Establishing the appropriate degree of social regulation requires that we set a price for what the regulation produces. In the case of environmental regulation, we need to &now what the value to society of additional pollution reduction will be before we can set the stringency of the standard. In the case of health and safety regulations, we need to know what is the value of preventing additional risks to life and health.

Although one can sidestep these issues in part by relying on cost-effectiveness analysis in which we calculate the cost per unit of social benefit achieved, such as the cost per expected life saved, the most that can be done with cost-effectiveness analysis is to weed out the truly bad projects. Ultimately, some judgment must be made with respect to the amount of resources society is willing to commit to a particular area of social regulation. In practice, this tradeoff may be implicit, as government officials may make subjective judgment with respect to whether a policy is too onerous. Implicit overall judgments come close to setting an implicit value on life, health, or pollution, but often these judgments may result in serious imbalances across policy areas.

One reason for these imbalances is that taking tradeoffs into consideration in an ad hoc manner may be a highly imperfect process. OSHA, for example, attempts to avoid regulatory actions that will lead to the shutdown of a particular firm. EPA likewise has similar concerns, as it has made an effort to phase in pollution requirements for the steel industry. When EPA policies would have serious repercussions for local employment, it has sought the advice of the residents in the affected area. Often the compromise that is reached is that the requirements will be phased in over a long period of time, which will reduce the costs of transition and which can better be accommodated given the normal process of replacing capital equipment over time. This practice of phasing in requirements has also been followed for automobile regulation, where pollution-control requirements and major safety innovations, such as airbag requirements, have been imposed with fairly long lead times so that the industry can adjust to the standards.

The focus of this chapter will be on how society can establish a mare formal, systematic, and uniform basis for establishing tradeoffs between the resources expended and the benefits achieved through social regulation efforts. For most economic commodities, this would be a straightforward process. The U.S. Bureau of Labor Statistics gathers price information on hundreds of commodities, so that finding out the price of a market-traded good is a fairly trivial undertaking. In contrast, social-regulation efforts for the most part deal with commodities that are not traded explicitly in markets. Indeed, from a policy standpoint, it is in large part because of the lack of explicit trade that we have instituted

government regulation in these areas. Victims of pollution do not sell the right to pollute to the firms that impose these pollution costs. Future generations that will suffer the ill effects of genetic damage likewise do not contract with current generations, the operators of genetic engineering experiments, or the firms that expose pregnant women to high levels of radiation. Nevertheless, to the extent that it is possible, we would like to establish a market reference point for how much of a resource commitment we should make to preventing these outcomes so that we can get a better sense of the degree to which various forms of social regulation should be pursued. We will use valuation of the risks to life as the case study for considering how the government can value the benefits associated with regulations affecting health and the environment.

Two approaches have been used. The first is to estimate the implicit prices for these social risk commodities that may be traded implicitly in markets. Most important is that workers receive additional premiums For the risks they face on the job, and the wage tradeoffs they receive can be used to establish an appropriate tradeoff rate. A second general approach is to ask people through an interview context how much they value a particular health outcome. This methodotogy may have greater problems with respect to reliability, but has the advantage in that one can obtain tradeoff information regarding a wide range of policy outcomes.

Policy Evaluation Principles

Suppose that this evening you will be crossing the street, and that you have one chance in 10,000 of being struck by a bus and killed instantaneously. We will offer you the opportunity to buy out of this risk for a cash payment now. For purposes of this calculation, you can assume that your credit is good and that, if necessary, you can draw on either your parents' or your future resources. To put the risk in perspective, a probability of death of one chance in 10,000 is comparable to the average fatality risk faced each year by a blue collar worker in American industries. How much would you be willing to pay for eliminating this risk?

This kind of thought process is exactly what the government should go through when thinking about how far to push various social-regulation efforts. In particular, the main matter of concern is society's total willingness to pay for eliminating small probabilities of death or adverse health effects.' Thus we are not interested in the dollar value of your future earnings that will be lost, although this of course will be relevant

to how you think about the calculation. In addition, we are not interested in how much you are willing to pay to avoid certain death. The level of the probability of risk involved with certain death dwarfs that associated with small risk events by such an extent that the qualitative' aspects of the risk event are quite different It is noteworthy, for example, that society views suicide with disfavor, but the taking of small risks, such as the decision to drive a compact car rather than a larger car that offers greater safety, is generally viewed as being acceptable.

Let us now take your response to the willingness-to-pay question above and convert it into a value of life. What we mean by the value of life terminology is the vatue that you would be willing to pay to prevent a statistical death. This amount is straightforward to calculate. To calculate this magnitude, one simply divides your willingness-to-pay response by the level of the risk that you are reducing, or:

$$\text{Value of Life} = \frac{\text{Willingness to Pay}}{\text{Size of Risk Reduction}} \tag{20.1}$$

This gives the amount you would be willing to pay per unit of mortality risk. For the specific values given in the example we considered, the value-of-life number can be calculated as

$$\text{Value of Life} = \frac{\text{Willingness to Pay}}{1/10,000} \tag{20.2}$$

or

$$\text{Value of Life} = 10,000 \times \text{Willingness to Pay} \tag{20.3}$$

An alternative way of thinking about the value of life is the following. Consider a group of 10,000 people, one of whom will die in the next year. As a result, there will be one expected death. If each person would be willing to contribute the same amount to achieve the risk reduction, then the value of preventing one expected death would be 10,000 multiplied by the willingness-to-pay amount per person. This calculation is identical to that in equation (20.3) above.

Your value of life implicit in the response you gave is consequently 10,000 times the amount of your response. Table 20.1 gives different value-of-life estimates depending on the level of your answer. If there is no finite amount of money 'that you would be willing to pay to prevent this risk, and if you were willing to &vote all of your present and future resources to eliminate it (presumably retaining enough for minimal subsistence), then it would be safe to say that you place an infinite value on your life, or at least a value that is very, very large. Any finite response below this amount implies that you would be willing to accept a finite value of life or make a risk-dollar tradeoff when confronted with a

Table 20.1
Relation of Survey Responses to Value of Life

Amount Will Pay (Dollars) to Eliminate 1/10,000 Risk	Value of Life (Dollars)
Infinite	infinity
Above 1,000	At least 10,000,000
500–1,000	5,000,000–10,000,000
200–500	2,000,000–5,000,000
50–200	500,000–2,000,000
0	U

i&-extending decision. When viewed in this manner, making a risk-dollar tradeoff does not appear to be particularly controversial. Indeed, one might appear to be somewhat irrational if one were willing to expend all of one's future resources to prevent small risks of death, particularly given the fact that we make such tradeoffs daily, as some of the risk statistics in Chapter 19 indicated.

