affected perceive the seriousness of the risk (Otway and von Winterfeldt 1980; Slovic, *et al.* 1979). In some cases it is not legitimate to consider the risk as a social or economic fact capable of being analyzed outside the context in which the risk is revealed and expressed. For example, it has been suggested (Otway and von Winterfeldt 1980) that risk of nuclear power has been used as an outlet to express an individual's dissatisfaction with high-technology society. A procedure whereby the analyst evaluates the risk by multiplying the probability of death by a life value determined from some other hazardous activity would clearly not catch the essence of the situation.

the costs of every aspect of our economic existence? Is the fact that the rescue of individuals facing high risks might be funded from a hypothetical lifesaving budget a compelling reason for singling out this expenditure for such scrutiny? As a case in point, Justice Stewart, who was concerned about the effects of a decision that allowed publication of a report revealing critical military secrets, asked what would be the consequences if publication meant the judicial sentencing to death of a hundred people. On this question, Calabresi commented that there are harms that depend on the process used to decide terribly important issues of life and death. He concluded that institutions must avoid allowing an issue to be framed in such a way.[39]

Alternatively, the economist would certainly argue that no matter how diverse the values of a society nothing can be lost by making the tradeoffs open and visible, and the gains will be evident by limiting abuse of discretion. If, indeed, the opportunity cost of purchasing a television could be calculated in terms of the lives lost from neglecting highway safety, would this not help us reorder our priorities? Surely, we can accept that at some point watching our favorite television program is worth the costs in terms of our national health.

And, after recognizing this inevitable tradeoff between our lifestyle and the lifespan of our members, could we not recognize further that a similar tradeoff exists between spreading the human costs from this lifestyle and the additional lives this equality costs. Contrary to the utilitarian's efficiency strategy, an egalitarian distribution of the risks to

[39]This discussion is taken from Blumstein (1976).

life and limb does, from my point of view, have social value. Of course, this equality has a cost in terms of human life, as does every human activity, and this cost should be made explicit so that our elected representatives can make clear and open choices.[40]

By recognizing the value of favoring the high-risk case, it seems that I arrive at identical conclusions as implied by the economist's model of individual choice. The difference is that I base this policy recommendation on a social concern for the distribution of the risks of industrialized society, rather than on individual "votes" for safety in the marketplace. This distinction, important from a philosophical point of view, may have significant empirical implications as well.

[40]Calabresi argues against explicit criteria for making society's tragic choices, or deciding who shall live and who shall die. There is no right answer to these decisions, Calabresi reasons, because there are no consistent, fundamental values in a pluralistic, democratic nation. Thus, in tragic-choice situations, "a-responsible" agencies may serve a useful function by blurring the hierarchy of values used to decide. While Calabresi's argument has strong merits for the difficult choice of assigning a life-saving device to either Mr. Jones or Mrs. Smith, its merits for deciding the issue of priorities on differential risk situations where there are no *ex ante* identifiable victims, is not so evident.

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APPENDIX

THE UTILITARIAN VALUE OF LIFE
A REEXAMINATION OF THE CASE MADE BY BROOME (1978)

While the strategy of maximizing lives saved requires a fixed value on a life or on a life year, it does not tell us what this value should be in order to reflect the priority given life extension relative to other social needs. For this purpose, a measure of aggregate utility change accruing from all projects under consideration is needed. Since it is especially convenient to express utilities in money, the question can be phrased, is there a money measure that corresponds directly to the utility change from an increased or a decreased risk of dying?

It can be recalled from Section III.B. that a person's willingness to pay for his own safety, or the compensating variation, does *not* reflect his changed utility position from the safety expenditure without appropriate adjustments for his survival probability and for his marginal utility of money. In what follows here, I shall propose a simple devise for making these adjustments in order that one might arrive at the utilitarian value on a human life.

From the model outlined in Section III, where $\Theta = PU^L$, and $d\Theta = U^L\, dP$, a change in lifetime utility is a linear function of the change in the probability of surviving. From this result, we need only obtain one money measure of a change in P. This money equivalent can then be extrapolated linearly for the value of changes in mortality over the entire range, including certain death.

