Value of Life, Economics of

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Abstract

The economics of the value of life is about what individuals and societies are willing to sacrifice to get longer expected lifetimes. Value of life is about private choices that individuals make implicitly and explicitly about their own health and safety. Value of life is also about collective, public choices that societies make concerning tax and expenditure programs which affect expected lifetimes and regulations that shape the environment in which individual decisions are made. Inferences from individual choices inform public decisions and expert-based public policy is offered to improve the quality of individual decisions and consequences. Estimates from risk compensating wage differences, consumption activity which affects risk, and hypothetical markets yield values of life in a range from $1 million to

$9 million. While ethical and estimation concerns remain, these values have proved useful in policy decisions about health, safety, and the environment.

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1. The Term "Value of Life"

Value of life typically refers to an amount of money an individual is willing to trade for a small change in his or her own probability of survival. This definition is typical because this situation is typically what individuals face in life and what decision makers face in public policy. Exceptions exist, of course, and they will be addressed below.

1.1 Value of a Statistical Life

The typical situation is illustrated by thinking about an individual who is one of a group of 10 000 people. Everyone in the group is identical and knows that during the next year nine

people in the group will die. Everyone also knows that the number of people who are going to die could be reduced to eight if sufficient funds can be raised. If somehow it is known that each individual is willing to pay $500 for the reduction of one death in the group, then the value of life is $500 per person times 10 000 people, or $5 million. Sometimes this amount is referred to as the "value of a statistical life" because the identity of the individual who would have been the ninth death, yet lives, is unknown at the beginning of the period when the decision is made.

1.2 Value of a Change in Mortality Risk

The numerical example illustrates another way of interpreting value of life. The reduction in the number of deaths implies that the probability of death faced by each individual decreases from 0.0009 to 0.0008. The $500 that the individual is willing to pay reduces the probability of his or her death by 0.0001. Because information is available from similar situations with small changes in the risk of death, but the changes are not exactly the same, for convenience, the value is standardized to a unit change (1 to 0). The standardized "value of a change in mortality risk" is $500 times the 10 000 needed to standardize 0.0001 to 1, or $5 million. Both the "value of a statistical life" and the standardized "value of a change in mortality risk" represent what is typically meant by value of life. For further illustration see, Viscusi et al. (1995, Chapter 20).

2. Characteristics of Value of Life

The nature of value of life as defined above can be described further by considering a simple

equation of individual expected utility. Let

$$E(U) = PU(C) \quad (1)$$

where E(U) is expected lifetime utility for an individual. U is a well-behaved utility function with marginal utility U`>0 and diminishing marginal utility U``<0. C is consumption and P is the probability of survival. Differentiating Eqn. 1 keeping the individual at the same level of E(U), and solving for dC/dP yields the rate at which the individual is willing to trade off current consumption for a small change in the probability of survival.

$$dC/dP = - U(C)/PU` \quad (2)$$

Eqn. 2 says that the rate at which an individual is willing to trade consumption for a small change in mortality risk equals (the negative of) the utility of consumption divided by the expected marginal utility of consumption. The negative sign indicates a tradeoff, i.e., less C for more P. If consumption were expressed in monetary terms, U` would be the marginal utility of income, and PU` would be expected marginal utility of income. This would mean that the value of a change in mortality risk, dC/dP, would be the expected monetary value of the utility of consumption. It is the willingness to pay for risk reductions.

While the simple equation above captures the essence of the risk-dollar tradeoff, formal models of consumer and worker behavior include budget constraints, behavior which affects the probability of survival, insurance, workers' compensation, bequests, multiple periods, and multiple risks. For additional reading, see the book by Jones-Lee (1976), article by Rosen (1981), review by Jones-Lee (1985) and recent comprehensive book chapters by

Cropper and Freeman (1991) and Freeman (1993).

