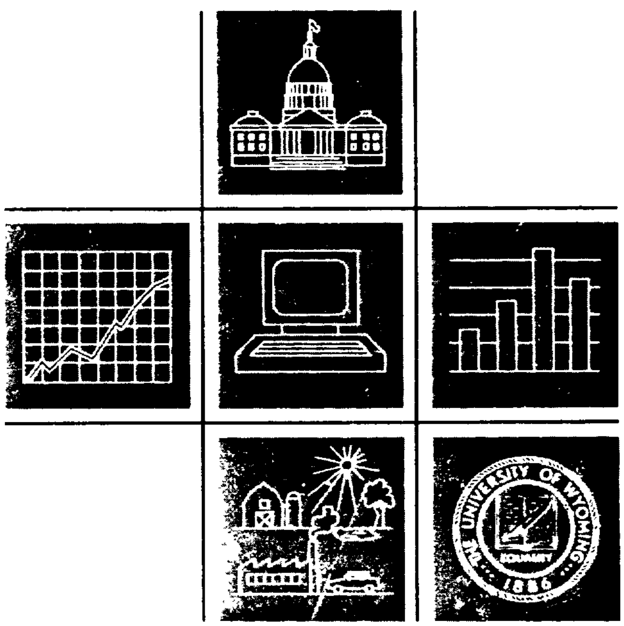
The Institute for Policy Research



...addressing public policy issues for the '80's.

Volume IV

Valuing Safety: Two Approaches

EPA-
November, 1985

EXPERIMENTAL METHODS FOR ASSESSING ENVIRONMENTAL BENEFITS

Volume IV

Valuing Safety: Two Approaches

by

Doug Gegax
Shelby Gerking
William D. Schulze
Donald Anderson

USEPA Contract #CR-811077-01-0

Project Officer

Dr. Alan Carlin
Office of Policy Analysis
Office of Policy, Planning and Evaluation
U.S. Environmental Protection Agency
Washington, D.C. 20460

OFFICE OF POLICY ANALYSIS
OFFICE OF POLICY, PLANNING AND EVALUATION
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

DISCLAIMER

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

Valuing life is controversial and problematic. Much of the dispute concerning what role the economist should play in this matter stems from our reluctance to trade dollars for lives. Death is certainly unique--the ultimate irreversibility. To put an objective value on the anxiety, grief, and mystery that surrounds it is obviously beyond the competence of the economist. But it is just this mystical characteristic of death that binds most people in one common desire: "We nearly all want all lives extended and are probably willing to pay for it."[1]

Viscusi (1978b) summarizes the controversial nature of "valuing life" as follows:

> Ignoring the issue of valuation of life and limb may circumvent the problem of offending people's sensitivities by making the trade-offs explicit. But at the same time it may be very costly in that it sacrifices lives that could have been improved or saved by a more systematic allocation process. An important issue for society as a whole, and one that many people are unwilling to face, is whether lives will be sacrificed in an effort to maintain the illusion that we will not trade off lives for dollars.

The idea of valuing life is more palatable when put in proper perspective. It is not the worth of a particular human being that is at issue, but the value of preventing a "statistical death." Relevant preferences to be taken into account are not those for avoiding certain death, but rather those for avoiding a small probability of death. For economic policy the question is then asked to what extent should resources be devoted to programs which reduce the probability of death from a specific cause within a specific group of people. In order to assess the benefits of such programs, policymakers are forced to place a value on an expected life saved. The concept of expectations removes the mysterious, personal nature of the problem. No one within a specific group expects to die, but each possesses an intuitive feeling towards the risks he faces, and it may be worthwhile to reduce such risks.

The "good" which is to be valued is safety and it comes in the form of a reduction in the risk of death. Many government programs have been implemented which attempt to reduce the risks we face. These efforts have led to safety regulations affecting nuclear reactors, automobiles, hazardous wastes, food additives, and the like. Such regulations decrease the health risks faced by individuals, and prove beneficial by making our lives safer. In order to weigh these benefits against the costs of regulation, a value must be placed on reducing risk. This area of concern is referred to as the economics of safety.

If we view the economics of safety as valuing reductions in risk, rather than measuring the worth of a particular individual, our aversion towards trading dollars for safety may be lessened. A certain reluctance, however, persists and this is better understood after reviewing early attempts at measuring the value of safety.

Early work by economists exclusively dealt with the problem of valuing safety by attempting to place a monetary value on human life. Such efforts gave economists a "bad name" since it is often felt that "if additional expenditures can save lives we will spare no expense in doing so."[2] This precept is plausible in the case of specific individuals. Understandably, parents of a young tumor victim would be upset with an economist's attempt at placing a value on having the tumor be benign.

Though possibly offensive to some, quantification of the value of a human life is not a new concept. Dublin and Lotka (1946) have traced this valuation attempt to ancient times in which the valuation of a slave's 1' "made possible the enduring monuments in stone raised by the Pharoahs."[3] Anglo-Saxon law required that a value be placed on every free man's life, called wergild, for establishing compensation in cases of homicide.[4]

The idea that one can place a dollar value on human life has outlived these early civilizations. It manifests itself today in the form of the so-called human-capital approach. This widely accepted procedure for imputing a price on an expected change in mortality, equates the value of a person's life to expected discounted future earnings. Thus, the cost of a death is the expected loss in earned income. Implicit in this method is the value judgment that an individual is "worth" what he contributes to GNP. Further, for earnings to reflect this "value added" it is assumed that wages are equated to marginal product.

Originally the human-capital procedure was used to estimate optimal levels of life insurance. Later, it was utilized as a means of measuring economic losses from accidents and illnesses. Out of the latter application, the human-capital approach emerged as a convenient way to measure the benefits from life-saving programs. Despite strong criticisms based both on ethical and economic theoretical grounds, this approach still remains popular for policy purposes because of its appealing actuarial properties.[5]

Ethical objections to the human-capital approach cut deeper than the common negative reaction to placing a monetary value on life. Even if such an evaluation were acceptable, the human-capital method would value a retired autoworker's life or that of someone's grandmother at zero since such individuals have no future or current earnings. Such an approach ignores an individual's personal desire to live, and disregards the value an individual would attach to the opportunity of living a longer life. This latter point is crucial. It is the crux of why the "human-capital" approach, in spite of the label, has never been a salient component of human-capital theory.[6]

The reluctance of human capital theorists to accept this approach is due to the lack of a conceptual link between an individual's future earnings and willingness to pay for increased life expectancy. Linnerooth (1979), in reviewing the value of life models, concludes that "... there are no theoretical grounds for establishing an empirically useful relationship between the value, in the form of the Hicksian compensating variations in wealth [i.e., willingness to pay], of current period changes in a person's risk of death and his lifetime earnings."[7] Mishan (1971) points out that,

> If the j^{th} pesson is made better off, a compensating variation (CV) measures the full extent of his improvement, this CV being the maximum sum V_j he will pay rather than forego the project,--the sum being prefixed with a positive sign.--If the j^{th} person is made worse off by the introduction of the project, his CV measures the full decline in welfare as a minimal sum V_j he will accept to put up with the project, this sum being prefixed with a negative sign. [If] the algebraic sum of all n individual CV's is positive - there is a potential pareto improvement, its positive value being interpreted as the excess benefits over costs arising from the introduction of the project. (p. 692)

If the human-capital approach bears no relationship to an individual's willingness to pay for a reduced risk of death, then for economic purposes it is a useless concept. On the other hand, a willingness to pay measure of the value of life is compatible with economic efficiency and is perhaps more ethically acceptable. As Schulze and Kneese (1981) point out, "the economist's notion that individuals do voluntarily trade off safety for monetary compensation in no way attempts to value life." Rather, a willingness to pay measure estimates the maximum amount individuals would voluntarily give up in wealth in order to reduce a small risk of death by a small amount. When aggregated across many people, this gives a marginal value of safety (MVS) for preventing a statistical death. MVS, therefore, does not attempt to establish a value on a particular human life, but instead measures the benefits of preventing a statistical death. In light of the ethical and economic advantages of using the willingness to pay notion, this research will adopt the MVS concept for evaluating the benefits of life-saving programs.

The idea that benefits from life-saving programs should be based on MVS was first noted by Mishan (1971) and Schelling (1968). It is currently the framework within which all the principal theoretical economic research into the "value of life" operates.[8] Research of this type attempts to derive a demand for safety. Since many types of safety are public in nature, justification for government regulation rests in the theory of public goods. Further, since this issue is probabilistic in nature, the theoretical underpinnings lie in the expected utility model.

With the adoption of MVS, the controversial nature clouding this area of economics has subsided.[9] Gone, however, is the straightforward calculus inherent in the human-capital approach, though there has been a recent attempt (Arthur, 1984) to develop a method for valuing lives that is based on welfare theory yet has the desirable actuarial properties of the human capital approach. MVS calculations are much more problematic. The purpose of this research is to isolate the major problems inherent in the MVS and add to the body of literature which addresses them.

Five major areas of concern are confronted in this research effort. They are: (1) alternative methods for obtaining MVS measures, (2) the problem of measuring risk, (3) the divergence between willingness to pay (WTP) and willingness to accept (WTA) measures, (4) the determinants of the demand for safety, and (5) the so-called failure of the expected utility model.

1.1 ALTERNATIVE METHODS FOR OBTAINING MVS MEASURES

There are three methods which have been commonly used to obtain an MVS measure: the hedonic price method (HPM), the direct cost method (DCM) and the contingent valuation method (CVM). The HPM involves regressing the wage rate of a particular job on a vector of worker and job characteristics. Included in the latter is the job-related risk of death. The coefficient on risk is interpreted as a market risk premium and from this an MVS measure is obtained. The DCM, on the other hand, is based on examining the consumption and use of safety items such as smoke alarms and seat belts. The CVM utilizes surveys which ask the respondent directly his willingness to pay for a reduction in risk contingent on the existence of such a market for risk.

In the safety literature, estimates of the value of life based on all three methods have been compared (Blomquist, 1982). However, to date no study has based these comparisons on the same sample. Making such a comparison between the HPM and CVM is a major purpose of this report.

1.2 THE PROBLEM OF MEASURING RISK

As will be shown, risk measures generally used in MVS studies are suspect. Hedonic studies, in particular, purport to be measuring actual levels of job-related risks. Due to data limitations, however, such a goal is not realized. Further, even if such a measure existed, individuals accept risk on the basis of their perceptions (i.e., "perceived risk"). If we accept the proposition that the worth of safety programs, indeed any economic good, should be based on subjective preferences, then perceived risk is the ideal measure.

The psychological literature reveals that individuals have problems perceiving actual risk, yet MVS studies typically assume that people correctly calculate actual probabilities of death. This explains the persistent use of "actual risk" measures in these studies.

1.3 DIVERGENCIES BETWEEN WTP AND WTA

Willig (1976) makes the theoretical case that WTP and WTA measures should be similar. Empiric studies, however, have revealed the two to be significantly different.[10] This difference has not been adequately explained in the literature. In the area of safety, two possible explanations for these discrepancies are offered: (1) individuals behave differently towards gains in wealth than they do towards losses, and (2) individuals value voluntary and involuntary types of risk differently.

1.4 THE DETERMINANTS OF THE DEMAND FOR SAFETY

The amount an individual is willing to pay for reductions in risk depends on such characteristics as age, sex, relative levels of risk aversion, initial levels of risk, and income endowments. Since these characteristics vary across members of the population, one would expect their marginal values for safety to differ; therefore, it would not be of much use to derive a single number for the value of an expected life saved. Rather, it would be more useful to isolate the group that is to be affected, characterize that group's socio-economic make up and, after estimating how MVS varies with these characteristics, determine which MVS measure(s) is(are) appropriate. In light of this, MVS schedules may be more useful than trying to estimate a single elusive number.

1.5 FAILURE OF THE EXPECTED UTILITY MODEL

Schoemaker (1982) suggests that, for small probabilities of catastrophic events, the expected utility model (EU) fails as a device for describing or predicting human behavior. The p psychological literature has also attacked the assumptions underlying EU.[11] Yet, more recent studies have shown EU to work well.[12] Since MVS is built on the expected utility framework, these concerns require discussion.

In Chapter 2, these five issues are discussed in detail along with other relevant topics from the safety literature. Chapter 3 develops an intertemporal expected utility model of career choices where different jobs are characterized by their levels of risk. In this model, an MVS measure is obtained and a hypothesis that the market does not correctly compensate individuals for the risk they face on the job is developed. Existence of such a "wedge" is tested by comparing CVM and hedonic MVS estimates of the MVS obtained from the same sample.

A survey was conducted for the purpose of collecting data on (1) individuals' perceptions of their job-related risks, (2) WTP and WTA measures for hypothetical changes in these risks, and (3) socio-economic characteristics for the purpose of estimating a hedonic wage equation. The survey methodology and sample design are discussed in Chapter 4. Finally, in Chapter 5, the results of this survey are reported, the aforementioned hypothesis is tested, and a direct comparison of the contingent valuation and hedonic methods is made.

REFERENCES

1. Schelling (1968) p. 129.

2. Viscusi (1978b) p. 379.

3. Dublin and Lotka (1946).

4. Pollock and Maitland (1968) p. 47.

5. Linnerooth (1979) pp. 52-3.

6. Viscusi (1978b) p. 361.

7. Linnerooth (1979) p. 71.

8. Viscusi (1978b) p. 361

9. It should be pointed out that the MVS measure still converts changes in risk of death into dollars. Although this procedure places a dollar value on a statistical life rather than a specific life, some may still have ethical problems with it.