To calculate the money measure for $d\Theta/dP$, we can begin with a willingness-to-pay measure. From equation (4), willingness to pay for a marginal change in mortality is expressed

$$\frac{dM}{dP} = -\frac{U^L}{P\lambda}$$

A way around the complication of a decreasing value of money is to calculate this tradeoff between risk and money *at that point where the person considers his chances of surviving without the risk to be close to one*, so that

$$d\Theta = \left[\lambda \frac{dM}{dP}\right] dP \qquad \text{for } P \approx 1$$

This equation has empirical significance, since if we can approximate a value for λ (marginal utility of money), we can assign a money value to risk changes over the entire range, $0 \leq P \leq 1$, from the slope of the indifference function at $P \approx 1$.

To illustrate, consider a person who views his chance of surviving the period as almost certain and who is willing to take on a .001 chance on his life for $300. Assuming his marginal utility of money is around 0.8, then from equation (13) we can calculate the dollar

equivalent of changes in his lifetime utility as $d\Theta = \$240{,}000\, dP$, which can be interpreted to mean that the dollar equivalent of certain death is $240,000. From the utilitarian's standpoint, the value of this individual life is $240,000. In sum, with information on the requisite compensation for a small risk given $P \approx 1$, and with an assumption on the marginal utility of money, it is possible to estimate (to a linear transformation) changes in personal utility resulting from increased or decreased survival probability over the entire range of probabilities ($0 \leq P \leq 1$).

It can be recalled from Section II that there are two different, but conceptually similar methods for arriving at lifetime utility changes resulting from risks to life. One is based on a person's evaluation of a small probability of death (the compensating variation) when his survival chances are good; the other is based on the equivalent variation weighted by the marginal lifetime utility of money as shown above. In both cases, the disvalue of death is finite.

From this discussion, it becomes clear that Broome (1978) is only partially correct in his claim to have demonstrated the following two things:

> Firstly, if an attempt is made to fix a monetary value on life, it is quite wrong to do it on the basis of people's evaluations of *probabilities* of death. Secondly, because the monetary compensation required for loss of life is infinite, cost-benefit analysis will be inapplicable for judging any proposal involving deaths. There is one exception to this last point. A finite monetary valuation for life could in theory be obtained by taking the equivalent variation, as opposed to the compensating variation, and weighting it by a suitable marginal utility (p. 100).

Broome's two results are contradictory. His advocacy (qualified since he rejects the utilitarian logic) of a weighted form of the equivalent variation--to reflect utility change--is, as shown above, quite the same as advocating the use of personal assessments of the probability of dying and adjusting for λ, where P is close to unity. The latter concept he rejects wholeheartedly as exploiting the *ex ante* ignorance as to *who* will die on the part of those making the valuation. But it is just this *ex ante* ignorance that allows a relatively unbiased valuation of the utility loss from dying, since, as Broome himself points out, if one knows he will die, his money loses all value. So it appears that Broome rejects the utilitarian value of risk changes when he rejects the *ex ante* measure, but embraces the utilitarian value when he suggests, as an alternative, the equivalent variation as the appropriate measure. As I have shown here, the equivalent variation is *not* an alternative, but simply a different way of expressing the value of small changes in P in the range of $P \approx 1$.

Because of the significance attributed to Broome's arguments, these points deserve some more elaboration. Consider Broome's summary of his main points:

> A way of summarizing what I have argued is this. A valuation of a project may be made before it is carried out and before the distribution of its costs and benefits is exactly known, on the basis of people's choices about the risks involved. Call this an "*ex ante*" valuation. An "*ex post*" valuation, on the other hand is one made at the time of the implementation of the project, when the details of all its effects are settled. The two will often be different. My claim is that, of the two, the *ex post* valuation is the correct one (in so far as any cost-benefit analysis is correct) because it is the valuation of the actual project, whereas the other is really a valuation of the expectations created

> by the project. The *ex ante* valuation is useful only to the extent that it approximates to the *ex post* valuation. But, in the particular case of a project causing deaths, it is no sort of approximation at all, since the former has finite costs and the later infinite ones. The *ex ante* valuation, in the case of death, is worthless, and furthermore it can be shown to be worthless at the time it is made.

From this summary, it appears that

(1) Broome rejects the *ex ante* valuation of mortality risk, which seems to suggest an infinite value on a death.

Yet, as noted above, Broome shows that a way out of the infinite-value-on-a death dilemma is to adopt a utilitarian approach. Hence

(2) Broome advocates a finite value on a life based on the equivalent variation.

But, as I have shown in this section, for the range of high survival probabilities relevant for the valuation of "statistical deaths," the *ex ante* valuation of life Broome rejects in (1) is the same as the equivalent variation Broome advocates in (2).