2.1 Relationship with Earnings

Within the context of intense interest in economic growth and national income accounting and from an emphasis on manufacturing and machinery following World War II grew an appreciation for the potentially high returns from investment in human beings. In a special conference issue of the *Journal of Political Economy* in 1962, Mushkin articulated the case for investment in human beings through promoting better health. She argued that the return would be through future increases in labor earnings. If one more person were to live because of an investment in health, then national income would be greater by the amount that person would earn in the labor market. Expected future or forgone labor earnings became a standard measure of the value of life. Notwithstanding the fundamental contribution made by establishing human health as an important factor in economic growth, reference back to Eqn. 2 above yields no clear, precise connection between the value of life and labor earnings. P may be close to one, and C may be positively related to labor earnings, but the primary difference is that the value of U(C) is not likely to equal C. No allowance is made for consumption which occurs outside the formal market, and no allowance is made for the value of living. Schelling (1968) clearly distinguished between earnings, which he referred to as livelihood, and value of life or living. What matters is the value of the statistical life, or value of change in mortality risk, *to the individual who is affected*. The value to the individual influences individual behavior and should be the starting value for public decisions which

affect risks to the individual's life. This point is a reminder that either gross national product, or national income measured with traditional accounting, is a highly imperfect and sometimes misleading indicator of well being.

2.2 Costs of Illness

In valuing investments in health Mushkin, added to earnings the saving of future health expenditures. The sum of these health expenditures saved (direct costs) and the labor earnings not forgone (indirect costs) became known as the "cost of illness" avoided. Cost of illness was used extensively because of the wide acceptance of the importance of investment in human beings and because estimation was manageable. The shortcoming that homemakers would be valued at zero was overcome by estimating the value of the services performed or the amount of earnings the person would have had if the individual had worked in the labor market. The low values for infants whose future earnings were heavily discounted and zero values for retirees who are not in the market were troublesome. The most troublesome aspect of cost of illness, however, is the lack of a theoretical basis which includes the individual's own value of living. Further discussion can be found in Tolley et al. (1994), who provide a comparison of the cost of illness and the value of life based on an individual's willingness to trade money and risk.

2.3 No Single Value

Eqn. 2 is useful for demonstrating that there is no single value of life which applies to all individuals in all circumstances. The amount an individual is willing to trade for a small

change in his or her probability of survival depends on P, the base level of the probability. Because P is in the denominator, the value of life can be expected to increase as P deceases. For example, adult aging reduces the probability of survival and can be expected to increase the value of life, holding constant consumption. Automobile drivers who must travel alone at night on winding roads covered with snow and ice can be expected to have higher values of life than at other times.

The value of life depends on idiosyncratic factors that are reflected in the utility function. U(C) can vary among individuals with the same measured consumption, C, due to differences in family or environment. Individuals enjoying close, supportive family relationships and living in clean, ecologically rich natural environments and societies with high quality civil institutions and public services can be expected to have higher values of life.

Lastly, from Eqn. 2 the value of life depends upon C. Since C can be expected to increase with income, U(C), and the value of life will be higher with higher income and consumption.

2.4 Ex Ante and Unidentifiable

Eqn. 2 displays another characteristic which is inherent in the situations illustrating the value of life. The situations for the value of a statistical life with one fewer person of 10 000 people dying and the value of reduction in mortality risk by 0.0001 share an ex ante perspective. The situation is confronted, the life lottery must be played, but the outcome is not yet known. The identity of the individual who would have been the ninth death among the 10 000 is not known. Or, whether the individual facing a lower probability of death

survives or dies is not known. Decisions which must be made by individuals and by societies about risks to their health, safety and environment are often made in a similar manner. Situations in which the individual is identifiable are inherently different. If the individual is thrust into a life threatening situation by an unforseen natural event, such as a tornado which causes entrapment in a collapsed building, the individual and society will often spend whatever is available or do whatever is possible to save the life. The situation involves a potentially large change in survival for a known individual. Saving the individual's life from almost certain death is usually valued very highly. If the trapped person is saved, all may end well. If the person cannot be found in the collapsed building after some time, then the probability of saving the person becomes small and the rescue effort decision is transformed into one involving the more typical value of a change in mortality risk. Medical situations involving identifiable patients with known diagnoses have some similarities and are considered below.

Court cases involving wrongful death of a specific individual are also inherently different because they too are ex post. Nothing can change the fact that the individual is dead. Nothing can be done to compensate the deceased for death. The value relevant to forensic decisions is the amount that can compensate the survivors or the estate for the individual's death. The value depends on the deceased individual's contribution to the well being of the other members of the family, an amount that is related to labor market earnings. The amount that fully compensates the family for loss of a loved one can be practically infinitely large.