10. Cummings, Brookshire and Schulze (1984) p. 42.

11. Kahneman and Tversky (1979).

12. Brookshire, Thayer, Tschirhart and Schulze (1985).

CHAPTER 2

MARGINAL VALUE OF SAFETY ESTIMATES: A SURVEY

Through the insight of economists such as Mishan (1971) economic theory now embraces the theoretically correct willingness-to-pay measure of the value of life. This approach is more ethically acceptable than the human capital approach because it values small reductions in the risk of death rather than attempting to put a value on an individual human life. The relative ease of human-capital calculations, however, has lead to a persistent use of this approach for policy purposes. As a result, there is continued public disdain aimed at economists because it is perceived that the worth of an individual life is the object of analysis. This perception, however, may lessen with the refinement of marginal value of safety (MVS) estimates of the "value of life."

2.1 THE THEORETICAL STRUCTURE OF MVS

In theory, the MVS idea is straightforward. For potential reductions in risk it is merely an individual's maximum willingness to give up wealth $\Delta WLTH$, for a small change in risk, $\Delta\pi$, holding the initial level of utility, $\bar{U}$, constant. In general we say that:

$$MVS = \left.\frac{\Delta WLTH}{\Delta\pi}\right|_{\bar{U}} \qquad (1)$$

when $\Delta\pi < 0$, $\Delta WLTH$ measures willingness to pay (WTP) and when $\Delta\pi > 0$, $\Delta WLTH$ measures willingness to accept (WTA). MVS, therefore, measures the slope of an individual's indifference curve in risk-income space, and is merely a Hicksian compensating variation.

To illustrate how MVS can be used as a measure of benefits from environmental safety programs, consider a program that is expected to decrease the deaths, from exposure to a certain toxin, in a community of 1,000,000 people from ten to five. If the program is implemented, therefore, the expected number of lives saved is five with each person's risk of dying decreasing from 10/1,000,000 to 5/1,000,000 or $\Delta\pi = 5 \times 10^{-6}$. Suppose that each individual in the community is willing to pay ten dollars for his personal reduction in risk. Appealing to equation (1) then,

$$MVS = \frac{\Delta WLTH}{\Delta\pi} = \frac{10}{5 \times 10^{-6}} = \$2{,}000{,}000.$$

In this hypothetical situation the value per expected life saved is $2 million. With the total expected lives saved being five, expected life-saving benefits from this program are $10 million.

When the element of risk is introduced, the individual faces a world of uncertain outcomes. In such a world where the possibility of death is probabilistic in nature, the "true" compensation variation is more correctly measured within the framework of an expected utility model. Jones-Lee (1974) provides a simple single-period expected utility model in which there are only two states of the world - "life" and "death". His model is as follows:

$$E(U) = (1 - \pi)U(WLTH) + \pi D(WLTH) \tag{2}$$

where π is the probability of death, U(WLTH) is utility as a function of wealth WLTH, conditional upon the occurrence of the "life" state, while D(WLTH) is utility conditional upon the occurrence of the "death" state. Both U'(WLTH) and D'(WLTH) refer to first derivatives and are positive. E(U) is a von Neumann/Morgenstern expected utility function. Provided that the individual obeys a set of reasonable axioms,[1] he will act as if (2) is maximized.

Utility in death is usually referred to as bequest value. As Jones-Lee notes, the function D(WLTH) "... is not meant to imply that the individual is able to bequeath all of WLTH to his heirs but signifies merely that the bequeathable sum is related to current wealth." Therefore, it is assumed that the individual receives some utility from the knowledge that a portion of his current wealth will be left to his heirs if he dies.

Jones-Lee derives a Hicksian compensating variation by assuming that the individual initially faces a probability $\bar{\pi}(0 < \bar{\pi} < 1)$ of death and has some level of wealth $\overline{WLTH}$ (>0). He then proposes that the individual has an opportunity to reduce $\bar{\pi}$ to $\tilde{\pi}(<\bar{\pi})$ by forfeiting a positive amount, V, of his wealth. The maximum value for V is such that:

$$(1 - \tilde{\pi})U(\overline{WLTH} - V) + \tilde{\pi}D(\overline{WLTH} - V) = (1 - \bar{\pi})U(\overline{WLTH}) + \bar{\pi}D(\overline{WLTH}). \tag{3}$$

Differentiating (3) yields

$$\frac{\partial V}{\partial \tilde{\pi}} = \frac{U - D}{(1 - \tilde{\pi})U' + \tilde{\pi}D'} \tag{4}$$

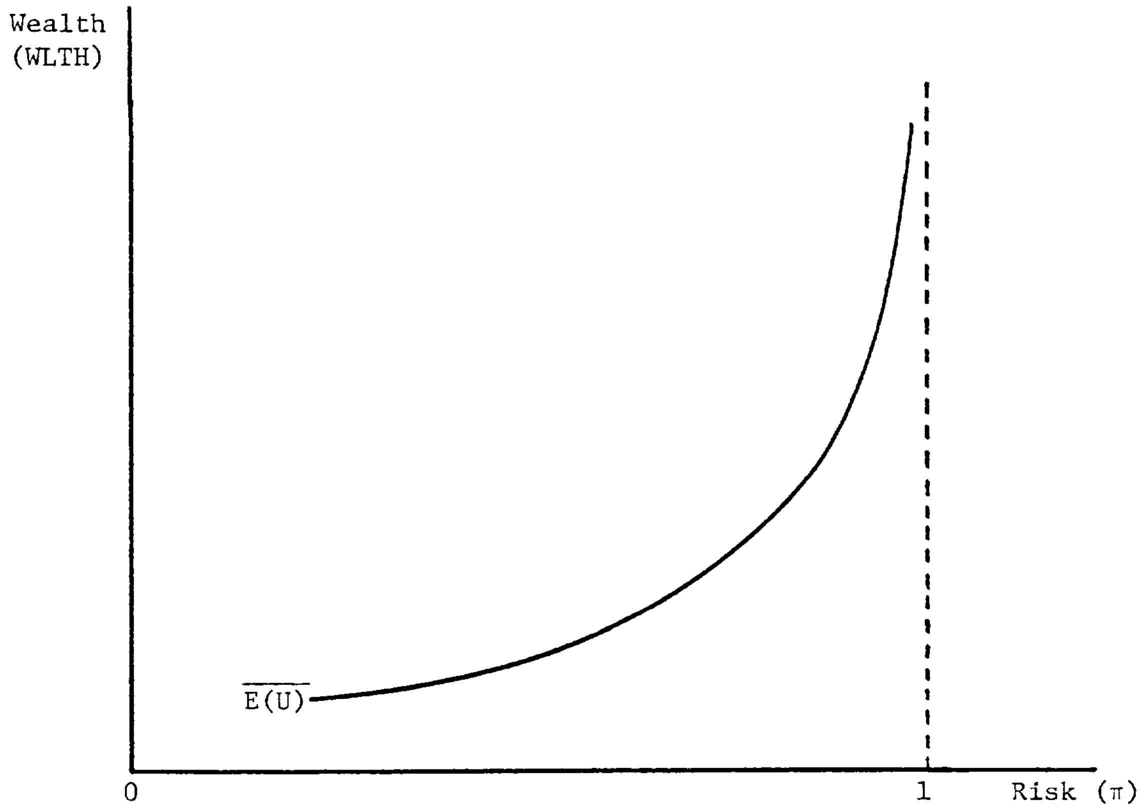
From equation (4) Jones-Lee concludes that: (1) the marginal value of a change in risk increases with both initial risk and initial wealth, (2) V is positive for values of $\tilde{\pi} < \bar{\pi}$ denoting the maximum WTP for reductions in risk, (increases in safety), and (3) V is negative for values of $\tilde{\pi} > \bar{\pi}$ denoting the minimum WTA for increases in risk (decreases in safety).

Jones-Lee's first point is perhaps clarified by deriving MVS in a slightly different manner. First, if we assume utility in death to be substantially small, relative to utility in life, as to be approximately zero, (2) simplifies to

$$E(U) = (1 - \pi)U(WLTH). \tag{5}$$

Totally differentiating (5) with respect to π and WLTH and holding E(U) constant yields:

Figure 2.1: Indifference Curve for Wealth and Risk



$$\left.\frac{dWLTH}{d\pi}\right|_{\overline{E(U)}} = \frac{U(WLTH)}{(1 - \pi)U'(WLTH)} = MVS. \qquad (6)$$

Note that for U"(WLTH) < 0, as π approaches one, or as WLTH approaches infinity, MVS approaches infinity. Again, (6) describes the slope of an individual's indifference curve when utility is uncertain and in the absence of a bequeathment motive. Figure 2.1 shows a graph of such a level of expected utility with expected utility levels increasing as we move upward and to the left.

Because MVS approaches infinity as IT approaches one, there is no compensation adequate for the individual to accept a probability of death equal to one. For small levels in risk, however, MVS is small. This is the situation facing individuals for most environmental safety programs; therefore, for most relevant economic analysis the extreme upper end of Figure 2.1 is meaningless.

Another important determinant of the MVS is an individual's level of risk aversion. Economists generally assume individuals exhibit risk-averse behavior.[2] If a certain outcome is preferred to a gamble with an equal or greater expected payoff, then a "risk-averse" choice is made. Bernoulli (1899) originally explained this by suggesting that individuals do not maximize expected wealth but rather maximize expected utility. A "risk-loving" individual also maximizes expected utility but does so by rejecting a certain outcome in favor of a gamble with an equal or lower expected payoff.

Both types of behavior are described in Figures 2.2.1 and 2.2.2. Consider three options: (A) a certain outcome, $WLTH_A$, of receiving $50, (B) a gamble whose expected outcome, $E(WLTH_B)$, is $60 (e.g., a gamble with a 60 percent chance of winning $100 and a 40 percent chance of winning nothing) and (C) a gamble whose expected outcome, $E(WLTH_C)$, is $40 (e.g., a gamble with a 40 percent chance of winning $100 and a 60 percent chance of winning nothing). Figure 2.2.1 shows a risk-averse individual described by the concave utility function ODE while Figure 2.2.2 shows a risk-loving individual described by the convex utility function OIH. Given a choice between options A or B, the risk-averse individual maximizes expected utility by choosing the certain outcome, A, even though gamble B affords a higher expected payoff.

On the other hand, given a choice between options A or C, the risk-loving individual maximizes expected utility by opting for gamble C, even though the certain outcome, A, affords a higher level of potential wealth.

To examine how preferences towards risk affect safety evaluations, let the function U(WLTH), in equation (5), take the specific form:

$$U(WLTH) = WLTH^{\eta}. \qquad (7)$$

The parameter η can be interpreted as a measure of the individual's attitude towards risk with $0 < \eta < 1$ implying risk aversion, $\eta = 1$ implying

Figure 2.2.1: Utility Function for a Risk Averse Individual

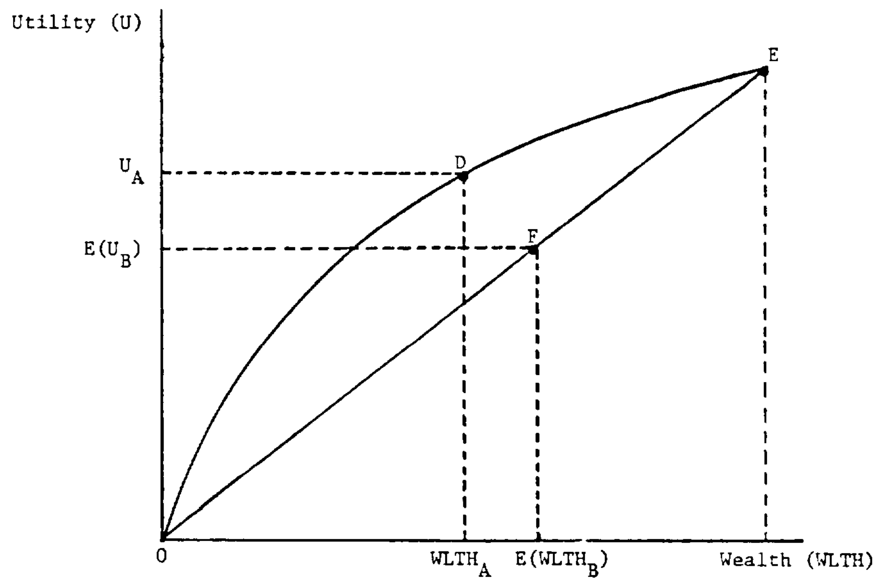
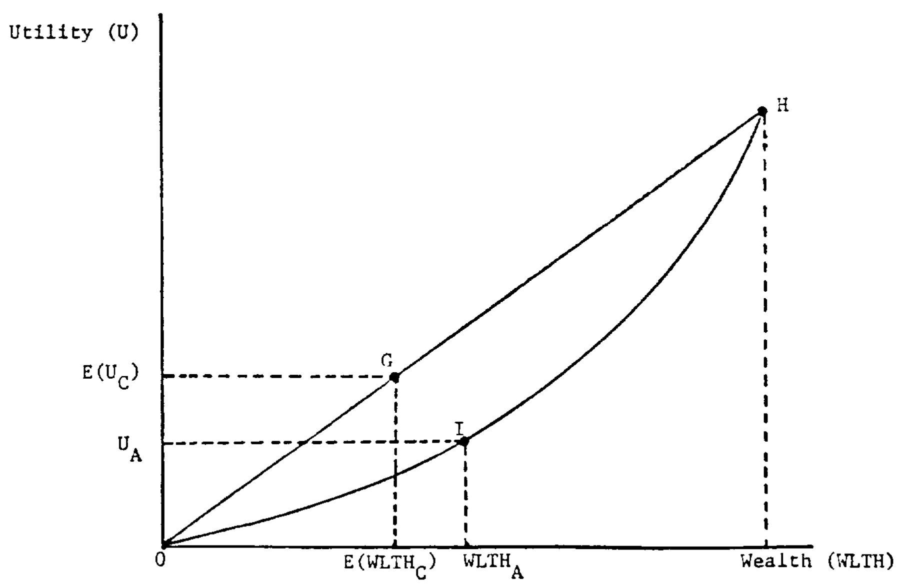


Figure 2.2.2: Utility Function for a Risk Loving Individual



risk neutrality, and $\eta > 1$ implying risk-loving behavior. The expression for MVS in equation (6) becomes

$$\frac{dWLTH}{d\pi}\Big|_{\overline{E(U)}} = \frac{WLTH}{\eta(1 - \pi)} = MVS \qquad (8)$$

and

$$\frac{d^2WLTH}{d\pi^2}\Big|_{\overline{E(U)}} = \frac{WLTH}{\eta(1 - \pi)^2} . \qquad (9)$$

Note first that for WLTH, η, $\pi > 0$ both (8) and (9) are strictly positive. Furthermore, as the individual becomes less risk averse (i.e. η increasing) MVS decreases for any level of wealth or risk.

