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Abstract

The economic approach to valuing risks to life focuses on risk-money tradeoffs for very small risks of death, or the value of statistical life (VSL). These VSL levels will generally exceed the optimal insurance amounts. A substantial literature has estimated the wage-fatality risk tradeoffs, implying a median VSL of $7 million for U.S. workers. International evidence often indicates a lower VSL, which is consistent with the lower income levels in less developed countries. Preference heterogeneity also generates different tradeoff rates across the population as people who are more willing to bear risk will exhibit lower wage-risk tradeoffs.

Keywords: value of life, risk regulation

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The Value of Life
by W. Kip Viscusi

Issues pertaining to the value of life and risks to life are among the most sensitive and controversial in economics. Much of the controversy stems from a misunderstanding of what is meant by this terminology. There are two principal value-of-life concepts—the amount that is optimal from the standpoint of insurance, and the value needed for deterrence. These concepts address quite different questions that are pertinent to promoting different economic objectives.

The insurance value received the greatest attention in the literature until the past several decades. The basic principle for optimal insurance purchases is that it is desirable to continue to transfer income to the post-accident state until the marginal utility of income in that state equals the marginal utility of income when healthy. In the case of property damage, it is desirable to have the same level of utility and marginal utility of income after the accident as before. In contrast, fatalities and serious injuries affect one's utility function, decreasing both the level of utility and the marginal utility for any given level of income, making a lower income level after a fatality desirable from an insurance standpoint. Thus, the value of life and limb from the standpoint of insurance may be relatively modest.

The second approach to valuing life is the optimal deterrence amount. What value for a fatality sets the appropriate incentives for those avoiding the accident? In the case of financial losses, the optimal insurance amount, the optimal deterrence amount, and the ‘make whole’ amount are identical; however, for severe health outcomes such as fatalities, the optimal deterrence amount will exceed the optimal level of compensation.

The economic measure for the optimal deterrence amount is the risk-money tradeoff for very small risks of death. Since the concern is with small probabilities, not the certainty of death, these values are referred to as the value of statistical life (VSL). Economic estimates of the VSL amounts have included evidence from market decisions that reveal the implicit values reflected in behavior as well as the use of survey approaches to elicit these money-risk tradeoffs directly. Government regulators in turn have used these VSL estimates to value the benefits associated with risk reduction policies. Because of the central role of VSL estimates in the economics literature, those analyses will be the focus here rather than income replacement for accident victims.

Valuing Risks to Life

Although economics has devoted substantial attention to issues generally termed the ‘value of life’, this designation is in many respects a misnomer. What is at issue is usually not the value of life itself but rather the value of small risks to life. As Schelling (1968) observed, the key question is how much are people willing to pay to prevent a small risk of death? For small changes in risk, this amount will be approximately the same as the amount of money that they should be compensated to incur such a small risk. This risk-money tradeoff provides an appropriate measure of deterrence in that it indicates the individual’s private valuation of small changes in the risk. It thus serves as a measure of the deterrence amount for the value to the individual at risk of preventing accidents and as a reference point for the amount the government should spend to prevent small statistical risks. Because the concern is with statistical lives, not identified lives, analyses of government regulations now use these VSL levels to monetize risk reduction benefits.

Suppose that the amount people are willing to pay to eliminate a risk of death of 1/10,000 is $700. This amount can be converted into a value of statistical life estimate in one of two ways. First, consider a group of ten thousand individuals facing that risk level. If each of them were willing to contribute $700 to eliminate the risk, then one could raise a total amount to prevent the statistical death equal to ten thousand people multiplied by $700 per person, or $7 million. An alternative approach to conceptualizing the risk is to think of the amount that is being paid per unit risk. If we divide the willingness to pay amount of $700 by the risk probability of one in ten thousand, then one obtains the value per unit risk. The value per statistical life is $7 million using this approach as well.

Posing hypothetical interview questions to ascertain the willingness to pay amount has been a frequent survey technique in the literature on the value of life. Such studies are often classified as *contingent valuation surveys* or *stated preference surveys*, in that they seek information regarding respondents' decisions given hypothetical scenarios (see Jones-Lee 1989 and Viscusi 1992). Survey evidence is most useful in addressing issues that cannot be assessed using market data. How, for example, do people value death from cancer compared with acute accidental fatalities? Would people be interested in purchasing pain and suffering compensation, and does such an interest vary with the nature of the accident? Potentially, survey methods can yield insights into these issues.