From an efficiency perspective, the value relevant for forensic situations should consider generating sufficient incentive to influence future decision makers who deal with similar risks. The typical value of life may well be relevant, but the differences between the values in court cases and the values in benefit-cost analysis tend to be large. See Jones-Lee's (1982) book. The value of life in wrongful death cases is likely to be an area of great interest in future research. Experiences in natural resource damages assessment under Superfund in the United States could be relevant. They too are values for ex post compensation. See, Kopp and Smith (1993) for issues involving damage assessment.

2.5 Willingness to Pay and Willingness to Accept

In contrast to the court cases about ex post wrongful death of a specific individual, Eqn. 2 shows the tradeoff an individual is willing to make between consumption and a small change in mortality risk. For small changes Eqn. 2 suggests that it makes no difference whether the individual is paying for small reductions in mortality risk or accepting compensation for small additions to mortality risk. For example, for small, equal (and opposite) changes in mortality risk, the amount the individual is willing to pay for a slightly safer job is approximately the same as the amount the individual is willing to accept for a job which is slightly riskier.

3. Criticisms of a Value of Life Based on Individual Willingness to Tradeoff

A value of life based on individual preferences as defined above is not without criticism. Criticism ranges from the ethical to the technical.

3.1 Deontology.

One saying goes that economists know the price of everything and the value of nothing. In this spirit, one objection to the value of life as defined above is that it is vulgar and ethically wrong to place a monetary value on human life. A deontologist is one such as Plato or Kant whose moral theory is based on obligate moral rules independent of the desirability of the consequences of acting on the rules. If it is morally wrong that people are exposed to risks of death, then it is wrong to construct a value of life to be used to guide decisions involving risks of death. Systematic choices involving risk are practically impossible.

In contrast, a teleologist such as Bentham or Mill whose moral theory is based on the goodness of the consequences is highly interested in a value of life which might guide decisions so as to generate the greatest good for the greatest number. While strident deontology can lead to paralysis in decision making when faced with risky situations, ardent teleology can produce policy recommendations, such as euthanasia, which a majority often deems morally wrong. Because teleology is the ethical basis of benefit-cost analysis which uses the value of life, its criticism by deontologists is understandable. For more on a deontological objection, see Brandt-Raufs (1980), who analyze the ethical conflict over occupational safety and health.

3.2 Ex Ante Becomes Ex Post

Another ethical criticism is that neither ex ante nor ex post willingness to pay is acceptable because at some time the lottery is played the individual knows what is going to happen and will either pay everything to avoid death or demand an infinitely large amount in

compensation for death. This situation, Broome (1978) argues, is morally unacceptable. Broome's criticism is complex, but it seems to have a deontological dimension to it. While this may be a quandary, the fact individuals frequently make decisions in which they are tradeoff risk suggests that the tradeoffs are not completely reprehensible to individuals.

3.3 Murdering Statistical Lives

Recall that there is no single value of life and that one factor which determines the value is the base level of the probability of survival, P. As P decreases, reflecting the increased risk of death faced by the individual, the value of a specified amount of risk increases. If decision makers for public health and safety programs use the values of the individuals as a guide, then programs will be directed at individuals in high risk situations. With a fixed budget for managing risks, the prospect of spending everything on a few high risk individuals at the expense of numerous individuals facing lower risks is unattractive. This murdering of statistical lives is something that Linnerooth (1982) believes should be made explicit in social decisions which affect the distribution of mortality risk in society. She argues that society should care about the distribution of risk just as it cares about the distribution of income. Another concern about too little attention to low risk situations is based not on ethics, but on perceptions. If individuals perceive risk and changes in risk less accurately when faced with low risk of death, then they will not make efficient decisions about their own health and safety. It follows that public programs which target reductions in risk for low risk situations would be especially important for improving the well being of society. Jones-Lee (1985)

provides a review of these and other criticisms of value of life defined as the amount of money an individual is willing to trade for a small change in his or her own probability of survival.