Figure 2.3 shows the indifference curves of two different individuals individuals where $E(U)_1$ is a level of expected utility for a more risk averse individual while $E(U)_2$ describes an expected utility level for a less risk averse (or risk loving) individual. From equations (8) and (9) the following conclusions can be drawn: (1) the slope of an expected utility level curve is positive and convex to the origin, (2) the convexity of this curve is invariant to attitudes towards risk, and (3) as the individual becomes less risk averse (or more risk-loving) the expected utility level curves become more flat for a given level of wealth or risk.

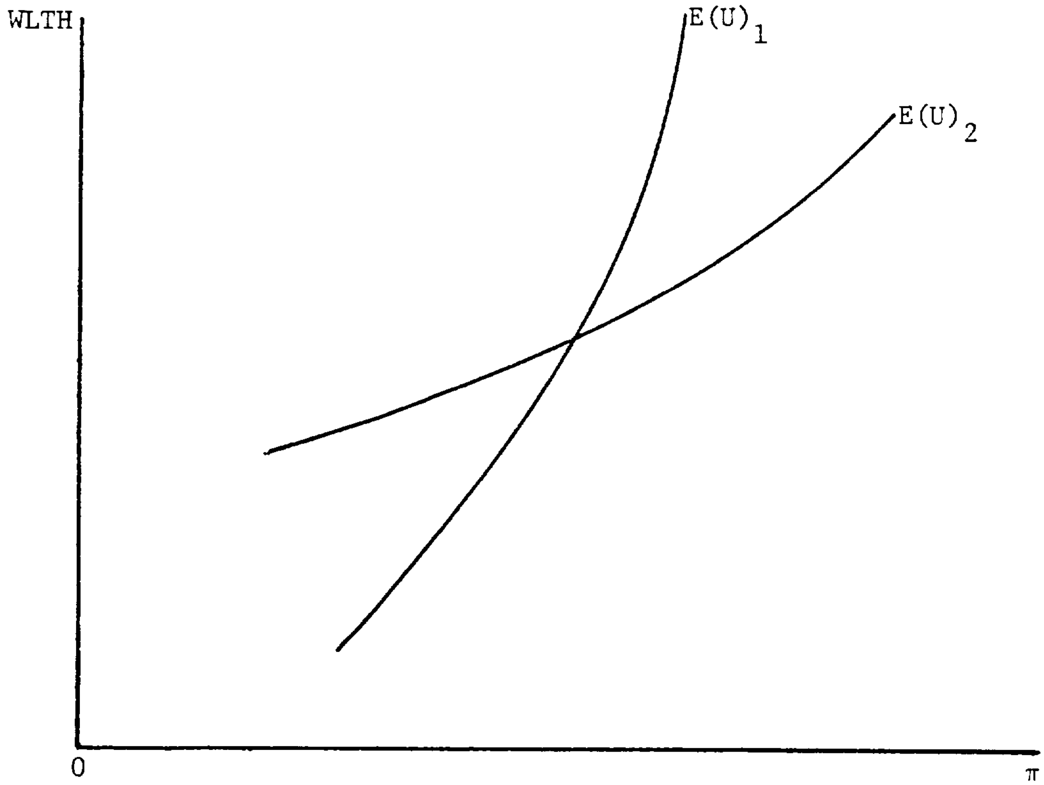
In summary, the basic theory behind an individual's willingness to pay for and marginal valuation of safety is a straightforward application of expected utility analysis. The process of obtaining information needed to measure an individual's MVS, however, is more problematic and involves different assumptions depending on the procedure used. In the next section, various methods for obtaining an MVS measure are discussed along with the theoretical assumptions of each and their empirical results found in the literature.

2.2 ALTERNATIVE METHODS FOR EVALUATING MVS

Studies which attempt to derive a MVS measure can be grouped into three major categories. First are the hedonic wage-risk studies which investigate tradeoffs in the labor market between job-related risks and wages. Contingent valuation studies, which directly ask individuals their willingness to pay for changes in safety, comprise the second category. The third group consists of consumer market studies that examine consumption and activity choices people make which affect their safety.

Rosen (1974) makes a strong case that it is difficult to infer risk valuation from consumption patterns. Such problems stem from deciding how preferences are split between the direct utility the activity renders and indirect longevity effects.[3] Due to these difficulties, few consumer market studies are found in the literature; therefore, this research will focus on the hedonic and contingent valuation methods. However, a couple examples of consumer market approaches are worth noting.

Figure 2.3: Indifference Curves for a Risk Averse and Risk Loving Individuals



Looking at the decision of an optimal highway speed, Ghosh et.al. (1975) attempted to measure MVS by looking at the trade off between saving time and the increased risk of a traffic fatality. In this study, the direct utility or (disutility) individuals derive from driving is ignored and is, therefore, an example of the problem Rosen eluded to above. Further, in assuming time saved is the only benefit received, the resulting MVS measures are perhaps lower bound estimates.[4]

Dardis (1980) utilized the price of smoke detectors as an MVS measure. While this may be correct for the marginal consumer, others would have been willing to pay an amount greater than the market price. This study, therefore, underestimates these non-marginal individuals' marginal values of safety.

Consumer market studies, in general, yield relatively low MVS estimates.[5] Violette and Chestnut (1983) attribute this to the apparent invalid assumptions made in these studies. This research will directly compare results obtained from using both the hedonic and contingent valuation methods; consequently, a detailed review of these two methods is warranted.

2.2.1. Hedonic Wage-Risk Studies: Hedonic Price Theory

Analyzing wage differentials across jobs with varying levels of risk is the primary method used for estimating safety valuations. Hedonic price theory forms the basis of these studies. According to this theory, market goods are described in terms of a vector of attributes, and a consumer's willingness to pay for a good is related to the sum of utilities he anticipates receiving from each of these characteristics. Hedonic price theory attempts to "impute" a price on these attributes for which there are no explicit markets.

Thaler and Rosen (1975) were the first to apply hedonic price theory to the labor market. In this situation, a worker is viewed as receiving a wage in exchange for supplying labor for a particular job represented by a set of job characteristics. Among these characteristics is the risk associated with working on the job.

While the market wage is represented by equilibrium between the supply and demand for the job in its entirety, an individual hedonic price measures the equilibrium premium a worker is to receive for a specific attribute of the job. The hedonic price for job-related risk is also based on both supply and demand factors.

On the supply side, it is hypothesized that workers will voluntarily accept a higher level of job-related risk for a higher wage. Demand is influenced by the fact that employers, faced with this positive relationship between wages and risk, have the option of making expenditures on safety equipment which decrease the level of job-related risk. As a result of job-safety improvement, workers will require a lower wage-risk premium. At the point where the marginal cost of safety improvements equals the marginal benefit of a reduced wage-risk premium, expenditures on safety equipment will cease. Hence, employers face a tradeoff between expenditures on wages and on safety equipment.

This trade-off faced by employers is described by an iso-profit curve in wage-risk space, while the trade off facing the worker is described by an indifference curve. Figure 2.4 shows these curves which are labeled ϕ and Θ respectively. In this figure, $W(\pi)$ denotes the market risk-related wage differential: also referred to as the hedonic wage-risk gradient. $W(\pi)$ describes a locus of tangencies between workers' indifference curves and employers' iso-profit contours and, therefore, corresponds to equality between a worker's marginal rate of substitution (between risk and wages) and an employer's marginal rate of technical substitution (described by the trade-off between expenditures on wages and safety improvements). The hedonic wage-risk gradient establishes the market equilibrium risk premium for various levels of risk.

There is an important point to note about $W(\pi)$. It cannot be used to estimate an individual's wage-risk indifference curve. Rather, by appealing to $W(\pi)$, only a specific point on the indifference curve associated with the market-clearing wage-risk level is known.[7] As such, hedonic wage-risk studies cannot directly estimate an individual's demand for safety.

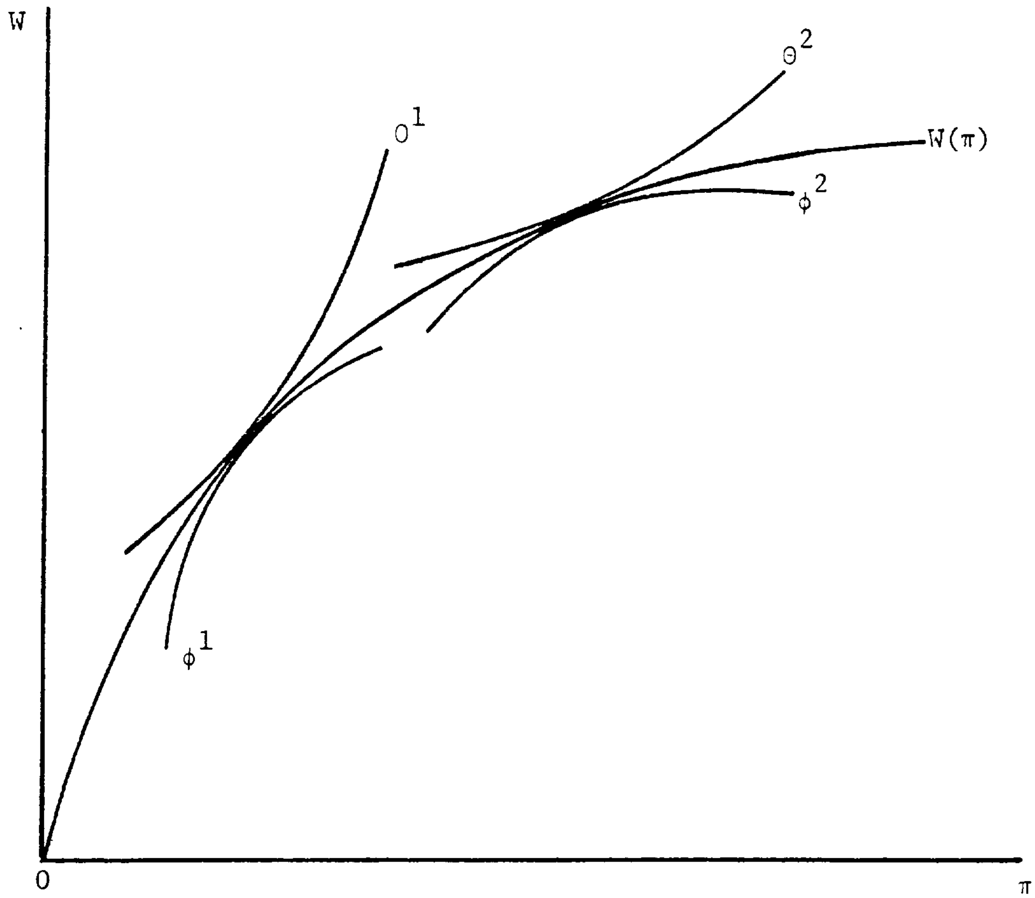
2.2.2 Hedonic Estimation Technique and Assumptions

According to hedonic wage-risk theory, market equilibrium occurs at a point of tangency along a worker's wage-risk indifference curve. Therefore, the rate at which the market compensates a worker for bearing job-related risk, described by the slope of $W(\pi)$, exactly equals his subjective MVS, as described by the slope of his indifference curve. If this theory holds, the technique for estimating an individual's MVS involves measuring how the labor market compensates workers for bearing risk.

Utilizing market data, wage-risk studies attempt to estimate $W(\pi)$ by regressing wage rates from various jobs on their associated job-characteristics. The coefficient on risk describes the rate at which the market compensates workers for taking on additional levels of risk. For a person's subjective MVS to be reflected by these market conditions, various important assumptions must be met. Especially enigmatic are the assumptions that: (1) the labor market operates freely and is in equilibrium and (2) workers know exactly how risky various potential jobs are.[8]

Violation of the first assumption will render MVS estimates which are biased.[9] An example of a market imperfection is labor unions. By using interaction terms between risk and union status, Olson (1981) found that union members receive higher wage-risk premiums than did non-union workers. Thus, the bargaining power of unions may push these premiums higher than would be expected under competitive conditions. An implication from Olson's analysis is that there may be two different markets at work--union and non union. Segmented markets are suggestive of barriers to entry since

Figure 2.4: Indifference and Isoprofit Curves



if labor was perfectly mobile across union and non-union markets, the difference in wage-risk premiums would disappear.

Another possible barrier to entry and exit emerges from the intertemporal expected utility model in Chapter 3. There it will be shown that the level of job-related risk a worker would optimally accept decreases through time; that is, individuals become more risk averse as they get older. The worker, however, cannot continually search for a lower risk job due to the transaction costs of re-locating and retaining: there are, in other words, barriers to exit. In this less than perfectly competitive situation it will be shown that hedonic wage-risk estimates of the MVS are biased downwards.