For the finite value of life responses, a willingness-to-pay of $1,000 to prevent a risk of death of one chance in 10,000 implies a value of life of $10 million. A response of $500 to prevent the small risk implies a value of life of $5 million. Similarly, at the extreme end, a zero response implies a value-of-life estimate of zero. Table 20.1 summarizes the relationship between various willingness-to-pay amounts and the value of life.

When presented with this survey task, most students tend to give fairly low responses, at the lower end of the range of the table. When we examine the implicit values of life of workers based on the wages they receive for the risks they face in their jobs, we will show that their values of life are much greater than those often given by students responding to the 1/10,000 death risk question. The best estimates of the value of life for a worker in a typical blue-collar job are in the $3 million to $6 million range,

Two explanations come to mind for these low responses. First, dealing with low-probability events such as this is a very difficult undertaking. Second, there is a tendency to think in terms of one's immediate resources rather than one's lifetime resources when answering this question. The current budget of a typical college student is substantially below that of an average blue collar worker, but the student's ultimate lifetime earnings will be greater.

Willingness-to-Pay versus Other Approaches

The procedure used to value life, health, and environmental outcomes more generally is exactly the same as is used in other contexts in which we are assessing the benefits of a government program. In particular, the benefit value is simply society's willingness to pay for the impact of the program.' This outcome may be in the form of a lottery, as in the case where the probability of an adverse event is reduced through a beneficial risk-regulation effort. Although reliance on the willingness-to-pay approach may seem to gain us little in terms of enabling us to assess benefit values in practice, it does offer a considerable advantage in terms of preventing one from adopting a benefit assessment procedure that is not economically sound.

The economic pitfalls that may be encountered are apparent from considering some of the alternative approaches that have been suggested. For the most part, these approaches rely on various human capital measures related to one's lifetime earnings.[3] However, the kind of' approach that is useful in assessing the value of training or education may be wholly inappropriate for assessing the implications of life-extending efforts. The first human capital measure one can consider is the present value of one's lifetime earnings. This might be taken as a good gross measure of one's value to the GNP, and it is an easy number to calculate. The fallacy of using this measure is apparent in part from the fact that the elderly and people who choose to work outside of the labor force would fare particularly badly under such a procedure. In addition, although one's income level is clearly going to influence one's willingness to pay for risk reduction, it need not constrain it in a one-to-one manner. Thus, when dealing with a small risk of death, such as one chance in 10,000, one is not necessarily restricted to being willing to spend only 1/10,000 of one's income to purchase a risk reduction. One could easily spend 5/10,000 or more for small incremental reductions In rink. Difficulties arising from budgetary constraints are encountered only when we are dealing with dramatic risk increments. Moreover, if one were faced with a substantial risk of death, one might choose to undertake unusual efforts such as working overtime or moonlighting on a second job if one's survival depended on it.

A variant on the present value-of-earnings approach is to take the present value of lifetime earnings net of the consumption of the deceased. This is a common measure used in court cases for compensating survivors, inasmuch as it is a reflection of the net economic loss to the survivors after the death of a family member. This type of calculation abstracts from the consumption expenditures of the individual who is deceased, and it is certainly the individual whose health is most affected who should figure prominently in any calculation of the benefits of pursuing any particular social regulation.

A Anal approach that has appeared in the literature is to look at the taxes that people might pay. Focusing on tax rates captures the net

financial contribution one makes to society, but it has the drawback of neglecting the income contribution to oneself or one's family.

Notwithstanding the inappropriateness of the various earnings approaches, this technique has not only appeared in the literature but has been widely used by government agencies. Much of the appeal of the method is that it lends itself to calculation.

A major policy event that led to a shift in the approach taken was the OSHA hazard-communication regulation that was the subject of intense debate in the early 1980s.[4] OSHA prepared its regulatory analysis, assessing the value of the risk reduction achieved by valuing these impacts according to the lost earnings of the individuals whose death or nonfatal cases of cancer could be prevented. OSHA justified this approach on the basis that it was much too sensitive an issue to value life, so that it would follow the alternative approach of simply assessing the costs of death.

Because of OSHA's overoptimistic risk assessment assumptions, the Office of Management and Budget rejected the regulatory proposal. OSHA appealed this decision to then-Vice President George Bush, who had delegated authority over regulatory matters. OSHA was ultimately permitted to issue the regulations after there was a reassessment of the benefits using the sound economic approach-willingness-to-pay measures for the value of life-which led to the result that benefits exceeded costs. Because willingness-to-pay amounts generally exceed the present value of lost earnings by roughly an order of magnitude, using an appropriate economic methodology greatly enhances the attractiveness of social regulation efforts and makes these regulations appear more attractive than they would otherwise be. Indeed, the substantial size of the benefit estimates that can be achieved using the willingness-to-pay measure, rather than its economic soundness, may be the principal contributor to the increasingly widespread adoption of this approach throughout the Federal government.

There also appears to be less reluctance to address the life-saving issues directly. One or two decades ago, raising the issue of the value of life appeared to be intrinsically immoral. However, once it was understood that what is at issue is the amount of resources one is willing to commit to small reductions of risk, rather than to prevent a certain death, then the approach becomes less controversial. Moreover, because the measure is simply the total willingness of society to pay for the risk reductions, it does not use economic pricing in any crass or illegitimate way, as would be the case with the various human capital measures noted above. Society has also become aware of the wide range of risks that we face, including those imposed by our diets and a variety of per-

sonal activities. The idea that it is not feasible to achieve an absolutely risk-free existence and that some tradeoffs must ultimately be made is becoming more widely understood.

Variations in the Value of Life

One dividend of going through the exercise summarized in Table 20.1 is that individuals will give different answers to these willingness-to-pay questions. There is no right answer in terms of the value of life. Thus we are not undertaking an elusive search for a natural constant such as e or π. Rather, the effort is simply one to establish an individual's risk-dollar tradeoff. Individuals can differ in terms of this tradeoff just as they could with respect to other kinds of tradeoffs they *might make- concerning various kinds of consumption commodities that they might purchase. It makes no more sense to claim that individuals should have the same value of life than it does to insist that everyone like eating raw oysters.

A major source of differences in preferences is likely to be individuals' lifetime wealth. People who are more affluent are likely to require a higher price to bear any particular risk. This relationship is exhibited in the nubstantial positive income elasticity in the demand for medical insurance, as well-as in a positive relationship between individual income and the wage compensation needed to accept a hazardous job. The amount workers are willing to pay to avoid a given injury risk increases proportionally with worker income, which is consistent with this pattern of influences.[5]

Overall, there is likely to be substantial heterogeneity in individual preferences, and this heterogeneity will be exhibited in the choices that people make. Empirical evidence suggests that smokers are more willing to bear a variety of risks other than smoking in return for leas compensation than would be required for a nonsmoker.[6] Individuals who wear seatbelts are particularly reluctant to incur job risk, which one would also expect. If one examined a distribution of job-related risks, such as that provided in Table 20.2, one would expect that the individuals who are in the relatively safe occupations listed at the top of the table would generally be more averse to risk than those in the riskiest pursuits. In contrast, people who tend to gravitate to the high-risk jobs, who choose to sky-dive, or who smoke cigarettes are more likely to place a lower value on incurring such risks than do those who avoid such pursuits.