4. Estimates of Value of Life

Value of life is about private choices that individuals make implicitly and explicitly about their own health and safety. Bland, healthy diets are traded for tasty food and drink which increase blood pressure and cholesterol levels. Comfortable, safe dwellings are left for skiing and rock climbing. Jaywalking is done to save valuable time. Time and sweat are spent exercising to improve physical condition. Travel is postponed in order to avoid treacherous conditions and increase the chances of a safe trip. Jobs are given up to pursue a safer, healthier lifestyle. If the changes in risk and the values of whatever is traded are known by the individuals and can be known by researchers, then values of life can be estimated.

Values of life are implied by observable behavior. If realistic risk tradeoff scenarios can be constructed, then values of life can be elicited directly. Values of life have been estimated using these approaches for at least 27 years. The models upon which the estimation is based typically use a utility function which in some way resembles the one shown in Eqn. 1, make P endogenous so that individuals can change the probability of survival through their behavior, and finally introduce a resource constraint to reflect limited money and time. An implication of these models is that individuals will engage in risk changing activity to the extent that the marginal value of the activity equals the marginal cost.

Letting V be the value of life as defined in Eqn. 2, P` the change in the probability of survival, and K the cost of changing P, the condition of interest is:

$$VP` = K \quad (3)$$

If P`,the change in risk, and K, the cost of changing P, can be determined, then V, the value of life implied by individual behavior can estimated. For comprehensive presentations of models for estimation of the value of life see Cropper and Freeman (1991), Freeman (1993), Johansson (1995) and Johannesson (1996).

4.1 Risk Compensating Wages

The labor market has proven to be a fertile area for producing estimates of individuals' willingness to tradeoff safety and money. Faced with an array of jobs with different characteristics, workers will choose jobs that suit them best. If two identical workers are confronted with two jobs which are identical except for risk of death associated with the job and pay, then equilibrium implies that the worker who chooses the riskier job must be compensated by a higher wage. This risk compensating wage difference implies a value of life. In Viscusi's (1993) survey of the literature on the value of risks to life and health, he lists 24 studies which report estimates of the value of life based on analysis of labor markets. The studies use data from various years from 1967 to 1986 and from several countries including the United States, United Kingdom, Canada, Australia and Japan. The risk variables are based on actuarial data, industry and occupation data collected by the Bureau of Labor Statistics and worker assessments. He judges that the most reasonable estimates of

value of life are clustered in the $4 million to $9 million range, in 1999 dollars.

Several concerns exist about the reliability of these estimates. The fatality rates used to measure risk may not reflect actual risks on the job. Worker information about the risks may be lacking or worker perception of the risks may not reflect actual risks. Risks of nonfatal injury risks may be correlated with fatality risks and may not be measured well or at all. Unmeasured and omitted job disamenities may be correlated with fatality risks. Estimates of values of life may not be representative because of self selection of more adept or less risk averse individuals into risky jobs.

4.2 Risk Tradeoffs in Consumption

Markets other than the labor market and activities other than work have also produced estimates of individuals' willingness to tradeoff safety and other things they value. By estimating the effect of air quality on housing values and isolating the effect of air quality on mortality risks, the value of life implicit in the housing market can be estimated. By estimating the effect of the occupant fatality rate on the prices of automobiles, the value of life implicit in the automobile market can be estimated. These situations match well with Eqn. 3 in that numerous options are available from which the consumer can choose. Other consumption decisions are less continuous, but still imply values of life. Wearing a seat belt while driving in a motor vehicle involves a tradeoff between the gain in safety versus the time and discomfort associated with belt use. Installing smoke detectors involves a tradeoff between a reduction in risk of a fatal fire and installation costs. The value of life estimates

from consumption studies tend to be less than the estimates from the labor market and fall in the range of $1 million to $5 million.

The concerns about the reliability of these estimates are similar to the estimates from the labor market. Some concerns can be readily addressed. For example, if risks are misperceived according to known relationships, the implied values of life can be adjusted. Two other concerns may not be addressed as easily. One is about the ability to separate the risk of fatality from other characteristics of the product. The other is the ability to estimate the value of disutility associated with the consumption.