The assumption that workers can correctly calculate the actual risk level of potential jobs is necessary for observed (i.e. market) wage-risk premiums to reflect individuals' marginal values of safety.[10] Lichtenstein et al. (1978) show, however, that individuals reveal systematic errors in their perceptions of risk. If an individual's subjective MVS is based on perceived risk, utilizing actual risk measures (as is done in hedonic studies) amounts to an error in variables problem. MVS estimates from hedonic studies, therefore may, be inefficient and biased. The problem of measuring risk will be explained further in Section 2.3. The point here is that the assumption that perceptions of risk are identical to actual risk levels is, at best, extremely suspect.

2.2.3 Contingent Valuation Studies

Contingent valuation has been used to value a range of public and private goods. In valuing goods for which market prices are unavailable, prices must be imputed in order to measure the benefits these goods provide. In the previous section, it was shown that hedonic price theory, by imputing a price for individual characteristics of a good, attempts to place a value on specific attributes for which there is no explicit market. The contingent valuation method (CVM) is another approach to this problem.

The CVM utilizes surveys. For safety valuation, respondents are directly asked their willingness to pay (i.e., their "bids") for hypothetical reductions in risk, contingent on the existence of a market for safety. Randall et al. (1983) add that:

> contingent valuation devices involve asking individuals in survey or experimental settings, to reveal their personal valuations of increments (or decrements) in unpriced goods by using contingent markets... contingent markets elicit contingent choices.

By directly asking an individual's willingness to pay, the CVM elicits the tradeoffs he is willing to make between income and risk reduction. We observe individuals making these tradeoffs every day and it is "the challenge of the survey approaches . . . to elicit accurately the valuations on safety that are behind these kind of choices."[11]

Through the use of surveys, the CVM has the advantages of direct data collection and flexibility. For example, it was shown above that in order for hedonic techniques to yield true subjective evaluations, it must be assumed that people accurately perceive probabilities of injury or death. The CVM can be structured in such a way as to utilize subjective risk measures and thereby directly elicit the respondent's personal MVS. Therefore, the stringent assumptions required by the hedonic method are not necessary for contingent valuation studies. Considering the aforementioned psychological research that has been conducted on risk perceptions, use of methods may be the only viable approach for safety valuation. This point was made early on by Mishan (1971). He notes that:

> ...one can observe the quantities [people] choose, at least collectively, whereas one cannot generally observe their subjective valuations. In the circumstances, economists seriously concerned with coming to grips with the magnitudes may have to brave the disdain of their colleagues and consider the possibility that data yielded by surveys based on the questionnaire method are better than none... In the last resort, one could invoke contingency calculations.

If the CVM affords the economist the opportunity to directly obtain subjective evaluations, where does the "disdain" towards surveys stem from? Psychological research generally supports the hypothesis that surveys which attempt to elicit opinions or attitudes do poorly in predicting behavior. This criticism, however, cannot necessarily be directed at the CVM since respondents are not asked for their opinions but rather their contingent valuation.[12] However, as Cummings, Brookshire, and Schulze (1984) point out, "a large part of the criticisms of the CVM in terms of reliability or accuracy arise from the hypothetical nature of the CVM."

Many economists (e.g. Schelling, 1968; Viscusi, 1978b; Feenburg and Mills, 1980) feel that since the CVM asks hypothetical questions, respondents have no incentive to tell the truth; that is, responses obtained from a survey will be biased from an individual's "true" willingness to pay. Freeman (1979) explains the source of "hypothetical bias" to be as follows:

> In the real world, an individual who takes an action inconsistent with his basic preference, perhaps by mistake, incurs a cost or a loss of utility. In the [CVM]... there is no cost to being wrong, and therefore, no incentive to undertake the mental effort to be accurate.

Ask a hypothetical question, it is felt, and you get a hypothetical answer.[13]

A second form of bias in the CVM is referred to as strategic bias. Rowe et al. (1980) defines strategic bias as "an attempt by any individual to influence the outcome or results by not revealing a true evaluation." If the respondent believes that the results of the survey will affect government policy, such an incentive could be strong. Empirical evidence on strategic bias suggests, however, that the hypothetical nature of surveys can alleviate incentives for strategic behavior.[14] Cummings, Brookshire, and Schulze are quick to point out that this places the researcher in a "potential dilemma: The more hypothetical the question, the less the incentive for strategic behavior but, also, the less the incentive for accurate responses."

There is yet another type of dilemma inherent in the CVM. Since contingent valuation techniques involve setting up a hypothetical market it is imperative that the survey design include relevant information regarding that "market." However, as Fischhoff et al. (1982) point out, the experimental setting is an important determinant of the survey results. To quote Fischhoff et al.:

> The fact that one has a question is no guarantee that others have answers, or even that they have devoted any prior thought to the matter. When one must have an answer . . . there may be no substitute for an elicitation procedure that educates respondents about how they might look at the question. The possibilities for manipulation in such interviews are obvious. However, one cannot claim to be serving respondents' best interests by asking a question that only touches on one facet of a complex and incompletely formulated set of views.

Economists have discovered "information bias" to be both troublesome and difficult to define. A broad definition of information bias is given by Rowe et al. (1980) as "[a] potential set of biases induced by the test instrument, interviewee, or process, and their effects on the individual's responses." Potential sources of information bias include: (1) the vehicle to be used for collecting the bids, (2) the order in which the information is given, and (3) what information is given to the respondent. Economists (e.g., Rowe et al., 1980; Brookshire et al., 1981; Cronin, 1982) as well as psychologists (e.g., Lichtenstein et al., 1978; Fischhoff and MacGregor, 1980; Fischhoff et al., 1982) have found these sources of information bias to be present in survey methods.

While it is not the purpose of this research to resolve these problems of the CVM, they should be pointed out. Cummings et al., however, conclude that "there is reasonably compelling evidence that suggests the possibility of resolving most of the above-mentioned issues . . . by thoughtful design of the CVM." In other words, ask a well constructed hypothetical question and people will try to give an honest answer.[15]

To summarize, the advantages of the CVM over the hedonic technique include: (1) the ability to directly obtain safety valuations without requiring individuals to correctly calculate probabilities of death or injury, (2) the flexibility of direct data collection, and (3) the lack of stringent theoretical assumptions. The disadvantages of the CVM stem from the problem of designing a survey which minimizes the hypothetical and information biases inherent in survey techniques.

2.2.4 Empirical Results Obtained from the Hedonic and CVM

Depending on the assumptions, procedures and data used, empirical estimates of the value of an expected life saved vary greatly from study to study. Estimates from hedonic methods range from $400,000 to $7.5 million while those from contingent valuation studies vary from $17,000 to $325 million.[16] An excellent summary of studies utilizing both the hedonic technique and the CVM is given by Violette and Chestnut (1983). While it would be redundant to reproduce their summary, a few major points will be made.

First, the hedonic wage-risk studies make inferences about safety valuation based on estimates of how the market compensates individuals for accepting job-related risk. These studies are based on the assumptions mentioned above and each study attempts to collect data on actual levels of job-related risk. Differences in MVS estimates from hedonic studies primarily stem from the various ways the risk data are obtained and the type of workers emphasized.

Most hedonic studies utilize data from either the Bureau of Labor Statistics (BLS) or a survey conducted by the Society of Actuaries. The large differences in MVS estimates among hedonic studies has been largely attributed to which of these two data sources are used.[17] The reasons for this are explained in the next section therefore this discussion is deferred until Section 2.3.

The choice of which workers to sample greatly affects the MVS estimates obtained. Thaler and Rosen (1975) based their study on a sample of very hazardous occupations and obtained relatively low value of life estimates --around $600,000 per expected life saved. Olson (1981) notes that "since the value of life declines as risk increases, [Thaler and Rosen] were dealing with the extreme tail of the work force's risk distribution." As suggested above, these workers may tend to be the least risk averse and, as a result, have lower valuations of safety. Using data on workers in relatively low risk jobs, on the other hand, Olson obtained larger MVS estimates of around $7 million.

The range of MVS estimates obtained from contingent valuation studies is much larger than that of hedonic approaches. Two reasons for this larger variation are, first, different types of risk are analyzed and, second, the survey designs employed vary greatly across studies. Examples of the different types of risk examined in contingent valuation studies include heart attack fatalities (Acton, 1973), airline accident fatalities (Jones-Lee, 1976), and nuclear plant accident injuries (Mulligan, 1977). Finally, a third reason for the wide variation in CVM estimates is that these studies were conducted during the early stages of developing this method. Presumably the same type of studies would yield closer results if done today, now that more is known about how to best apply the CVM.

That individuals reveal a disparity in their valuations for reductions in different types of risk is of no surprise to psychologists. Weinstein and Quinn (1983) suggest that such valuations depend on whether the risks of evaluation is ex ante or ex post. Starr (1969) notes that whether a risk is involuntary or voluntary affects safety valuations. Other studies conclude that people are willing to pay more for reductions in risk if the danger occurs in the form of a catastrophe (e.g., airline accidents) rather than if spread out over time (e.g., heart disease).[18] Therefore, it is not surprising that the use of different types of risk in the contingent valuation studies lead to a large range in MVS estimates.

Different survey designs found in the literature have varying degrees of the aforementioned biases and therefore their resulting MVS estimates will consequently differ. Moreover, Violette and Chestnut conclude that the majority of the contingent valuation attempts at valuing reductions in risk "could have benefited from the refinements in survey design that have been evolving in other areas of environmental quality valuations." Therefore, survey design is both a source of variation in MVS estimates and something which requires greater refinement.

2.2.5. Comparison Studies of the Hedonic and CVM

Because of the different types of risk measures used, it is impossible to directly compare the results from the hedonic and contingent valuation methods found in the literature. In Chapter 4, a survey design is discussed with this goal in mind. The emphasis there will be on perceived job-related risk.

In order to directly compare the two approaches, this survey was used to collect information on how risky individuals feel their jobs to be. This perceived risk measure was then used, along with socio-economic information collected from the survey, in order to estimate a hedonic wage-risk equation. In addition, the respondents were directly asked their willingness to pay for reductions in their job-related risk by one unit from their initial perceived level. In this way, the two approaches were directly compared.

In the next section some of the problems involved in obtaining a risk measure are discussed.

2.3 PROBLEMS OF MEASURING RISK

In order to measure individuals' safety valuations it is necessary to measure risk. Hedonic studies, for example, must measure job-related risk of death. At first glance this might appear to be quite easy since job-related risk of death is merely the frequency which workers die, per year, due to accidents and other stresses experienced on the job. Note that this frequency would include illnesses such as strokes and heart attacks suffered away from work but directly "caused" by the job. The more hazards associated with a particular job, the more risky that job is. Such objective probability figures will be referred to as the actual risk of job-related accidental death, π_a.

Let us assume initially that π_a is the ideal measure; an assumption made by the hedonic wage-risk studies. To accurately describe the actual level of risk a worker faces on the job, one would need a risk measure for each occupation within each specific industry. A welder on an assembly line, for example, does not face the same hazards as someone who welds ships: although both people share the same occupation. The available data, unfortunately, do not come in such detail. We can, however, use this "ideal" as a means to judge the data that are available.

Data on π_a which can be used come primarily from one of two sources--the Bureau of Labor Statistics (BLS) or the Society of Actuaries. Most hedonic wage-risk studies have utilized data from the BLS which provide average injury or death rates by industry.[19] However, because π_a is not the same across occupations within an industry, the use of these data introduces measurement error.[20] Utilizing BLS data, for example, would mean assigning a receptionist in the oil industry the same level of π_a as a "roughneck." This error-in-variables problem results in MVS estimates which are biased and inconsistent, the degree of each being related to the variance of the measurement error.[21] Some hedonic studies (e.g., Viscusi, 1978b) have attempted to reduce this problem by including dummy variables for occupation classes. The criticisms aimed at this data source, however, are still valid.

Thaler and Rosen's (1975) study attempted to avoid this problem of measurement error by obtaining risk of death data from the Society of Actuaries. These data measure the extra risk of insuring an individual in one of 37 narrowly defined and relatively hazardous occupations. In addition to the problems alluded to above of focusing on the least risk averse individuals, Thaler and Rosen's data introduced a form of measurement error. As Lipsey (1975) points out, this insurance risk reflects the death risks associated with an occupation and death risks associated with personal characteristics of the individuals in these occupations. According to these data, for example, a bartender has a level of π_a over four times as great as that of a fireman.[22] Clearly, these figures include factors other than just job-related risk. According to Violette and Chestnut (1983), "[t]he Society of Actuaries data used by Thaler and Rosen may have reduced one source of measurement error only to add another source of an unknown magnitude.'

Therefore, hedonic techniques, by incorrectly measuring π_a, introduce measurement error which yields MVS measures which are suspect. Moreover, even if a true measure of π_a could be obtained, there is compelling evidence that this is not the ideal measure to be used. Fischhoff et al. (1982) make a convincing argument that individuals have a problem calculating objective probabilities of risk of death. Their findings show that there is a systematic error in what individuals perceived the frequency of lethal events to be. Therefore, a person's perceived risk of job-related accidental death, π_p, is not equal to the actual level, π_a. Two implications fall from this observation: (1) workers voluntarily trade increase job-related risk for increased wages based on their perceptions of such risks thus forcing the market to make compensations based on π_p, and (2) benefits people receive from environmental programs which reduce risk, based on subjective evaluations of risk reduction, also stem from perceived risk. These implications suggest the "ideal" risk measure to be used is not π_a, but rather π_p. Therefore, by using π_a, even if measured correctly, another error in variables problem is introduced.

One could argue that if individuals misperceive risk, then why should policy be based on "bogus preferences"? Fromm (1968) perhaps epitomizes this school of thought by saying:

> [M]y own feeling is that society would be better advised to treat individual decisions in this area as imperfect and not rely on willingness to pay as the primary criterion for fixing the scope or magnitude of life-saving programs.