Evidence from actual decisions that people make is potentially more informative than tradeoffs based on hypothetical situations if suitable market data exists. Actual decision-makers are either paying money to reduce a risk or receiving actual compensation to face a risk, which may be a quite different enterprise than dealing with hypothetical interview money. In addition, the risks to them are real so that they do not have to engage in the thought experiment of imagining that they face a risk. It is also important, however, that individuals accurately perceive the risks they face. Surveys can present respondents with information that is accurate. Biased risk perceptions may bias estimates of the money-risk tradeoff in the market. Random errors in perceptions will bias estimates of the tradeoff downward. The reason for this result can be traced to the standard errors-in-variables problem. A regression of the wage rate on the risk level, which is measured with error, will generate a risk variable coefficient that will be biased downward if the error is random. The estimated wage-risk tradeoff will consequently understate its true value.

Empirical Evidence on the Value of Statistical Life

A large literature has documented significant tradeoffs between income received and fatality risks. Most of these studies have examined wage-risk tradeoffs but many studies have focused on product and housing risks as well. The wage-risk studies have utilized data from the United States as well as many other countries throughout the world. The primary implication of these results is that estimates of the value of life in the U.S. are clustered in the $4 million to $10 million range, with an average value of life in the vicinity of $7 million.

Since the time of Adam Smith (1776), economists have observed that workers will require a 'compensating differential' to work on jobs that pose extra risk. These wage premiums in turn can be used to assess risk-money tradeoffs and the value of life. The underlying methodology used for this analysis derives from the hedonic price and wage literature, which focuses on 'hedonic' or 'quality-adjusted' prices and wages. Rosen (1986) and Smith (1979), among others, review this methodology.

To see how the hedonic model works, let us begin with the supply side of the market. The worker's risk decision is to choose the job with the fatality risk p that provides the highest level of expected utility (EU). The worker faces a market offer curve w(p) that is the outer envelope of the individual firms' market offer curves. Let there be two states of the world: good health with utility U(w) and death with utility V(w), where this term is the worker's bequest function. The utility function has the property that good health is preferable to ill health, and workers are risk-averse or risk-neutral, or $U(w) > V(w)$; $U', V' > 0$; and $U'', V'' \leq 0$. The job choice is to

$$\underset{p}{\mathrm{MAX}} \quad EU = (1-p)U(w(p)) + pV(w(p)),$$

leading to the result

$$\frac{dw}{dp} = \frac{U(w) - V(w)}{(1-p)U'(w) + pV'(w)}.$$

The wage-risk tradeoff dw/dp based on the worker's choice of a wage-risk combination for a job is the value of statistical life (VSL), which equals the difference in utility between the two health states divided by the expected marginal utility of consumption.

What tradeoff rate dw/dp the worker will select will depend not only on worker preferences but also on the shape of the market offer curve. The best available market opportunities will be those that offer the highest wage for any given level of risk, or the outer envelope of the offer curves for the individual firms. Each individual firm will offer a wage that is a decreasing function of the level of safety. The cost function for producing safety increases with the level of safety, so the wage decline associated with incremental improvements in safety must be increasingly great to keep the firm on its isoprofit curve.

Figure 1 illustrates the nature of the hedonic labor market equilibrium. The curves OC_1 and OC_2 represent two possible market offer curves from firms with risky jobs. As the risk level is reduced, firms will offer lower wages. EU_1 and EU_2 are expected utility loci of two workers, each of whom has selected their optimal job risk from available market opportunities. The curve w(p) represents the locus of market equilibria, which consists of the points at which worker indifference curves are tangent to the market offers. Thus, the empirical estimation of the hedonic labor market equilibrium focuses on the joint influence of demand and supply.

The tradeoffs reflected in market equilibria do not represent a schedule of individual VSL tradeoff values at different risks, but rather different VSLs for different workers. Worker 1 chooses risk p_1 with associated wage $w(p_1)$, and worker 2 chooses risk p_2 for wage $w(p_2)$. However, worker 1 would not accept risk p_2 for $w(p_2)$ even when that is the point on the hedonic equilibrium curve. Rather, worker 1 will require wage $w_1(p_2) > w_2(p_2)$ to accept this risk.