Although substantial differences such as those exist, from a policy standpoint it is not quite clear the extent to which we would use such distinctions. Should we provide individuals with less stringent government

Table 20.2
Average Annual Traumatic Occupational Fatalities Listed by Industry, United States, 1980–1985

Industry	Fatality Rate (per 100,000 workers)
Mining	31.9
Transportation, communications	25.4
Construction	24.1
Agriculture, forestry, fishing	20.7
Manufacturing	4.4
Services	3.1
Retail trade	2.7
Finance, insurance, real estate	1.2
Wholesale trade	1.0

Source: National Traumatic Occupation Fatalities, 1980-85, National Institute for Occupation and Health, Division of Safety Research.

regulations to protect them if they have revealed by other activities that they are willing to bear a variety of risks to their well-being? Viewed somewhat differently, should we override the decisions of people who find a particular wage-risk tradeoff in the labor market attractive or who find the nuisance of wearing a seatbelt to outweigh the perceived benefits to themselves? Although one should generally respect individual values in a democratic society, we may wish to distinguish situations in which individuals are believed to be irrational or where it is not feasible to educate people inexpensively with respect to the rational course of action. One danger of regulation of this type, however, is that we may impose the preferences of policymakers on the individuals whose well-being is supposed to be protected, which may trot necessarily be welfare-enhancing for those affected by the regulation.

The one area in which the differences in the value of life should clearly be utilized is in assessing future impacts of regulatory programs. Because further benefits are deferred, discounting these benefits to bring them to present value reduces the current value of regulatory policies with long-run effects such as pollution control to reduce the depletion of the ozone layer around the atmosphere. if, however, we recognize that future generations are likely to be wealthier, then much of the role of discounting will be muted. Consider, For example, the situation in which the income elasticity of the value of the benefits is 1.0. Let the benefit n years hence be B, the growth rate in income between now and the time when the benefits are realized be g, and the interest rate be r. The equation below gives the present value of the benefits, which simply equal the

dollar benefit value B multiplied by a growth factor, which is the spread between the growth rate in income minus the interest rate:

$$\text{Present Value of Benefit} = \frac{B(1+g)^n}{(1+r)^n} \approx B(1+g-r)^n \qquad (20.4)$$

Thus the growth in income will mute to a large extent the influence of discounting when weighing the consequences of policies in the future.

One might raise the question whether one should discount at all or simply treat all policy outcomes in different years equally, irrespective of the time in which they transpire, This procedure has been advocated by the U.S. Environmental Protection Agency because doing so will greatly enhance the attractiveness of its efforts, many of which have deferred effects. The fallacy of ignoring discounting altogether is apparent when one considers that in the absence of discounting one would never take an action in which there will be a permanent adverse effect of any kind. The costs of such efforts will always be infinite, and such policies would never be pursued.

The Labor Market Model

Most of the empirical estimates of the value of life have been based on labor market data. The general procedure is to estimate the wage-risk tradeoff that workers implicitly make as part of their jobs and to use implications of this tradeoff as an estimate of the value of life.
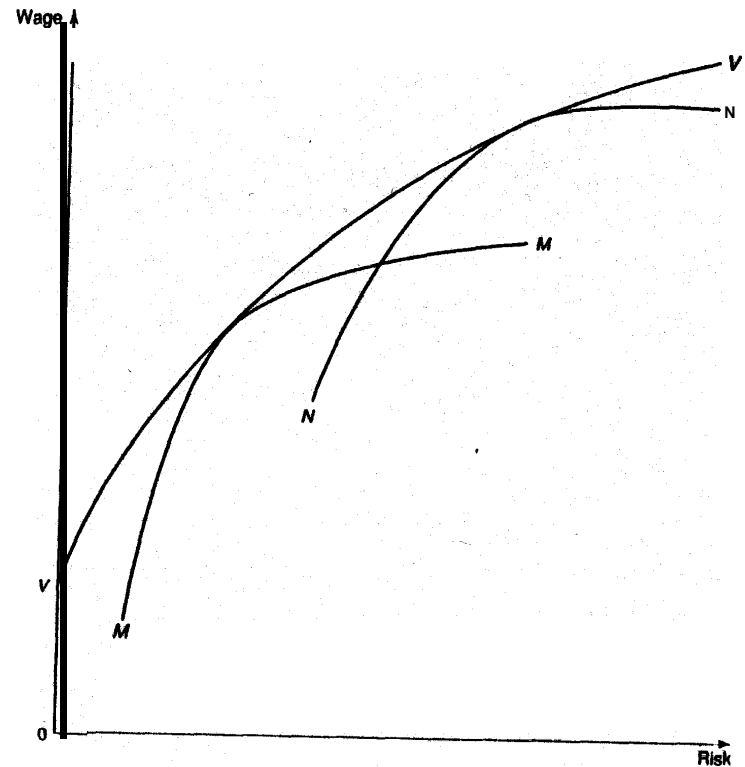
As the starting point for the analysis, consider Figure 20.1. Sketched in this diagram are two curves, EU_1 and EU_2, which are constant expected utility loci far the worker, This combination of wages and risk on each curve gives the worker the same expected utility. The required wage rate is an increasing function of the risk, which is true for a wide range of individual preferences. All that is required is that one would rather be healthy than not. It is not necessary that one be risk-averse in the sense of unwilling to accept actuarially unfair financial bets. Two expected utility loci offering constant expected utility are EU_1 and EU_2. Higher wage rates and lower risk levels are preferred, so that the direction of preference is toward the northwest.