While Fromm suggests that government policy should be careful in adhering to the "anarchy of individual preferences," such an idea is primarily philosophical in nature. The question raised is whether individual preferences, "right" or "wrong," should prevail; or is it the role of the government to induce "correct" preferences on individuals.

Welfare economics argues that "people's subjective preferences of the worth of a thing must be counted."[23] If, for example, an individual living next to a nuclear power plant personally feels that his chance of dying from radiation is twice as high as it is in actuality, then his subjective willingness to pay for increased regulations will be relatively high. Government policy should be based on such willingness to pay measures because there is a personal reduction in anxiety and a greater sense of well-being which will be included in the benefits of such a policy. The fact that some may feel that the anxiety is based on false risk-calculations does not change the fact that he is willing to pay some amount based on personal subjective evaluations. Indeed, the fact that some people are willing to pay more than others for a roller-skating experience at Venice beach does not, at least in economic terms, make them incorrect or irrational. It does, however, reflect their subjective evaluations of the benefits of such an experience. Schelling (1968) perhaps put it best by saying:

> As an economist I have to keep reminding myself that consumer sovereignty is not just a metaphor and is not justified solely by reference to the unseen hand. It derives with even greater authority from another principle of about the same vintage, "no taxation without representation." Welfare economics establishes the convenience of consumer sovereignty and its compatibility with economic efficiency; the sovereignty itself is typically established by arms, martyrdom, boycott, or some principles held to be self-evident. And it includes the inalienable right of the consumer to make his own mistakes.

Arguments for utilizing perceived risk of death in methods which attempt to estimate a person's willingness to pay for safety are plentiful. The process of measuring perceived risk must involve some type of well-designed survey or laboratory experiment. As a result, the contingent valuation method, along with experimental economics, must play a larger role in the evaluation of risk reduction. To this end, a survey is described in Chapter 4 which attempts to measure perceived job-related risk of death.

There is yet another advantage that survey methods have over hedonic approaches: the potential of eliciting different willingness to pay estimates for different types of risk. As was mentioned above, psychologists suggest that individuals value reductions in different types of risk differently. If this is true, then the appropriateness of utilizing estimates of willingness to pay for reductions in job-related risk to measure benefits from reductions in environmental risk may be suspect. Survey methods may circumvent this problem by establishing hypothetical markets for different types of risk.

In the next section the large difference between willingness to pay (WTP) and willingness to accept (WTA) are discussed. Here it is suggested that different risk valuations can be partially explained as individuals' valuations of two different types of risk: voluntary and involuntary. Further, behavior differences toward gains and losses in wealth may also explain divergencies between WTP and WTA measures.

2.4 DIVERGENCIES BETWEEN WTP AND WTA

Changes in environmental commodities, such as safety, affect individual welfare and it is the attempt to measure these welfare changes which makes estimating the MVS important. In theory, changes in welfare can be defined in terms of compensating variation (CV) or equivalent variation (EV); both measure the area under the Hicksian compensated demand curve.[24] For quantity increases in an environmental "good," the CV measure denotes an individual's willingness to pay (WTP) while his willingness to accept (WTA) is described by the EV measure.

Appealing to equation (5) above, these measures of welfare change can be applied to environmental risk. WTP is described by the value of $\Delta WLTH_P$ which maintains the equality:

$$(1 - \pi^\circ)U(WLTH^\circ) = [1 - (\pi^\circ - \Delta\pi)]U(WLTH^\circ - \Delta WLTH_P) \qquad (10)$$

where π° and $WLTH^\circ$ are, respectively, initial levels of risk and wealth. WTA, on the other hand, is described by the value of $\Delta WLTH_A$ which maintains the equality:

$$(1 - \pi^\circ)U(WLTH^\circ) = [1 - (\pi^\circ + \Delta\pi)]U(WLTH^\circ + \Delta WLTH_A) \qquad (11)$$

Therefore, WTP is the maximum decrease in wealth, $\Delta WLTH_P$, the individual will voluntarily give up in order to receive a reduction in risk, $\Delta\pi$, and still maintain his initial level of expected utility. Conversely, WTA is the minimum level of compensation to wealth, $\Delta WLTH_A$, the individual must receive in order to voluntarily accept an increase in risk, $\Delta\pi$, and still maintain his initial level of expected utility.

It has long been felt the EV and CV measures of a welfare change will not be exactly the same except in the case where the demand for the good in question exhibits a zero income effect. Moreover, there is no theoretically decisive case which can be made for using one measure over the other.[25] Willig (1976), however, shows theoretically that, for price changes, differences in CV and EV measures, along with the observable consumer surplus measure, are negligible. According to Takayama (1982), the same holds true for changes in quantity. In theory, therefore, WTP and WTA measures should be approximately the same: implying that $\Delta WLTH_P$ in equation (10) should equal $\Delta WLTH_A$ in equation (11).

There is, however, strong empirical evidence that suggests WTP and WTA measures are significantly different. Table 2.1 shows the results from a number of studies which estimate both WTP and WTA measures for different environmental commodities other than environmental risk. These studies reveal WTA measures to be many times greater than the WTP counterpart. It is hypothesized, therefore, that the amount of compensation required for a one unit increase in risk may well be many times greater than what an individual would be willing to pay for a one unit reduction in risk. This hypothesis is tested in Chapter 5.

The large discrepancies between WTP and WTA estimates have not been adequately explained in the economics literature.[26] In the area of risk-evaluation two possible explanations for these discrepancies are offered: (1) individuals exhibit different behavior towards gains in wealth than they do towards losses, and (2) individuals respond differently towards voluntary versus involuntary types of risk.

2.4.1. Behavior Towards Gains and Losses in Wealth

Equation (10) above describes an individual's willingness to pay for a reduction in risk as the maximum loss in wealth he would voluntarily sustain such that the initial level of expected utility is unchanged. Figure 2.5 shows this situation. For simplicity it is assumed that utility in death is zero. Another way to view this is that no wealth, WLTH, is realized in the "death" state and that U(WLTH = 0) is zero.

In Figure 2.5, the individual's utility curve is described by the curve OBD. Here, initial wealth is labeled $WLTH^\circ$ while initial risk of death is π° = CD/OD = .35, and, therefore, the initial probability of life is $(1 - \pi^\circ)$ = OC/OD = .65. Since it is uncertain whether the individual will live to realize $WLTH^\circ$, expected wealth is $(1 - \pi^\circ)WLTH^\circ$ while expected utility, E(U), is described by $(1 - \pi^\circ)U(WLTH^\circ)$. If the individual is asked for his maximum willingness to pay in order to obtain a lower level of risk, π = AB/OB = .25, then by construction, $\Delta WLTH$ is the change in wealth which satisfies equation (10).

Further, assuming a concave utility function and appealing to equation (6), his MVS will fall from MVS" to MVS. That is, since $\pi^\circ > \pi$ and $WLTH^\circ > WLTH$:

TABLE 2.1

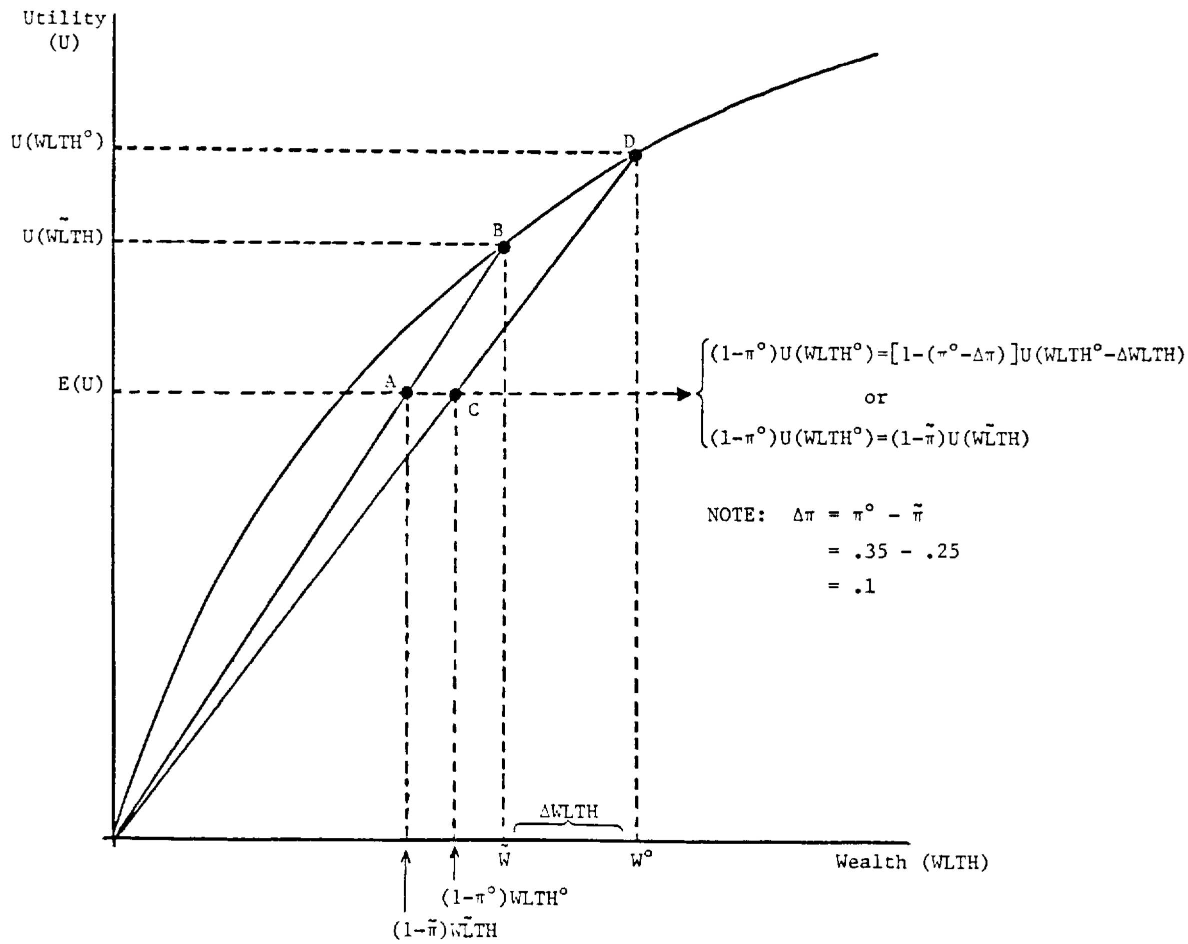
MEASURES OF WTP AND WTA[a]

Study	WTP	WTA
Hammack and Brown (1974)	$247.00	$1044.00
Banford, Knetsch, and Mouser 91977)	43.00	120.00
	22.00	93.00
Sinclair (1976)	35.00	100.00
Bishop and Heberlein (1979)	21.00	101.00
Brookshire, Randall, and Stoll (1980)	43.64	68.52
	54.07	142.60
	32.00	207.07
Rowe, d'Arge, and Brookshire (1980)	4.75	24.47
	6.54	71.44
	3.53	46.63
	6.85	113.68
Hovis, Coursey, and Schulze (1983)	2.50	9.50
	2.75	4.50
Knetsch and Sinden (1983)	1.28	5.18

[a]All figures are in year-of-study dollars.

SOURCE: Valuing Environmental Goods: A State of the Art Assessment of the Contingent Valuation Method. Cummings, R. G., Brookshire, D. S. and Schulze, W.D., Draft (May 1984).

Figure 2.5: Willingness to Pay for Reduced Risk



$$MVS^{\circ} = \frac{U(WLTH^{\circ})}{(1 - \pi^{\circ})U'(WLTH^{\circ})} > \tilde{MVS} = \frac{U(WLTH)}{(1 - \tilde{\pi})U'(\tilde{WLTH})} \qquad (12)$$

Figure 2.5 also shows that if the above situation were reversed so that the initial level of wealth and risk were respectively $\tilde{\pi}$ and WITH, the compensation required to accept the higher level of risk, π°, is also AWLTH and his MVS will increase from MVS to MVS°. Within this theoretical construct, therefore, we would expect WTP and WTA to be the same.

One possible explanation for the fact that estimates of WTA have been shown to be much larger than those of WTP is that individuals tend to value gains to wealth (compensation for increases in risk) differently than losses in wealth (payment for reductions in risk). Kahneman and Tversky (1982) note that individuals are much more sensitive towards losses in wealth than they are towards gains in wealth.

The idea that people may value losses stronger than gains is suggestive of a tendency towards conservatism. The individual may simply lack the experience necessary to correctly calculate the resulting utility associated with changes in wealth from the norm. In this situation an individuals ex ante perceptions of what his utility will be from, say an increase in wealth, may differ from what it ends up being ex post. To compensate for what is essentially an exploration process, the individual may act conservatively by underestimating the potential gains and overestimating the potential losses in utility from respective increases and decreases in wealth.

Figure 2.6 describes such a situation. This figure shows the individual's initial level of risk and utility as being $WLTH^{\circ}$ and $U(WLTH^{\circ})$ respectively while their utility function is described by the curve OAB.