4.3 Contingent Market Values

Early in the emergence of value of life based on individual willingness to pay, Mishan (1971, p.174) encouraged economists to employ a questionnaire method to estimate values of life rather than rely upon the forgone earnings or cost of illness measures. Since Mishan's exhortation, economists working primarily in environmental, safety, and health economics have developed the contingent valuation method. Mitchell and Carson's (1989) book on using surveys to value public goods presents the method after 18 years of development. This method elicits the tradeoff choice through direct questioning of the individual. The hypothetical setting or market is described, the choice is presented, and information about the respondent is collected. The survey might be in person, by mail, by phone, or some combination. Individuals have been presented with more rapid response ambulance service for higher taxes, changes in risk on the job for compensating changes in wages, safer highway

travel for more money, and safer medications for more out-of-pocket expense. Risk-dollar, risk-risk, and hybrid risk-risk and risk-dollar tradeoffs have been designed to elicit values of life. Contingent valuation estimates tend to fall in the range of the estimates from the labor market.

A great advantage of contingent valuation is the ability to provide information and describe the tradeoff precisely. Concerns exist about the reliability of estimates based on contingent valuation, and they are debated in the symposium in the Fall 1994 issue of the *Journal of Economic Perspectives*. Two of the most worrisome for estimating the value of life is the hypothetical bias due to not actually having to pay and the insufficient sensitivity of values to the scale of the change in risk. Future research on "cheap talk" and statements of intensity of commitment to pay and research on ways to communicate risk may increase confidence in these estimates.

5. Policy Considerations beyond the Typical Values of Life

5.1 Values for Various Types of Individuals

Benefit-cost analysis of environmental, health, and safety proposals value anticipated changes in mortality risks using the average of values of life for all members of society. In this way the values which individuals place on their own lives inform public policy. For public policies such as improvements in traffic safety which have broad effects across many types of individuals in society, average values of life are appropriate. However, some policies primarily affect specific types of individuals who may have values of life which differ from the

typical individual. Whether it is socially acceptable to value lives differently is a sensitive issue. A consensus seems to be emerging that it is unacceptable to use different values for groups which differ by income; an average value of life across all of society is normally used. While no consensus exists yet, there is interest in estimating values of life for vulnerable groups such as the elderly and children. Future research is likely to focus on values of life for types of individuals who get special attention in health, safety, and environmental policy. Related is the question about discounting changes in risk which occur in the future. Discounting future risks can be relevant to people of all ages, but it can matter greatly for the very young and old. Contingent valuation studies in the U.S. and Sweden which address age and discounting find lower values of life for the elderly and that future changes in mortality risks are discounted substantially. See Cropper et al. (1994) and Johannesson et al. (1997).

5.2 Values of Others' Lives - Altruism

Values which individuals place on changes in their own probabilities of survival may be less than the value to all of society because the values that others place on the individual's life are not counted. The strongest case for including others' values is within the individual's immediate family. Since people sort themselves into households based on mutual caring it makes sense that interdependencies are greatest within the household. Bonds within the household are thought to be strong enough that decision making is sometimes modeled at the household level and transfers are made within the household. Differences between individual value and a household value are likely to be dominated by the other factors which influence

estimates of the value of life and not produce much change in the range of values relevant for public policy.

Beyond the household it is not clear that the values others have for an individual's change in the probability of survival should be included in benefit-cost analysis. In a general model of a society constrained by limited resources it can be demonstrated that the value of a statistical life is the same with universal pure altruism with caring about the overall well being of others and universal pure self-interest with no caring at all for others. In other words, the individual's value of his or her change in risk need not be supplemented for benefit-cost analysis. This result follows from the recognition that adding others' values causes the individual to consume more health and safety and less of other desirable things than the individual would choose to consume. The individual's value is sufficient as long as there is not substantial concern with the distribution of income. With impure, safety-focused, paternalistic altruism, however, it can be appropriate to augment the individual's value by others' willingness to pay. Future research is likely to explore ways in which safety-focused altruism should augment individuals' values of their own lives. For further readings, see Jones-Lee (1992) and Johansson (1995).

5.3 Fiscal Externalities and Burden

Another reason for considering adjusting the individual value of life is the impact that an individual's death has on others through public tax and expenditure programs. In Martin Bailey's (1980) influential policy book, he advocated the use of individual value of life for

guiding policy decisions. One adjustment he made was for the individual's contribution to the public tax and insurance system. The amount of adjustment is potentially greater the more extensive is the welfare state in the society of which the individual is a part. A topic for future research is whether the adjustments average out to zero for individuals living in a society with a balanced budget constraint where net contributions are presumably zero.