Workers do not have all wage-risk combinations to choose from, but instead are limited to those that are offered by firms. Figure 20.2 illustrates how the available set of job opportunities is constructed. Each particular firm has a constant expected profits locus. Thus, one firm will have a locus MM, where this isoprofit curve gives the locus of wage-risk
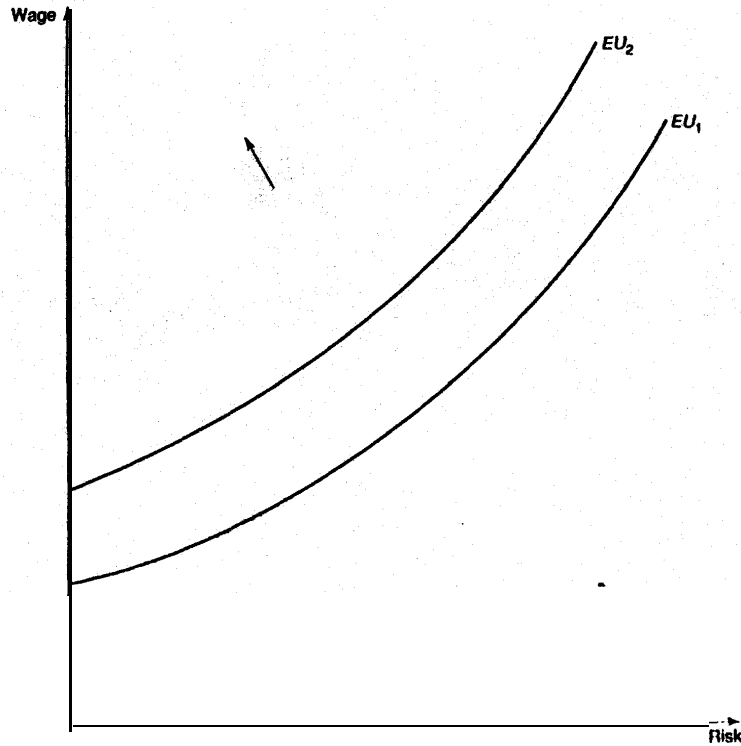
Figure 20.1
Worker's Constant Expected Utility Locus for Wages and Risk

Figure 20.2
Derivation of Market Offer Curve

combinations that give the firm the same level of profits. For example, if a firm lowers the risk level by investing in additional health and safety equipment, to maintain the same level of profits the wage rate must go down. As a result, the wage that the firm can offer and maintain the same level of profits will be an increasing function of risk. The curvature of the MM isoprofit curve is dictated by the fact that additional safety reductions become increasingly difficult to achieve, so that as one moves to the left along the risk axis, the additionat cost expenditures on the part of the firm become increasingly great. Consequently, the magnitude of the wage increase required for any particular risk reduction becomes greater. Curve NN is another example of an isoprofit curve for a different firm in the industry.

The outer envelope of the isoprofit curves for the entire industry provides the offer curve available to workers. Thus a worker's task is to select the point along the offer curve VV that gives the worker the highest level of expected utility. Points below this curve will be dominated by points along it, since a point below VV will be less desirable than a job that offers the same risk at a higher wage rate.

The nature of market equilibrium is illustrated in Figure 20.3.' Worker 1 achieves his constant expected utility at the point of tangency with the market opportunity locus VV, where his tangency point is at X. In contrast, worker 2 selects a higher risk-wage combination at point Y. Because of the aforementioned heterogeneity in individual tastes, the individuals will generally sort themselves along the part of the wage offer curve that best suits their preferences.
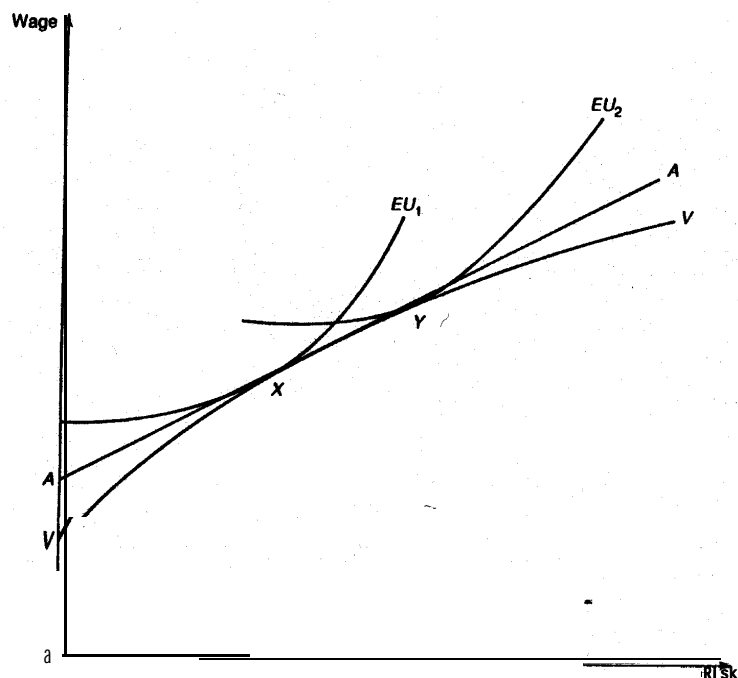
Figure 20.3
Equilibrium in the Market for Risky Jobs

The task of empirical analysis in this area is to analyze the nature of the observed market squifibrium points reflected in data sets on worker behavior. Thus, if we observe points X and Y, the estimation of a linear relationship between wages and risk would yield the curve AA shown in Figure 20.3. The slope of AA gives the estimated wage-risk tradeoff. In effect, what this curve does is indicate the terms of trade that workers, on average, ate willing to accept between risk and wages. These terms of trade in turn can be used to extrapolate the implicit value that workers attach to a statistical death.

The details of the methodology vary depending on the particular data set used for the estimation. In general, the statistical approach involves the use of a large set of data on individual employment behavior. Table 20.3 summarizes the principal aspects of thirteen studies that have appeared in the literature.' These studies have been ordered according to the level of the risk being examined, with the studies focusing on the highest risk groups being at the top of the table. Although these studies

Table 20.3
Summary of Selected Value-of-Life Studies

Author/Year	Sample	Risk Variable	Mean Risk	Implicit Value of Life (S millions)[a]
Smith (1976)	Current Population Survey (CPS)	Bureau of Labor Statistics (BLS)	0.0001	4.0
Thaler and Rosen (1976)	Survey of Economic Opportunity	Society of Actuaries	0.001	0.7
Viscusi (1979)	Survey of Working Conditions	BLS	0.0001	3.6
Brown (1980)	National Longitudinal Survey of Young Men	Society of Actuaries	0.002	1.3
Olson (1981)	CPS	BLS	0.0001	4.5
Viscusi (1981)	Panel Study of Income Dynamics (PSID)	BLS	0.0001	5.7
Arnould and Nichols (1983)	U.S. Census	Society of Actuaries	0. 001	0.8
Dillingham (1985)	Quality of Employment Survey (QES)	Constructed by author	0.00014	2.2-4.6
Dillingham (1985)	QES	U.S. Department of Labor	0.00008	5.9
Gerking, DeHann, and Schulze (1988)	Mail survey conducted by authors	Perceived risk of death, based on Society of Actuaries	0.0007	3.0
Moore and Viscusi (1988)	QES	Discounted Expected Life Years Lost; based on BLS Death Rate	0.00006	6.4
Moore and Viscusi (1990)	PSID	BLS	0.00005	2.2
Moore and Viscusi (1990)	PSID	National Traumatic Occupational Fatality Survey	0.00008	6.4

• Expressed in 1988:3 prices using the GNP deflator, 8s reported in the Economic Report of the President, 1989.

are based on labor-market behavior, these estimales are now widely used throughout the federal government to value regulatory policy effects ranging from aviation safety to environmental health effects.