The canonical hedonic wage equation is

$$\ln w_i = \alpha + X_i^{'}\beta + \gamma_1 p_i + \gamma_2 q_i + \gamma_3 WC_i + \varepsilon_i ,$$

where w_i is worker i’s wage, X_i is a vector of personal characteristics and job characteristics, p_i is the worker's fatality risk, q_i is the nonfatal injury and illness risk, and WC_i is a measure of the worker's compensation benefits. Not all labor market studies of VSL include the q_i and WC_i terms. Moreover, there are some differences in the form of the workers' compensation benefit term that is included. The most common is the expected workers' compensation replacement rate, which is the product of the injury risk and the benefit level divided by the wage rate. These differences in the empirical specification account for some of the differences across studies in the estimated VSL.

As a practical matter, there are many systematic differences that have becomes apparent in these studies. Workers at very high risk jobs tend to have lower values of life on average since they have self-selected themselves into the very risky occupation. Through their job choices these individuals have revealed their greater willingness to endanger their lives. Workers at lower risk jobs typically have greater reluctance to risk their lives, which accounts for their selection into these safer pursuits. Such differences are apparent in practice, as the estimated values of life for workers in the average risk jobs tend to be several times greater than those for workers in very risky jobs.

Other differences correlated with worker affluence are also evident. Health status is a normal economic good, and individuals' willingness to pay to preserve their health increases with income. Blue-collar workers, for example, have a lower value of life than do white-collar workers. In addition, there is a positive income elasticity of the estimated values of risks to life and health. Based on a sample of 50 wage-risk studies from ten countries, Viscusi and Aldy (2003) estimate that VSL has an income elasticity of 0.5 to 0.6.

These differences by income level in the VSL amounts are also borne out in the international evidence on wage-risk tradeoffs, such as the study of Australia and Japan by Kniesner and Leeth (1991). Table 1 summarizes representative VSL studies from throughout the world. More affluent countries such as Japan and Canada tend to have higher revealed VSL levels than countries such as South Korea, India, and Taiwan. The major international anomaly is the United Kingdom, for which labor market estimates have been very unstable across studies and sometimes quite high. Deficiencies of the U.K. fatality risk data or correlation of these values with other unobservables may account for this pattern. Because of these limitations, the benefit assessments for risk reductions in the U.K. are based on stated preference values rather than labor market values, which is the approach taken by U.S. regulatory agencies.

Because of individual heterogeneity in preferences and resources, it is not surprising that estimated values of life often differ considerably across empirical studies. These differences are not a sign that such studies are necessarily in error. These samples often consist of workers with quite different risk levels and who are situated differently. International comparisons, for example, consistently reveal differences across countries, not only because of the aforementioned aspects of heterogeneity, but because of the differences in the social insurance and workers' compensation arrangements that may be present in these countries.

The role of heterogeneity is evidenced in estimates for the implicit value for non-fatal job injuries for different worker groups. This analysis follows the same general methodological approach as does the literature on the implicit value of life. The difference is that the focus is on non-fatal job risks rather than fatalities. On average, workers value non-fatal loss injuries on the job at values ranging from $20,000 to $70,000 per expected job injury. Thus, for example, a worker at the high end of this range would require $2,000 to face a one chance in 25 of being injured that year.

The estimates of the implicit values of injuries for other labour market groups who have different attitudes towards risk vary substantially from this amount. Interestingly, women often work at hazardous jobs and appear to have wage-risk tradeoffs similar to those of men. Other personal characteristics generate more evidence of heterogeneity in preferences. Cigarette smokers and people who don't use seat belts in their automobiles work on risky jobs for less per expected injury than do people who don't smoke and who use seat belts in their automobiles. What is noteworthy is that these results are not hypothetical willingness-to-pay values that these groups have expressed with respect to risks. Rather, they represent actual differences in compensation based on observed patterns of decisions in the marketplace. Markets work as expected in that they match workers to the jobs that are most appropriate for their preferences. This is a constructive role of market sorting that promotes a more efficient match-up than if, for example, all individuals were constrained to have the same job riskiness.