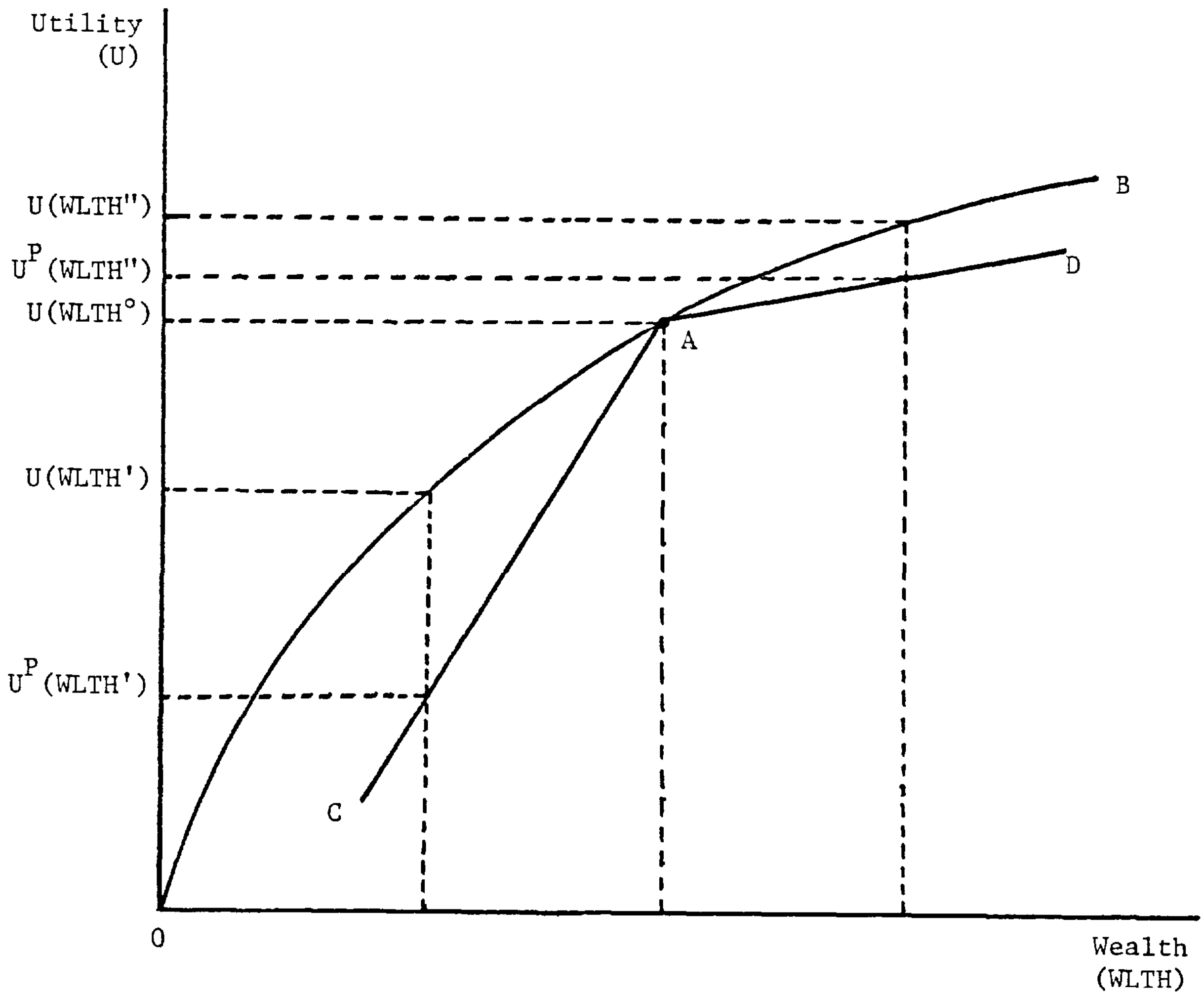
If we assume that the individual correctly calculates the change in utility that results from a small change in wealth, then their MVS (evaluated at $WLTH^{\circ}$) is the same for both gains and losses in wealth; that is:

$$MVS = \frac{U(WLTH^{\circ})}{(1 - \pi^{\circ})U'(WLTH^{\circ})} = \frac{\Delta WLTH}{\Delta \pi} \qquad (13)$$

where $U'(WLTH^{\circ})$ is the same whether we are moving to the right (+) or to the left (-) of $WITH^{\circ}$. Therefore, MVS is the same for both small positive changes in WLTH and π (i.e., WTP) or small negative changes in WLTH and π (i.e., WTA) Hence, WTA = WTP.

On the other hand, if we assume that gains from wealth increases are underestimated while losses from wealth reductions are overestimated, the individual evaluates changes in wealth along the perceived utility function CAD in Figure 2.6. For a potential loss in wealth ($WLTH^{\circ}$ to WLTH') the resulting utility level is ex ante perceived to fall to U^{p}(WLTH'): an overestimate of the true loss in utility (i.e., $U(WLTH^{\circ})$ to U(WLTH')). On the other hand, for potential gains in wealth ($WLTH^{\circ}$ to WLTH") Figure 2.6 shows the individual underestimates the resulting gains in utility.

Figure 2.6: Valuation of Losses and Gains



For small changes in wealth, movements along the perceived utility function suggest that an increase in WLTH° does not render the same marginal utility, $U'(WLTH°)^+$, as decreases in WLTH°, $U'(WLTH°)^-$. Specifically,

$$U'(WLTH°)^+ = \text{slope of } \overline{AD} < U'(WLTH°)^- = \text{slope of } \overline{AC} \qquad (14)$$

Assuming this conservative type of behavior, it is easily shown that WTA will be greater than WTP. For a potential. one unit reduction in risk, $\Delta\pi(-)$, an individual's WTP is described by $\Delta WLTH(-)$ in equation (15). Conversely, for a one unit increase in risk, $\Delta\pi(+)$, WTA is shown to be $\Delta WLTH(+)$ in equation (16).

$$\frac{U(WLTH°)}{(1-\pi°)U'(WLTH°)^-} = \frac{\Delta WLTH(-)}{\Delta\pi(-)} \qquad (15)$$

$$\frac{U(WLTH°)}{(1-\pi°)U'(WLTH°)^+} = \frac{\Delta WLTH(+)}{\Delta\pi(+)} \qquad (16)$$

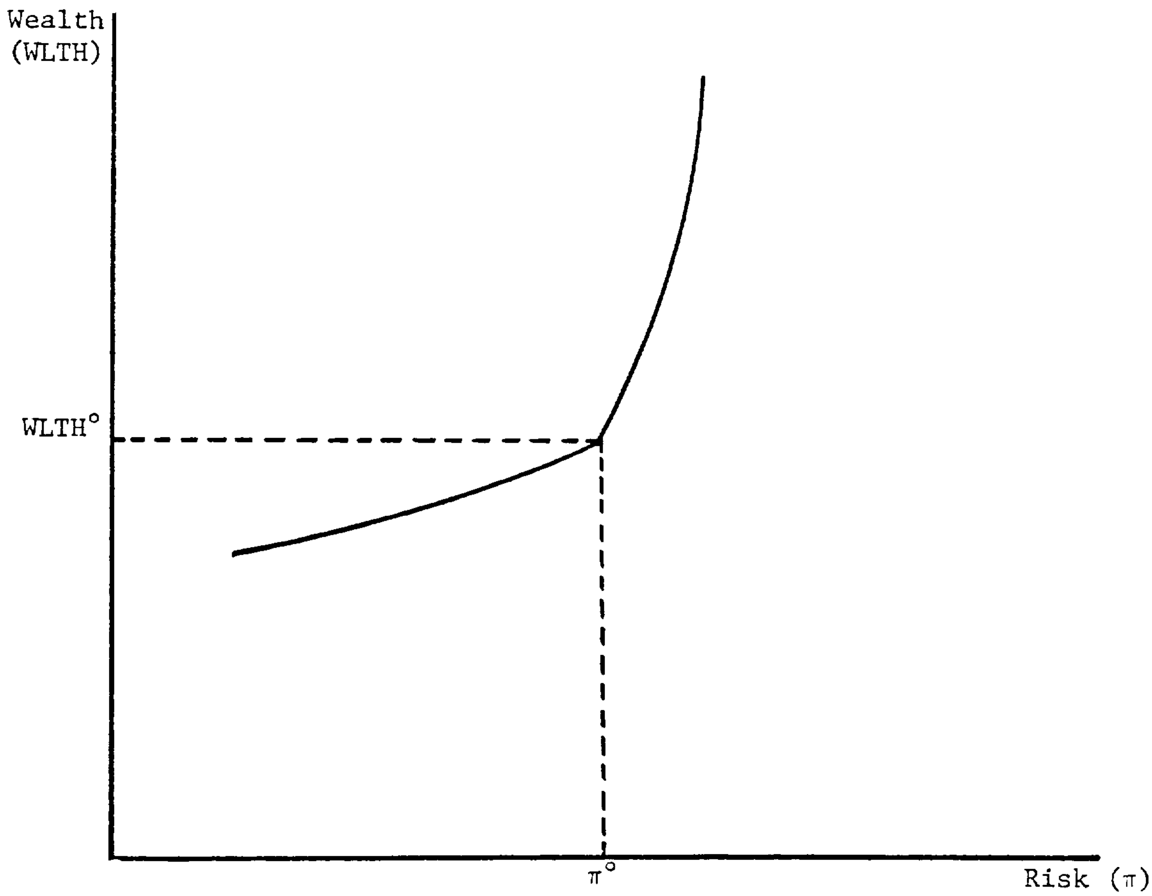
Since $U'(WLTH°)^-$ is greater than $U'(WLTH°)^+$, the left-hand-side of (16) is larger than the left-hand-side of (15). Moreover, since both $\Delta\pi(-)$ in (15) and An(+) in (16) are equal to one unit, it follows that $\Delta WLTH(-) < \Delta WLTH(+)$; that is, WTA is hypothesized to be large than WTP.

The effect of this difference between WTA and WTP is to put a "kink" in the individual's indifference curve between risk and wealth. Figure 2.7 shows that this kink occurs at the initial level of risk and wealth (π° and WLTH° respectively). This figure shows that for an increase in risk from π° the individual's MVS sharply increases which is associated with the relatively large compensation required (WTA large). Conversely, for a decrease in risk from π° their MVS slowly decreases due to the relatively small compensation required (small WTP).

Recall that above it was stated that relatively steep indifference curves are suggestive of risk-averse behavior while relatively flat indifference curves are suggestive of risk-loving (or less risk-averse) behavior. Therefore, in the realm of safety evaluation, it can also be concluded that divergencies between WTA and WTP are associated with higher risk-averse preferences for deductions in safety (increases in π) while increases in safety (decreases in π) are associated with less risk-averse preferences.

If the above conservative process is repeated through trial and error, differences between WTP and WTA may eventually converge. Results in experimental economics are suggestive of this phenomenon. Coursey, Hovis, and Schulze (1985) found that in an experimental auction type situation for an environmental "bad," WTA and WTP measures were statistically similar after a number of trials. These same measures were significantly different, however, at the beginning of the experiment.

Figure 2.7: Indifference Curve Between Risk and Wealth



In summary, different behavior towards losses and gains in wealth may help to explain divergencies between WTA and WTP. Such behavior is conservative in nature and involves over-estimating changes in utility from losses in wealth and underestimating changes in utility which result from gains in wealth. This suggests that individuals exhibit conservative behavior when exploring areas of their utility functions that deviate from the norm or "status-quo." With time, however, through repeated experience with other areas of utility people may be able to accurately calculate ex ante the gains or losses from deviating from the norm. Therefore, this conservative tendency might be alleviated after repeated experiences with situations that deviate from the status-quo. Further, as norms change, a fairly accurate mental mapping of the utility function may result.

2.4.2. Voluntary and Involuntary Risk Acceptance

It has been shown that individuals have different evaluations for different types of risk. On the most general level, exposure to risk can be categorized as being either voluntary (e.g., risks associated with rock-climbing) or involuntary (e.g., risks associated with public transportation).

In situations of voluntary risk exposure, the individual evaluates the tradeoffs involved and can make a decision whether exposure to the risk is worthwhile: in short, they have control over the situation. Involuntary risk, on the other hand, is imposed on the individual by someone or something, and therefore, evaluation of the tradeoffs involved are outside his control.

Starr (1969) shows that individuals seem to be more averse towards involuntary than voluntary risk and, therefore, would require a higher level of compensation, if such compensation is available, for being exposed to the former. The fact, for example, that more of society's resources are devoted to airline safety than automobile safety is suggestive of this.

The reasons behind the differences in voluntary and involuntary risk evaluation is perhaps founded in ethics. Individuals are more sensitive to activities which are imposed on them by others than they are to activities they freely choose to engage in. It is felt, for example, that exposure to a drunken driver is "wrong" and no compensation is high enough to accept such risk. On the other hand, voluntarily exposing oneself to risk, as long as there are no external effects imposed on others, is viewed as an individual right.

It may be that questions attempting to elicit a willingness to pay measure trigger an ethical system associated with voluntary risk while those that attempt to elicit a willingness to accept are associated with involuntary risk valuation. This being the case WTA estimates would be expected to exceed estimates of WTP.

2.5 THE DETERMINANTS OF THE DEMAND FOR SAFETY

Estimation procedures which attempt to estimate an individual's subjective MVS afford economists the opportunity to approximate an indifference curve such as the one in Figure 2.1. From this, one can plot the relationship between MVS and risk which essentially will look the same as Figure 2.1: with MVS approaching infinity as π approaches one. This relationship can be viewed as the demand for safety.

The various studies discussed above all attempt to estimate "the" marginal value of safety. Given that the MVS estimates vary greatly across studies, it might be natural to ask which estimate better reflects the value of an expected life saved. Viewing the problem in this manner, however, may not be appropriate for policy purposes.

Economic theory and empirical evidence suggest that there is no reason to expect the MVS to be the same for all individuals or in all circumstances. In particular, an individual's MVS depends on their personal characteristics and the nature of the risk involved.[27] Therefore, as Viscusi (1978b) points out, "[e]mpirical analyses should not be directed at estimating an elusive value of life number; rather they should estimate the schedule of values for the entire population." For policy purposes it may be necessary to estimate MVS curves which show how safety valuations vary across personal characteristics. Once the group which will be affected by a safety program is identified and their socio-economic characteristics are known, the analysis of MVS curves is crucial in obtaining the appropriate MVS estimate to be used in policymaking.