Empirical Estimates of the Value of Life

The general form of the estimation depends in part on the nature of the wage and risk information that is available, such as whether the data pertain to annual earnings or hourly wage rates.[9] One form of estimating the equation is the following:

Annual Earnings = $a + \beta_1$ Annual Death Risk

$$+ \sum_{i=1}^{n} \gamma_i \text{ Personal Characteristic}_i$$

$$+ \sum_{i=1}^{m} \psi_i \text{ Job Characteristic}_i + \varepsilon \qquad (20.5)$$

The dependent vatiabb in this analysis is the annual worker earnings, which is not as accurate a measure as the worker's hourly wage rate, but for expositional purposes it facilitates our task of indicating how one constructs the value-of-life estimates in the equation. The explanatory variables include the annual death risk facing the worker. In general, this information is matched to the workers in the sample based on their responses regarding their industry or occupation.

The coefficient β_1 in equation (20.5) indicates how annual earnings will be affected by an increase in the annual death risk. If the annual death risk were 1.0, then β_1 would give the change in annual earnings required to face one expected death. Thus, for the equation as it has been set up here, β_1 is the value-o&life estimate. In particular, it represents the tradeoff that workers exhibit between earnings and the risk of death.

As the information in the third column in Table 20.3 indicates, several data sets have been used, including Society of Actuaries data on occupational risks and information on industry risk levels provided by the U.S. Bureau of Labor Statistics and the National Institute of Occupational Safety and Health, which has a detailed census of job deaths known as the National Traumatic Occupational Fatality data, Of the industry-based risk measures, the National Traumatic Occupational Fatality data is believed to be the most reliable.

The other variables included in equation (20.5) are designed to control for the other aspects of the worker and his job that will influence earnings. In general, the people who earn the highest incomes in our society also have fairly low-risk jobs. This observation, which can be traced back to the time of John Stuart Mill, reflects the positive income elasticity of the demand for health. By including a detailed set of other variables, including coverage of factors such as worker education and union status, one can successfully disentangle the premium for job risks as opposed to compensation for other attributes of the worker and his job.

The results of these estimations are summarized in the final column of Table 20.3. The value-of-life estimates range from under $1 million to more than $6 million. This heterogeneity is not solely a consequence of the imprecision of the statistical measures, but instead is due to the fact

that these studies are measuring different things. The value-of-life estimates for samples of different riskiness are expected to be different because the mix of workers and their preferences across samples may be quite different. In addition, the degree to which different risk variables measure the true risk associated with the job may differ substantially across risk measures. Examination of the same sample of workers using two industry-based risk measures, the Bureau of Labor Statistics data, and the National Traumatic Occupational Fatality data, indicates that this measurement error alone can lead to a doubling of the estimates.

Even with the current state of econometric techniques and the substantial literature devoted to this issue, economists cannot yet pinpoint the value of life that is appropriate in every particular instance. However, we have a good idea of the general range in which such values fall, and from the standpoint of making policy judgments with respect to the ballpark in which our policies should lie, this guidance should be sufficient.

Value of Life for Regulatory Policies

It is useful to examine the government policies that have actually been pursued in the social-regulation area to see the extent to which they conform with an appropriate value of life. Table 20.4 summarizes a variety of key aspects of major regulations issued between 1967 and 1wo." These regulations covered such diverse issues as cabin fire protection for airplanes, grain dust regulations fot grain handling facilities, and environmental controls for arsenic/copper smelters..

The main information of interest appears in the final column of the table, which is the cost per life saved by each of the programs. Some of these efforts, such as steering column protection for automobiles and other entries at the top of the table, are bargains. Their cost per life saved is well below $1 million. For concreteness, suppose that we took as the appropriate value of life a figure of $5 million. Then all regulations at the top part of the table including benzene/fugitive emissions regulations by EPA would pass a benefit-cost test. Similarly, all regulations at the bottom part of the table, including radionuclides/uranium mines, as well as all regulations with a higher cost per life saved could not be justified on benefit-c&t grounds.

What is most instructive from this table is that in general it is not necessary to pinpoint the exact value of Me that is appropriate for any government policy. For the most part, rough judgments regarding the efficacy of a regulation can tell us a great deal. We know, for example, if

Table 20.4
The Cost of Various Risk-Reducing Regulations per Life Saved

Regulation	Year and status	Agency	Initial annual Risk[a]	Annual Lives Saved	Cast per Life Saved (millions of 1984 $)
Pass benefit-cost test:					
Unvented space heaters	1980 F[b]	CPSC	2.7 in 10"	63.000	$ .10
Oil and gas well service	1983 P	OSffA-S	1.1 in 10^3	50.000	.10
Cabin fire protection	1985 F	FAA	6.5 in 10^8	15.000	.20
Passive restraints/belts	1984 F	NHTSA	9.1 in 10^5	1,850.000	.30
Underground construction	1989 F	OSHA-S	1.6 in 10^3	8.100	.30
Alcohd and drug control	1985 F	FRA	1.8 in 10^6	4.200	.50
Servicing wheel rims	1984 F	OSHA-S	1.4 in 10^5	2.300	.50
Seat cushion flammability	1984 F	FAA	1.6 in 10'	37.000	.60
Floor emergency lighting	1984 F	FAA	2.2 in 10"	5.000	.70
Crane suspended personnel platform	1988 F	OSHA-S	1.8 in 10^3	m o o	1.20
Concrete and masonry construction	1988 F	OSHA-S	1.4 in 10^5	6.500	1.40
Hazard communication	1983 F	OSHA-S	4.0 in 10^5	200.000	1.80
Benzene/fugitive emissions	1984 F	EPA	2.1 in 10^5	0.310	2.80
Fail benefit-cost test:					
Grain bust	1987 F	OSHA-S	2.1 in 10'	4.000	5.30
Radionuclides/uranium mines	1984 F	EPA	1.4 in 10^4	1.100	6.90
Benzene	1987 F	OSHA-H	8.8 in 10^4	3.80	17.10
Arsenic/glass plant	1986 F	EPA	8.0 in 10^4	0.110	19.20
Ethylene oxide	1984 F	OSHA-If	4.4 in 1 O	2 800	25.60
Arsenic/copper smelter	1986 F	EPA	9.0 in 10^4	0.060	26.50
Uranium miff tailings, inactive	1983 F	EPA	4.3 in 10'	2.100	27.60
Uranium mill tailings, actke	1983 F	EPA	4.3 in 10^4	2.100	53.00
Asbestos	1986 F	OSHA-H	6.7 in 10^5	74.700	89.30
Asbestos	1989 F	EPA	2.9 in 10^5	10.000	104.20
Arsenic/glass manufacturing	1986 R	EPA	3.8 in 10^5	0.250	142.00
Benzene/storage	1984 R	EPA	6.0 in 10'	0.043	202.00
Radionuclides/DOE facilities	1984 R	EPA	4.3 in 10^6	0.001	210.00
Radionuclides/elem. phosphorous	1984 R	EPA	1.4 in 10^5	0.046	270.00
Benzene/ethylbenzenol styrene	1984 R	EPA	2.0 in 10^6	0.006	483.00
Arsenic/low-arsenic copper	1986 R	EPA	2.6 in 10^4	0.090	764.W
Benzene/maleic anhydride	1984 R	EPA	1.1 in 1d	0.029	820.00
Land disposal	1988 F	EPA	2.3 ill 10^8	2.520	3.5W.W
EDB	1989 R	OSHA-H	2.5 In 10^4	0.002	15.6W.W
Formaldehyde	1987 F	OSHA-H	6.8 in 10^7	0.010	72,W0.W