Preference heterogeneity has additional implications as well. Recall from Figure 1 that workers may settle along different points of the available market opportunities. However, if workers face the same opportunities locus, then the worker choosing the higher risk p_2 must always be paid a wage $w(p_2) > w(p_1)$ if $p_2 > p_1$. Interestingly, that pattern does not always hold. As shown by Viscusi and Hersch (2001), smokers choose jobs that are riskier than nonsmokers' jobs but offer less additional wage compensation for incurring the risks.. Smokers and nonsmokers face different market offer curves and, most important, these offer curves provide for a flatter wage-risk gradient for smokers. There may be an efficiency-based rationale for these differences, as smokers are more prone to job accidents, so that there safety-related productivity is less.

Studies of the money-risk tradeoffs are not restricted to the labor market. There have been a number of efforts to assess price-risk tradeoffs for a variety of commodities. The contexts analysed by economists include the choice of highway speed, seat belt use, installation of smoke detectors, property values in polluted areas, and prices of automobiles. The most reliable of these studies outside the labor market are those pertaining to automobile prices in that they follow the same kind of approach as is used in the wage-risk literature. In particular, the analysts obtain price information on a wide variety of automobile models. Using regression analysis, they assess the incremental contribution of the safety characteristics *per se* to the product price, controlling for other product attributes. The results of these studies suggest a value of life around $5 million.

The Duration and Quality of Life

The value-of-life terminology is misleading to the extent that risk reduction efforts do not confer immortality, but simply extend life. Because of that, the major concern should not be with the value of life but with the value of extending life for different periods. In the case of preventing the risk of a young person, the increase in life expectancy that will be generated will exceed that for preventing a risk of death to older people. Some kind of age adjustment may be appropriate. The quantity of life matters, but which years of life matter most? Is a year of life at age 45 more valuable than a year of life at age five or age 70? How do various health impairments correlated with age affect the value one should attach to such years of life, and should the fact that very young children have not yet received the value of the education and rearing by their parents matter? The total 'human capital', which is the set of personal attributes such as education and training that affect one's income, will be greater for older children who are further along in their development. Resolving such questions remains highly problematic.

Considerable attention has been devoted to economic analysis of age effects, including studies by Shepard and Zeckhauser (1984) and Johansson (2002). If capital markets were perfect, then VSL would steadily decline with age, reflecting the shortening of life expectancy. If, however, there are capital market imperfections, then VSL will display an inverted U-shaped relationship with age. A similar pattern is exhibited empirically by lifetime consumption patterns, which some theoretical models have linked to VSL levels over the life cycle. Although empirical estimates of the age effects are still being refined, the available evidence from survey data and market-based studies suggests that there is an inverted-U-shaped relation. The main empirical controversies concern the tails of the age distribution. To what extent is there a flattening of the VSL-age relation for the very old age groups, and how should VSL levels be assigned to children?

The quality of the life of the years saved clearly matters as well. Life years in deteriorating health may be less valuable to the individual than years in good health. Some analysts have suggested that the measure should focus on quality-adjusted life years. Making these quality adjustments has yet to receive widespread empirical implementation and are often controversial. There may be quite legitimate fears of government efforts to target expenditures by denying health care to those whose life quality is deemed to be low. People often adapt to changes in health status so that external observers may overstate the decline in wellbeing that occurs with serious illnesses.

Conclusion

Economic estimates of the tradeoffs people make between risk and either prices or wages serve a variety of functions. First, they provide evidence on how people make decisions involving risk in labor market and product market contexts. The fact that there are probabilistic health effects does not imply that markets cease to function. Second, these estimates have proven useful in providing a reference point for how the government should value the benefits associated with regulations and other policies that reduce risk. Third, the existence of these estimates and economists' continuing efforts to refine the values has served to highlight many of the fundamental ethical issues involved, such as how society should value reducing risks to people in different age groups.

W. Kip Viscusi

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Table 1
Labor Market Estimates of Value of Statistical Life Throughout the World

Study/Country	Value of Statistical Life ($ millions)[a]
Median value from 30 U.S. studies	7.0
Australia	4.2
Austria	3.9 – 6.5
Canada	3.9 – 4.7
Hong Kong	1.7
India	1.2 – 1.5
Japan	9.7
South Korea	0.8
Switzerland	6.3 - 8.6
Taiwan	0.2 – 0.9
United Kingdom	4.2

a. All estimates are in year 2000 U.S. dollars. See W. Kip Viscusi and Joseph E. Aldy, "The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World," *Journal of Risk and Uncertainty* 27, No. 1 (2003): 5-76. For concreteness single representative studies are drawn from their Table 4.

Figure 1
Market Process for Determining Compensating Differentials