In Section 2.1 it was shown that initial levels of risk and wealth as well as preferences towards risk in general will affect an individual's MVS. The latter may partially be captured by including age as a determinant of safety evaluation. The results of the model in Chapter 3 are suggestive of this in that people are found to be more risk averse as they get older.

With respect to other factors that may influence an individual's MVS, Viscusi (1978b) shows that education is an extremely significant determinant in the evaluation of safety. Moreover, Olson (1981) found union membership to affect worker's valuations of changes in job-related risk. One explanation given for this is that unions supply their members with better information regarding risk on the job.

Furthermore, Thaler and Rosen (1975) hypothesize that marital status and race play a big part in MVS estimates. They suggest that one would expect a married individual to have a relatively high MVS since included in this person's valuation is the external benefits incurred by dependents in having the individual alive. Thaler and Rosen suggest that race is an important factor in market wage-risk premiums. Non-whites, for example, may face discrimination in the risk-premiums they receive; thus, one could, by appealing to hedonic studies, erroneously conclude that non-whites have lower marginal values of safety in general. Other factors which may affect an individual's MVS include sex and initial health status. For example

Cropper (1977) and Pliskin et al. (1980) set up dynamic utility models which suggest that an individual's current health state affects his valuation of reductions in risk.

In addition to personal characteristics, the nature of the risk involved is an important factor in evaluating the benefits from safety improvements. This was discussed in some detail in Sections 2.2.3 and 2.2. In addition to the research discussed in these sections, Litai (1980) developed risk conversion factors to compare different types of risk. Table 2.2 summarizes the results obtained by Litai. This table shows a distinct difference in the evaluation of different risk types.

In summary, the quest of a single "correct" MVS estimate may not be very useful for evaluating the benefits of environmental safety programs. Instead research in this area would better directed towards estimating the way in which safety evaluations are related to personal characteristics and how these values change with various types of risk. This research specifically will address the former. The results of the survey described in Chapter 4 will be used to characterize individual's marginal valuations of safety by personal characteristics. These results are included in Chapter 5.

2.6 THE EXPECTED UTILITY MODEL

In Section 2.1 it was shown that the economics of safety is an application of expected utility (EU) theory. The EU model is a specific example of the general area known as holistic choice theory.[28] This general view of human behavior assumes that individuals are able to comprehensively compare all dimensions of potential alternatives, assign each a separate level of utility and therefore choose the combination which renders the most satisfaction. In the case of EU theory individuals must also calculate subjective probabilities of each state in the same holistic fashion. By analyzing the entire situation before making a choice, individuals should exhibit cognitive consistency.[29]

There is, however, some evidence that suggests individuals to be "irrational" when faced with decisions involving uncertainty. Research in this area reveals that psychological phenomena account for these seemingly irrational choices. In general it is felt that individuals lack the cognitive abilities to make the comprehensive decisions implied by EU maximization. In his survey article on EU theory, Schoemaker (1982) makes the following conclusions:

> As a descriptive model seeking insight into how decisions are made, EU theory fails on at least three counts. First, people do not structure problems as holistically and comprehensively as EU theory suggests. Second they do not process information, especially probabilities, according to the EU rule. Finally, EU theory, as an "as if" model, poorly predicts choice behavior in laboratory situations. Hence it is doubtful that EU theory should or could serve as a general descriptive model.

TABLE 2.2

RISK CONVERSION FACTORS

Risk Characteristics	RCF Estimated*	Probable Error Factor
Delayed/Immediate	30	10
Necessary/Luxury	1	10
Ordinary/Catastrophic	30	10
Natural/Man-made	20	10
Voluntary/Involuntary	100	10
Controllable/Uncontrollable	5	10
Occasional/Continuous	1	10
Old/New	10	10

*These mean, for example, that immediate risks require 30 times more compensation than delayed risks.

Schoemaker, therefore, concludes that the EU model, while being "the major paradigm in decision making [theory] since the Second World War," falls short of being used either descriptively to model decisions under uncertainty or positively to predict such behavior.

While Schoemaker's survey article offers an extremely comprehensive summary of the psychological reasons for such a conclusion, this section will highlight four major phenomena. They are: (1) context effects, (2) certainty effects, (3) problems in evaluating small probabilities of large events, and (4) bounded rationality.

2.6.1. Context Effects

"Since EU theory focuses on the underlying structure of choices, as modeled by 'rational' outside observers, it is largely insensitive to . . . contextual differences."[30] Empirical evidence suggests, however, that "the utility assigned an outcome can be influenced by the lottery context in which the outcome is embedded."[31] Context effects arise when the same alternatives are evaluated in relation to different points of reference resulting in an apparent reversal of preferences.

Kahneman and Tversky (1982) observed such a phenomenon when a large number of physicians were asked to imagine a situation in which a rare Asian disease is expected to kill 600 people. Two groups of 169 physicians were asked to make a choice between two alternative programs. While the results of the two programs were objectively the same for each group, the alternatives were framed differently, i.e., the context differed. The choices facing the two groups were as follows:

Group I

A: if program A is adopted exactly 200 people will be saved

B: if program B is adopted, there is a 1/3 probability that 600 people will be saved, and a 2/3 probability that no one will be saved

Group II

A: if program A is adopted exactly 400 people will die

B: if program B is adopted there is a 1/3 probability that nobody will die and a 2/3 probability that 600 people will die.

In both groups, program A will render 200 people saved with certainty while program B has an expected number of lives saved equal to 200. However, while 76 percent of the physicians in group I opted for program A (exhibiting risk-averse preferences), only 13 percent of Group II preferred that same program (exhibiting risk-loving preferences). Kahneman and Tversky explain this reversal of preferences by the difference in reference points. In Group I, "the death of 600 people is the normal reference point and the outcomes are evaluated as gains (lives saved)"; while in the second group "no deaths is the normal reference point and the programs are evaluated in terms of lives lost." Such reversals are in violation of EU theory which suggests that, by comprehensively evaluating the different choices, the context should not matter.

2.6.2. Certainty Effects

In their 1979 article, Kahneman and Tversky develop what they call prospect theory. This theory suggests that individuals weigh payoffs obtained with certainty disproportionately large relative to outcomes that are uncertain.

The EU axiom which assumes invariance of preference between certainty and risk, ceteris paribus, will be violated by the existence of such a certainty effect.[32] Schoemaker (1982) offers experimental results of the following two-choice situations:

Situation I: (IA) a certain loss of $45

(IB) a .5 chance of losing $100 and a .5 chance of losing $0

Situation II: (IIA) a .10 chance of losing $45 and a .9 chance of losing $0

(IIB) a .05 chance of losing $100 and a .95 chance of losing $0

In this experiment, the subjects' preferred (IIA) to (IA) while (IB) was preferred to (IIB). This violates EU since "the former implies that $U(-45) < .5U(-100) + .5U(0)$, whereas the latter preference implies the reverse inequality."[33]

2.6.3. Evaluating Small Probabilities of Large Events

Schoemaker (1982) makes the point that individuals do not behave as if they are maximizing EU for low-probability, high-loss events. Interviewing 2,000 homeowners in flood plains and 1,000 homeowners in earthquake areas, Kunreuther et al. (1978) found that of those who were informed on the availability of insurance against these hazards, many acted contrary to subjective EU maximization.[34] These results seriously question an individual's ability to process information on low-probability, high-loss events.

Schelling (1968) relates this cognitive difficulty to safety valuations. He notes that:

> A difficulty about death, especially a minor risk of death, is that people have to deal with a minute probability of an awesome event, and may be poor at finding a way--by intellect, imagination, or analogy--to explore what the saving is worth to them. This is true whether they are confronted by a questionnaire or a market decision

> ...The smallness of the probability is itself a hard thing to come to grips with especially when the increment in question is even smaller than the original risk. At the same time, the death itself is a large event, and until the person has some way of comparing death with other losses it is difficult or impossible to do anything with it probabalistically, even if one is quite willing to manipulate probabilities.

Individuals may deal with these problems in cognition by choosing to ignore such risk (i.e., "risk-denial"); or, they may rationalize the level of risk they accept through a phenomena which is referred to as cognitive dissonance. Akerlof and Dickens (1982) describe the latter phenomena by noting that "most cognitive dissonance reactions stem from people's view of themselves as 'smart, nice people.' Information that conflicts with this image tends to be ignored, rejected, or accommodated by changes in other beliefs."

For example, a "smart" person may not choose to work in an unsafe place. If the worker continues to work in a dangerous job, he will try to reject the cognition that the job is dangerous. Such a rationalization will not only affect his perceptions of job-related risk, but also his evaluation of reduction in such risk.

It should be emphasized that just because people err in their perceptions of risk does not render the possibility of a violation of EU: Subjective EU maximization is not inconsistent with EU theory. Rather, that individuals may exhibit cognitive problems with evaluating small-probability, large-loss events at all may lead to violations of EU theory.

2.6.4. Bounded Rationality

The presumption made by EU theory that individuals take a holistic view towards utility maximization conflicts with various psychological principles of judgment and choice.[35] Further, Schoemaker (1982) suggests that the failure of EU theory to contain descriptive or predictive content stems from an inadequate recognition of these principles.

Underlying most of psychological theories on human behavior is "a general human tendency to seek cognitive simplification."[36] The bounded rationality view (Simon, 1955) of human behavior suggests that people may intend to act rationally but lack the mental capabilities to satisfy EU maximization, Schoemaker (1982) summarizes the bounded rationality view of behavior as being

> ...that of an information processing system which is narrow in its perception, sequential in its central processing, and severely limited in short-term memory capacity . . . This limited information processing capacity compels people to simplify even simple problems, and forces them to focus more on certain problem aspects than others (i.e., anchoring). Such adaptation implies sensitivity to the problem

presentation [i.e., context] as well as the nature of the response requested.

Such a view of human behavior suggests that individuals may not approach the maximization problem in a comprehensive fashion; rather, it is "cognitively easier to compare alternatives on a piece-meal basis, i.e., one dimension at a time."[37] If this is the case, then a model which requires a "portfolio perspective" (Markowitz, 1952) may fail to describe or predict human behavior and may well conclude individuals to be irrational.

2.6.5. In Defense of the EU Model

Proponents of EU theory sometimes respond to the aforementioned criticisms by saying laboratory experiments tend to be "artificial" and that situations in the "real" world render different behavior. This section will not appeal to such a defense. "Behavior in the laboratory is as real as other forms of behavior."[38] Further, Vernon Smith (1976) notes that 'if economic theory is proposed as a general model of scarce resource allocation, it should apply to experimental settings as well.'

Rather than criticizing the results of experiments that suggest EU theory may fail, one only need to look at other experimental research which suggests EU theory may work well in a dynamic setting. Particularly, in situations where there is a market for risk (e.g., the insurance market or the labor market), repeated experience with market mechanisms may correct misperceptions and individual decision biases.[39] Moreover, after many trials and errors the individual may gather the information needed to make holistic decisions. As Cummings, Brookshire, and Schulze (1984) point out, "some positive evidence does exist in the experimental economics literature that the expected utility model may be satisfied asymptotically after many interactions." Specifically, Plott and Sunder (1982) found that:

> There seems to be no doubt that variables endogenous to the operation of these markets served to convey accurately the state of nature to otherwise uninformed agents. We can conclude that . . . maximization of expected utility . . . must be taken seriously as not universally misleading about the nature of human capabilities and markets.

Moreover, there is "real world" empirical evidence that suggests the EU model to work well. Brookshire, Thayer, Tschirhart, and Schulze (1985) tested an expected utility model of self insurance against low-probability, high-loss earthquake hazards. They conclude that:

> Households process probability information in a reasonably rational and accurate way and that, at least in a market situation with a well defined institutional mechanism, the expected utility model may perform well in predicting behavior.

In summary, the case of the so-called failure of the expected utility model is by no means open and shut. The evidence suggests, however, that in situations where there is no market-like feedback, cognitive difficulties may render EU maximization difficult. On the other hand in cases where market information can be processed, the individual, at least over time, may develop the cognitive abilities to act rationally as described by EU theory. Further, because there does exist an implicit market for job-related-risk, applying the EU model to this "commodity", and attempting to elicit evaluations of reductions in such risk, may well be within the bounds of appropriateness.

REFERENCES

1. See Bacharach (1977) p. 23.
2. Kahneman and Tversky (1979) p. 160.
3. Rosen (1974) p. 244.
4. Violette and Chestnut (1983) p. 3-2.
5. Ibid., p. 3-1.
6. Ibid., p. 2-1.
7. Ibid., p. 2-1.
8. Ibid., p. 2-2.
9. Ibid., p. 2-2.
10. Ibid., p. 2-3.
11. Cummings, Brookshire, and Schulze (1984) p. 1.
12. Ibid., p. 2.
13. This quote is attributed to Richard Bishop.
14. Freeman (1979) pp. 915-20.
15. This quote is attributed to Richard Bishop.
16. See Violette and Chestnut (1983) pp. 2-7 - 2-10.
17. Ibid.
18. Bodily (1980).
19. Violette and Chestnut (1983) p. 2-7.
20. Ibid., p. 2-3.
21. Pindyck and Rubinfeld (1981) p. 176-7.
22. Thaler and Rosen (1975) p. 288.