[a] Annual deaths per exposed population. An exposed population of 10^3 is 1,000, 10^4 is 10,000, etc.
[b] F, P, or R = Final, proposed, or rejected rule.

Source: John F. Morrall 111 (1986), p. 30. These statistics were updated by John F. Morrall III via unpublished communication with the author, July 10, 1990.

OSHA arsenic regulations save lives at a cost of $92.5 million per life, that such efforts are out of line with what the beneficiaries of such an effort believe the value of such a regulation to be. Moreover, there are likely to be a wide range of other regulatory alternatives by OSHA or other agencies that are likely to be more cost-effective ways of saving lives.

Although the range in the value-of-lib estimates for the policies summa&d in Table 20.4 may seem to be substantial, in practice many government policies are proposed but not issued because the value of life is even higher than many of the outliers in this table. For example, in 1984 EPA proposed regulations for benzene/maleic anhydride that would cost $820 million pet life saved. This regulation was rejected by the Office of Management and Budget as being too expensive. One of the all-time leaders in terms of the cost pet life saved is a proposed OSHA regulation of formaldehyde exposures, which would have required an expenditure of $72 billion per expected life saved. Calculating the costs, benefits, and appropriate reference values for the value of life often highlights gross policy distortions such as this.

Survey Approaches to Valuing Policy Effects

Thcrc are many circumstances in which we do not have readily available market data that can be used to estimate either implicit or explicit prices. How much, for example, is it worth to prevent genetic damage or to reduce the risk of the greenhouse effect?

In the absence of existing data on these issues, an approach that has been used In the benefit-valuation literature for several decades has been to run a survey in which individuals are polled with respect to these values. This approach is now the dominant methodology for assessing environmental benefits because of the paucity of good data on explicit or implicit environmental transactions.

The actual procedures that have evolved for doing so in effect attempt to replicate the hedonic market estimate approach used to analyze wage-risk tradeoffs and similar factors using survey data. For example, such studies would not ask people how much they valued a job injury, but would instead ask how much wage compensation they would require to face extra risk. Similarly, assessment of an environmental amenity would focus on purchasing a reduction in certain risks in the environment rather than certain outcomes. The term contingent u&ration has been used to describe such studies because they represent values that are contingent on a hypothetical market existing." Thus they

represent a hybrid between the initial survey approaches used in the literature and the market-based valuation econometric studies that began in the 1970s.

The objective is to elicit benefit values by constructing survey questions concerning hypothetical situations. There are a variety of ways in which one could pose the valuation question. In each case one must first give individuals information regarding the risk or other outcome to be valued. The first approach would be to ask individuals how much that particular benefit would be worth to them. This is a one-step procedure. The second approach would be an iterative one in which the individual first answered the open-ended question, and then was asked whether he or she would be willing to pay a small amount more than the initial response. A third variant on this technique is that instead of asking open-ended questions, individuals could be given a series of bids, and they would then have to determine how high or low they would go. These bids could be given in either ascending or descending order. In the ascending case, an individual might first be asked whether he or she would be willing to pay $1 for improved air quality, and if the answer is yes, the respondent would be asked if he or she would be willing to pay $2 for improved air quality, and so on, until the individual is not willing to increase the 'bid. A fourth approach is to utilize paired comparisons in which an individual is given an alternative product or other binary choices to make. Using interactive computer programs, one can then give an individual a succession of options to pick from to locate the point of indifference.

All of these variations in terms of the methodology arc largely ones of process rather than economic content. The underlying issue is how we can best frame the survey questions to elicit the true underlying economic values that individuals have. In the case of market outcomes we know from revealed preference that these values will be expressed in individual decisions, but in the case of surveys the values that we elicit may be sensitive to the manner in which we attempt to determine individual preferences.

More generally, considerable care must be exercised in the design of such survey studies so that they will give us reliable results. Often such studies rely on "convenience samples" such as groups of students, but our ultimate objective is to ascertain the willingness-to-pay of actual beneficiaries of the project, not the willingness-to-pay of students in the class whose responses may be biased in part by substantial demand effects (they may give the answers that they expect their professor wants to see). Perhaps the major guidelines in assessing these studies is to de-termine the extent to which they replicate market processes in a meaningful manner.

When interview studies first became used in the literature, economists feared that there would be a major problem in individuals' misrepresenting their true values for strategic reasons. Advocates of pollution control efforts, for example, might give responses that indicate enormous willingness-to-pay amounts, knowing that they will not be taxed on the basis of their response and hoping that a high response will tilt the policy in their favor.

In practice, the strategic issue has not been a major problem with the survey studies. A more fundamental difficulty is that some individuals often may not give thoughtful or meaningful responses to the question, inasmuch as it does not involve a decision that they actually make. Moreover, because many of the decisions involve risks, some of which are at very low probabilities, the results will not reflect their underlying values but instead will be contaminated by whatever irrationalities influence one's decisions involving low-probability events.

Valuation of Air Quality

The nature of the performance of the survey approach varies from study to study, but some suggestions as to its likely precision are given by a recent study of air pollution valuation.[12] Two approaches were used to value air quality. In the first, a hedonic rent-gradient equation for the Los Angeles area was estimated, analyzing the relationship of home sale prices to a variety of factors likely to influence house price (such as house age, area, school quality, public safety, and distance to the beach). In addition, this equation included measures of pollution in the Los Angeles area, including either total suspended particulates or NO_2 concentration levels. The authors found substantial housing price effects of pollution; controlling fur other aspects of the housing market, higher pollution levels lowered the price of the house.