More recently the idea of fiscal externalities has motivated something which might be called social burden analysis. The fiscal impact on others of individuals who smoke cigarettes, drink heavily, or have sedentary lifestyles has been estimated to quantify the costs which individuals who do these things impose on others. The motivation for calculating such costs is that they are potential pecuniary benefits of policies which reduce these activities. Interestingly, if this adjustment were made to individual values of life for benefit-cost analysis of, say, environmental programs which reduce the risks of individuals who engage in these activities, they would have lower than average values of life and the benefits of the environmental program would be less than if it affected groups with healthier lifestyles. However, the fiscal burden adjustment is rarely used this way. Also interesting is the variance in fiscal consequences which are included in the burden analysis. For example, a RAND Corp. study estimates that smokers, roughly speaking, pay their own way because of the excise taxes they pay on cigarettes and the amounts they bequeath to survivors through net contributions to pension plans. Others who do burden analysis, including those who determine what is admissible in court, are more selective in what they are willing to accept as

relevant. They will count increases in some medical costs financed by others such as those associated with hospitalization but exclude other medical costs which would be saved, such as costs of long-term care. Social burden analysis awaits a theoretical grounding to put it on equal footing with benefit-cost analysis. For further reading on burden analysis see Manning et al. (1991).

5.4 Quality Adjusted Life Years

Early evaluation of medical outcomes was in terms of life years added. The demand to recognize quality of life lead to the development of adjusting a life year added by a quality weight to yield quality adjusted life years, or QALY. The quality weight for a health state associated with an illness (or injury) can be determined by a direct questioning method. The questioning may be as straightforward as picking a point representing the health state on a straight line scale between death and full health. It might be deciding what probability of full health in a standard gamble with full health and death as the possible outcomes is equivalent to the health state. QALYs place a value on the expected number of years of life.

QALYs emerged to be used in cost utility, or cost effectiveness in evaluating medical interventions for several reasons. One reason was the deontological repugnance to health professionals of putting a monetary value on changes in health and, especially, life. Another was the relative paucity and suspected unreliability of estimates of individual willingness to pay 20 years ago when QALYs were being developed. With the continued development of value of life estimation and the emergence of the contingent valuation method, future practice

is likely to be a blending of values of life, QALYs, and related measures. For further reading see Johannesson (1996), Sloan (1996), Drummond et al. (1997) and Gold (1996).

6. What is Known

What may seem on the surface to be impossible, place a value on life, for practical purposes is straightforward. People, individually and collectively, make choices all the time in which they implicitly make tradeoffs between changes in their probability of survival and valuable time and money. Estimates of these values of statistical lives, or, alternatively, values of changes in mortality risks, come from analysis of jobs with different wages and risks, consumption decisions involving changes in risk and time and money, and from direct questioning involving risk-money tradeoffs in constructed markets. The evidence from a large number and variety of studies suggests the typical value of life falls in a range from $1 million to $9 million. The values from the consumption decisions tend to be in the lower end of the range and the best estimate of an average value is $5 million. Studies which compare values of life with expected changes in labor earnings (or cost of illness) invariably find the value of life is greater. Clearly, value of life estimates based on willingness to pay are considerably more reliable than 20 years ago and a growing number of decision makers are finding values of life which are reliable enough for benefit-cost analysis and regulatory impact analysis.

Questions about risk information, perception, econometric estimation, contingent valuation and the values of life estimates remain. Risk-risk analysis developed as an

alternative to benefit-cost analysis in analysis of regulations. The central relationship is the connection between changes in disposable income and individual mortality. Valuing life directly is avoided. For examples, see the collection of studies by Graham and Wiener (1995) or the special issue of the *Journal of Risk and Uncertainty* in January 1997. As long as there are concerns about the ethical propriety of valuing life and about the reliability of value of life estimates, the incentive to develop alternatives to benefit-cost analysis based on values of life exists. As long as progress continues to be made in estimating values of life, their use in making policy will grow.

See also: *Cost-benefit analysis; Decision making under risk and uncertainty; Health economics; Human capital; Safety, economics of; Wage differentials and structure.*

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