A survey approach was also used lo assess the amount the individuals would be willing to pay in terms of a higher utility bill to achieve cleaner air. The expressed willingness to pay for different levels of air quality was roughly one-third of the market-based estimates. These results suggest that at least in this case overstatement of valuations in surveys may not be a problem, although fhis conclusion may not be true more generally. In addition, there may not be an exact correspondence between survey valuation estimates and market estimates. Comparisons that have been done for worker-wage equations have yielded more comparable results to those obtained with market data, but in the job risk case one is dealing with a risk that is currently traded in a market

and which individuals may have already thought about in this context, increasing the accuracy of the survey responses.

Exploratory Nature of the Survey Approach

Overall, survey approaches to establishing the benefits of social regulation represent an important complement to analyses using market data. This methodology should still be regarded as exploratory, however. Moreover, there will never be any general conclusions regarding the accuracy of such studies, because accuracy will vary from study to study depending on the extent to which a realistic market context was created and the degree to which the individuals running the survey motivated the survey participants to give thoughtful and honest answers.

Sensitivity Analysis and Cost Effectiveness

in the usual situation it will not be feasible to place dollar values on all outcomes of interest. In such circumstances one could wndcrtake cost-effectiveness analysis to analyze the cost per unit outcome achieved, and indices such as this may often be instructive.

in addition, if there are multiple outcomes that one would wish to value bwt cannot, one can perform a sensitivity analysis assigning different relative weights to them to convert all of them into a common cost-effectiveness index. Table 20.5 summarizes calculations of this type for the OSHA hazard communication regulation. The three health outcomes involved are lost workday job injuries, disabling illnesses, and cases of cancer. Suppose that, based on past studies on the relative valuation of cancer, we know that lost-workday job injuries have $1/20$ of the value of a case of cancer. In addition, suppose that the main uncertainty is with respeet to the value of disabling illnesses, where our task is to assess how severe this outcome is compared with injuries and cancer. The

Table 20.5
Cost-Effectiveness Measures for Hazard Communication Standard

	Lost Workday Equivalents	
	Weight — 1,1,20* Cost Effectiveness	Weights — 1,5,20* Cost Effectiveness
Net discounted costs less monetized benefits	52.632×10^9	2.632×10^9
Total lost workday equivalents (discounted)	9.5×10^4	24.7×10^4
Net discounted cost/lost workday equivalent	$27,900	$10,700

· These are the relative weights placed on lost workday cases (always 1), disabling illnesses (1 or 5), and cancers (always 20) in constructing a measure of lost workday equivalents.

calculations in this table explore two different sets of weights, one in which lost-workday injuries and disabling illnesses are given the same weight, and a second in which disabling illnesses are viewed as being five times more severe than lost workday cases.

The first row of Table 20.5 gives the net discounted costs less benefits of other kinds from the project, which total $2.6 billion. The second row gives the discounted (at 5 percent) number of lost workday injury equivalents prevented, where these lost workday equivalents have been calculated using the two sets of weights indicated above. Finally, the third row of the table gives the net discounted cost per lost workday equivalent prevented. These estimates are in the range of $10,000–$30,000, which is in line with the general estimates of implicit values of nonfatal injuries that have been obtained in labor market studies.

The approach used here is to establish one class of outcomes as the unit of metric and to put the other outcomes in terms of them when calculating a cost-effectiveness index that can capture all of the diverse impacts of a particular effort. In this case the metric is that of lost workday equivalents, but in other situalionn the metric may be death equivalents prevented or number of birth defects prevented.

Risk-Risk Analysis

In the absence of a benefit-cost for risk or environmental regulations, agencies will not be constrained regarding the stringency of these efforts. Because of the restrictive legislative mandates that these agencies have that often require that they reduce risk irrespective of cost, the result is that many regulations that are promulgated generate considerable costs, sometimes as high as $100 million per statistical life saved or more. Other than wasting societal resources, is there any harm from such profligacy?

Two classes of costs can be identified, where these come under the general heading risk-risk analysis. First, there is a direct risk-risk trade-off arising from regulatory efforts. An automobile recall, for example, may require that consumers drive their cars back to the dealer for the repair. Because all motor vehicle traffic is hazardous, requiring that people undertake extra driving will expose them to additional risk which may be more hazardous than the defect being repaired, if it is minor." In addition, risk regulations stimulate economic activity, such as manufacturing efforts to produce pollution-control equipment or construction efforts to carry away the waste at a Superfund site. All economic activity is dangerows, leading to worker injuries and illnesses. In

many instances, roughly 4 percent of every dollar of production in industry is associated with the health and safety costs of that production. Regulations that stimulate substantial economic efforts to meet the regulatory objectives will necessarily create risks in the process of stimulating economic activity. Even if for some reason the regulatory agency chooses to ignore the dollar costs a comprehensive tally of the risk consequences of the effort may suggest that it is counterproductive.

The newest form of risk-risk analysis that has emerged has drawn on the negative relationship between individual income and mortality. Regulatory expenditures represent a real opportunity cost to society as they take away resources from other uses, such as health care, that might enhance individual well-being. As a result, there is a mortality cost associated with these regulatory efforts. The U.S. Office of Management & Budget raised this issue with OSHA, suggesting that some of the more expensive OSHA regulations may in fact do more harm than good through these mortality effects.

Although the theoretical relationships are not controversial, the exact value of the regulatory expenditure that will lead to a statistical death remains a matter of debate. One approach has been to examine studies that directly link changes in individual income with mortality, where many of these estimates suggest that a statistical life may be lost for an income decrease on the order of $10 million to $15 million.[14] Another approach is to establish a formal theoretical link between the value of life from the standpoint of saving statistical lives and the amount of money spent by the government that will lead to the loss of a statistical life through its effect in making society poorer." This approach leads to a value of $50 million in government expenditures, which will lead to the loss of a statistical life.

This literature is still in its early stages. However, the general principle suggests that regulatory agencies should be cognizant of the harm that is done when they fail to take costs into account. Economists concerned with cost is not a professional bias, but ultimately has a link to individual welfare. These links in turn involve our health and are just as real as the concerns that motivate the government regulations.

Establishing Prices for Health, Safety, ad Environmental Regulation

Perhaps the most difficult policy issues arising in the social-regulation area will always stem from the setting of appropriate prices for the outcomes achieved. Because social-regulation efforts deal in large part with outcomes that are not the result of explicit market transactions, there will always be a need to establish the value of these efforts.

As a society we cannot allocate unlimited resources to any particular area of concern, however important it may seem. Because additional gains to health, safety, and the environment come at a diminishing rate for additional expenditures of money, we would quickly exhaust our resources long before we ran out of opportunities for spending.

As the discussion in this chapter indicated, the general economic approach to formulating a benefit assessment is not particularly controversial, but the empirical methodologies for establishing such values are still in their development stage. The greatest difficulties are encountered in situations where there are not even implicit markets that one could use as reference points for establishing appropriate risk-dollar tradeoffs.

As the discussion in subsequent chapters will indicate, in many instances the absence of a specific empirical estimate for the benefit value is not the most pressing policy problem. Rather, there is a more fundamental difficulty in that the importance of making tradeoffs at all has not even been recognized. In these cases, substantial gains could be made by noting that we are not in an unconstrained situation and that there must be some balancing among the competing objectives.

Questions and Problems

1. This chapter's discussion of the value of life has focused on estimates from the labor market. Economists have also estimated risk-dollar tradeoffs based on price data for risky products. Smoke detector purchases, differences in riskiness of cars. and seatbelt use decisions are among the contexts that have been considered. Can you think of any other market situations in which, if you had perfect data, it would be possible to infer an implicit risk-dollar tradeoff?

2. Environmental damage resulting from oil spills, such as that inflicted by the *Exxon Valdez*, is subject to quite specific environmental penalties. In particular, the companies responsible for the damage are required to pay an amount sufficient to compensate society for the environmental loss that has occurred. In economic terms, this compensation must be sufficient to put society at the same level of utility we would have had if it had not been for the accident. Can you think of methodological approaches for determining the appropriate compensation amount for oil spills such as the *Exxon Valdez*, which led to the death of thousands of fish and birds as well as oil residues on thousands of miles of Alaskan beaches?

3. Would you use the same value of life to assess the regulatory benefits in situations in which risks are incurred voluntarily, as apposed to situations in which they are incurred involuntarily? For example, would you treat smoking-risk regulation policies and nuclear hazard-risk regulation policies the same from the standpoint of benefit assessment?

4. Suppose we were faced with two policy alternatives. Under one alternative we will be saving identified lives, in particular Kip, John, and Joe. Under a

second policy option, we know that we will be saving three lives at random from the population, but we do not know whose lives they will be. Should we attach the same benefit value to each of these instances?

A variant on question 4 pertains to the girl trapped in a well. It has often been observed that society is often willing to spend almost unlimited resources to save identified lives. On the other hand, we seem to be wilting to spend little on saving statistical lives. Does this inconsistency mean that we are spending too much to save the identified lives, too little on the statistical lives, or is it that we cannot tell?

Suppose there are two policy options. Policy t affects a population of 10,000, of whom 100 will die, so that the risk of death per person is 1/100. The second policy wilt likewise save 100 individuals, but from a population of t million, so that the individual risk is 1/10,000. From the standpoint of regulatory policy, should we exhibit any preference for one policy over the other?

One mechanism for obtaining contingent valuation bids is to ask the respondent how much he is witting to pay for some outcome and then to ask if the respondent would be wilting to pay, for example, 10 percent more. This process continues until the respondent is no longer willing to increase his bid. Some researchers have argued that this approach will lead to a bias in terms of eliciting the true response. What direction do you believe the bias is, and why do you believe such a bias would occur?

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Notes

1. This general approach to valuation of risks to life can be traced back to the work of Thomas Schelling, "The Life You Save May Be Your Own," in S. Chase (ed.), Problems in Public Expenditure Analysis (Washington, D.C.: Brookings institution, 1968), pp. 129-62.

2. This principle is the same as in all benefit contexts. See Edith Stokey and Richard J. Zeckhauser, A Primer for Policy Analysis (New York: W. W. Norton, 1978).

3. Variations in the human capital approach are articulated in E. J. Mishan, "Evaluation of Life and Limb: A Theoretical Approach," Journal of Political Economy 99 (1971): 706-38.

4. The debate over the hazard communication regulation and over the value of life itself was the object of the cover story in The Washington Post Magazine, June 9.1985, pp. 10-13, 36-41.

5. The role of these income effects is explored in W. Kip Viscusi and William N. Evans, "Utility Functions That Depend on Health Status: Estimates and Economic Implications," American Economic Review 80, No. 3 (1990): 353-74.

6. This relationship is documented in Joni Hersch and W. Kip Viscusi, "Cigarette Smoking, Seatbelt Use, and Differences in Wage-Risk Trade&I&" Journal of Human Resources 25, No. 2 (1990): 202-27. The role of smoking behavior is also explored in Victor R. Fuchs, The Health Economy (Cambridge, Mass.: Harvard University Press, 1986).

7. For further elaboration on these market processes and the econometric basis for estimation of the value of life, see Sherwin Rosen, "The Theory of Equalizing Differences," in 0. Ashenfelter and Richard Layard (eds.), Handbook of Labor Economics (Amsterdam: North Holland, 1986), pp. 641-92. Also see, among others, Richard Thaler and Sherwin Rosen, "The Value of Saving a Life: Evidence from the Labor Market," in Nestor E. Terleckyj (ed.), Household Production and Consumption (Cambridge: National Bureau of Economic Research, 1976); Robert S. Smith, "Compensating Differentials and Public Policy: A Review," industrial and Labor Relations Review 32 (1979): 339-52; and W. Kip Viscusi, Employment Hazards: An Investigation of Market Performance (Cambridge, Mass.: Harvard University Press, 1979).

8. A more comprehensive review of the literature is provided in W. Kip Viscusi, Fatal Tradeoffs (New York: Oxford University Press, 1992).

9. For elaboration on the methodology underlying this estimation procedure, see in particular Rosen, 1986.

10. For a fuller description of these issues see John F. Morrall, "A Review of the Record," Regulation, 1986: 30.

t1. For a survey of this literature, see R. Cummings, D. Brookshire, and W. Schulze, Valuing Environmental Goods: An Assessment of the Contingent Valuation Method (Totowa, N.J.: Rowman and Allankeld, 1986).

t2. D. Brookshire, M. Thayer, W. Schulze, and R. d'Arge, "Valuing Public Goods: A Comparison of Survey and Hedonic Approaches," American Economic Review 72 (1982): 165-99.

t3. For a general discussion of risk-risk analysis issues such as these, see Lester Lave, The Strategy of Social Regulation: Decision Frameworks for Policy (Washington, D.C.: Brookings Institution, 1981).

14. See, for example, Randall Lutter and John F. Morrall III, "Health-Health Analysis: A New Way to Evaluate Health and Safety Regulation," Journal of Risk and Uncertainty 8, 1 (1993): 43-66.

15. This approach is developed in W. Kip Viscusi, "Mortality Effects of Regulatory Costs and Policy Evaluation Criteria," Rand Journal of Economics 25, 1 (1994): 94-109.