23. Mishan (1971) p. 695.

24. Freeman (1979) pp. 34-5.

25. Ibid.

26. The most common explanation centers around a significant income effect.

27. See Viscusi (1978b).

28. Schoemaker (1982) p. 530.

29. Ibid., p. 549.

30. Ibid., p. 547.

31. Ibid., p. 547.

32. Ibid., p. 543.

33. Ibid., p. 543

34. See also Hershey and Schoemaker (1980).

35. Schoemaker (1982) p. 548.

36. Ibid.

37. Ibid.

38. Ibid., p. 554.

39. Ibid., p. 553.

CHAPTER 3

SOME EXTENSIONS AND REFINEMENTS OF THE THEORY: A LIFE-CYCLE MODEL OF RISK CHOICE

In the previous chapter it was shown that hedonic wage-risk studies, by assuming individuals correctly calculate their job-related risks of death, yield MVS estimates which are biased and inconsistent. Further, it was noted that in order to measure a person's perceptions of risk, and hence estimate subjective evaluations of risk reduction, the refinement of survey techniques is worthy of greater attention. In this chapter another potential bias, which may be inherent in hedonic wage-risk methods, is explored and is offered as another justification for using the contingent valuation approach in estimating evaluations of safety.

The bias in hedonic wage-risk studies described here stems from a potential violation of the assumption that the labor market operates freely and is in equilibrium. When this assumption is violated, the labor market is said to experience structural constraints. Such constraints on the labor market can be shown diagramatically to render a situation in which the hedonic wage gradient is not tangent to workers' indifference curves as was the case in Figure 2.4. Rather, at an observed market level of risk and wages, the worker's maximum level of expected utility intersects the hedonic wage gradient.

That the hedonic wage gradient may be comprised of a locus of indifference curve intersections rather than tangencies, suggests that a "wedge" is formed between how the market transforms risk into wealth (as described by the slope of the hedonic wage gradient) and a worker's marginal value of safety (as described by the slope of the indifference curve).

This leads to two possibilities. Figure 3.1.1 shows the first case. In this situation Θ^1 and Θ^2 are two different levels of expected utility for the same worker where Θ^2 is greater than Θ^1. Further, the hedonic wage gradient is described by WLTH(π). If the labor market is operating freely, this worker will maximize expected utility by choosing a level of job related risk equal to π_2. In this situation, the worker's MVS (as described by the slope of Θ^2) is equal to the rate at which the market compensates workers for taking risk (as described by the slope of WLTH(π)). Therefore, if one was to estimate WLTH(π), calculate WLTH'(π_2), and interpret the former as the worker's subjective MVS, one would be correct in doing so.

However, if the worker was constrained to stay in a job with risk level π_1, maximum level of expected utility is Θ^1. At a level of risk equal to π_1, the rate at which the market compensates risk-bearing, WLTH'(π_1), is less than the worker's subjective MVS_1 (i.e., slope of Θ_1). A "wedge" is described by MVS_1 - WLTH'(π_1) and, therefore, WLTH'(π_2)

underestimates the worker's subjective evaluations. The opposite situation is described in Figure 3.1.2.

In this chapter, two sources of the aforementioned "wedge" will be discussed. The first is attributed to the worker-consumer's increasing risk-aversion through time, and the increased transaction costs he faces in changing jobs: referred to as "risk rigidities." The second stems from asymmetry in the capital market.

The theory developed in this chapter is based on an intertemporal model of career choices under uncertainty. This model can be used to elicit a marginal value of safety directly from analyzing the decision process an individual goes through in choosing a job. Differences in potential jobs are quantified in terms of perceived job related risks of death. Therefore, by picking a level of perceived risk the individual has chosen a career.

In the model, the individual maximizes expected life time utility subject to an intertemporal budget constraint. The model consists of three periods: the training period, the working period, and the retirement period. The more risky a job the individual chooses the less likely that individual is to realize future utility. However, it is assumed that job-related risk and wealth are positively related, ceteris paribus. The results of this model reveal reasons to believe there exists a wedge between how the market would transform job-related risk into wealth and an individual's MVS.

3.1 THE SIMPLE MODEL

3.1.1. A Life-Cycle Mode of Risk Acceptance

The theory of an individuals' career choice developed here is framed within a three period life-cycle model with a risk of death in each period. It is assumed that the individual's most income-productive years are towards the middle of the life-cycle with income earned during these years used to finance consumption during retirement and perhaps to pay off debts cumulated in the early years. Thus, the model here has an Ando-Modigliani (1963) flavor with the career decision viewed as one which affects all periods in an individual's life. Further, each period has a "life" state and a "death" state with the career choice affecting the probability of each state within the last two periods. Therefore, the decision of which career to enter will affect the individual's life cycle via the income the career renders and the risk associated with that particular job. Moreover, an MVS term is derived directly from the calculus.

Although there has been some attempt in the safety literature to derive an MVS from a life-cycle model (e.g., Blomquist, 1979), this model is novel in that the individual is assumed to re-evaluate his career choice (i.e., choice of job-related risk) at various points within the life cycle. This formulation affords the opportunity to examine how attitudes towards risk change during the course of one's life. Since an individual's

Figure 3.1.1: Market Transformation of Risk to Wealth (1)

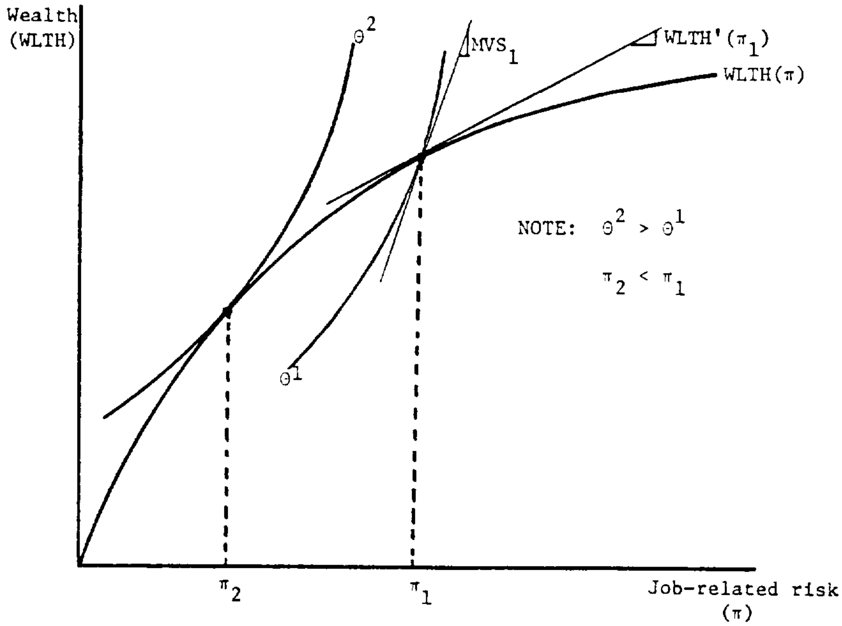
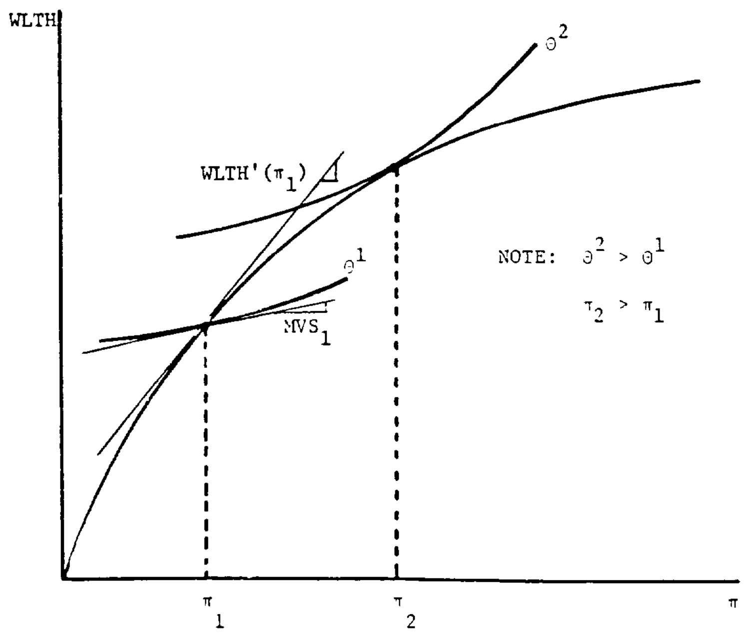


Figure 3.1.2: Market Transformation of Risk to Wealth (2)



preference towards risk is an important factor in his subjective MVS, it is felt that the examination of how these preferences change is a worthy endeavor.

To simplify the analysis, an individual's life is partitioned into four periods with each period's utility assumed to be a function of consumption in that period. The first period, period zero, is childhood. Here the child's consumption level is given to him by his parents. Therefore, consumption, and hence utility, in this period is assumed to be exogenous to the model. It should be noted, however, that an individual's optimal choice of job-related risk will be affected by his initial endowment of wealth given to him by his parents. Viscusi (1978b) sets up a one period expected utility model and concludes that the more assets, or exogenous consumption, an individual inherits from his parents, the less job-related risk he will accept. However, since we are examining decisions that the person has control over, this period is not included in the model. It is also assumed that the individual does in fact live through childhood.

After childhood, the individual is faced with the decision of what career to enter. It is therefore at the beginning of this period, period one, that the person makes a career choice. The rational individual is aware of the fact that this decision will affect his lifetime stream of utility.

Period one is assumed to be a period of training for the individual's career. Examples of such training could be enrollment in college, vocational schools, or apprenticeship programs. Earnings in this period are so small compared to income made on the job that they are assumed to be zero. Therefore, consumption in period one is financed through borrowing on future income. Elimination of this period due to the fact that some people do not go through training periods does not affect the basic results of the model.

Period two is then defined as the time in which the individual is actually working in his career. It is assumed that this is the only period in which the person earns income. Therefore, this income must be optimally distributed among the three periods since the person must (1) pay back loans taken out for period one's consumption, (2) consume some positive quantity in the second period, and (3) save for consumption in period three. It follows that period three is the retirement years.

In order to quantify the vector of possible careers, each potential job is described in terms of its perceived job-related risk of death. Clearly, each job is described by other characteristics other than risk but the relevant job attribute here is risk. Therefore, for the purposes of this model, by choosing a career, the individual chooses a level of job-related risk of death.

If the individual chooses a relatively risky job, the probability of living through periods two and three decreases, as do the odds of realizing utility in these periods. However, the benefit in taking such risk stems from the fact that riskier jobs yield higher incomes, ceteris paribus. As Viscusi (1978a) points out, the positive nature of this relationship is not an assumption but rather is a result of the nature of the job choice problem. He adds that, "the derivation of this result [does] not require that workers be risk averters. The only assumption required [is] that [a] good health state be more desirable than [an] ill health state."

That people engage in various consumption activities, other than work, which yield positive utility and increase the odds of dying (e.g., smoking), will not be of concern to this model. Such risks will be referred to as exogenous risk of death. This is done because the model concerns career decisions. Therefore, it is assumed that the only thing an individual does to affect his probability of death is the career choice. Further, since the individual only works in the second period, this is the only period where risk of death has an endogenous element. Given this, the probability of death is defined as follows:

π_1 = exogenous risk of death in period 1

π_2 = risk of death in period 2

$= \pi_2^\circ + \hat{\pi}_2$

where:

π_2° = exogenous risk of death in period 2

π_2 = level of additional risk due to job-related hazards

π_3 = exogenous risk of death in period 3.

It follows that;

$(1-\pi_1)$ = probability of living through period 1

$(1-\pi_2)$ = probability of living through period 2; given that the individual survived through period 1

$(1-\pi_3)$ = probability of living through period 3; given that the individual survived through periods 1 and 2.

Typically $\pi_2^\circ < \pi_1, \pi_3$.

Since $(1-\pi_i)$ is the probability of living through period i given that the individual has survived through all previous periods, $(1-\pi_i)$ is actually a conditional probability. Assuming that π_i is independent of π_j, the following expressions represent the unconditional probabilities of survival:

$(1-\pi_1)$ = probability of surviving to the end of period 1

$(1-\pi_1)(1-\pi_2)$ = probability of surviving to the end of period 2

$(1-\pi_1)(1-\pi_2)(1-\pi_3)$ = probability of surviving to the end of period 3.

Because exogenous risk of death is typically lowest in period two, an individual may not be too hesitant to increase π_2 (by increasing $\hat{\pi}_2$). This may be especially true in light of the fact that income in period two increases as the individual takes on more risk and that income must be distributed among the three periods. The positive relationship between risk and wages is given by the hedonic wage-risk gradient the individual faces in period two:

$$y_2 = y_2(\hat{\pi}_2)$$

where $\frac{dy_2}{d\hat{\pi}_2} > 0$ and where y_2 is defined as the income in period two.

An additive expected life time utility function is assumed which takes the form:

$$E(U^L) = E(U_1) + E(U_2) + E(U_3)$$

where $E(U_1) = (1-\pi_1)U_1(c_1) \equiv$ expected utility in period 1

$E(U_2) = (1-\pi_1)(1-\pi_2)U_2(c_2) \equiv$ expected utility in period 2

$E(U_3) = (1-\pi_1)(1-\pi_2)(1-\pi_3)U_3(c_3) \equiv$ expected utility in period 3

$U_i(c_i) \equiv$ utility in period i as a function of that period's consumption level.

Finally, the individual faces the following typical intertemporal budget constraint:

$$y_1 + \delta y_2 + \delta^2 y_3 = c_1 + \delta c_2 + \delta^2 c_3$$

where:

$y_i \equiv$ income in period i

$c_i \equiv$ consumption in period i

$\delta \equiv 1/(1+r)$

$r \equiv$ the real rate of interest.

Since it is assumed that $y_1 = y_3 = 0$, $y_2 = y_2(\hat{\pi}_2)$ and because wealth, WLTH, is defined as the present discounted value of future earnings, the constraint reduces to:

$$WLTH \equiv \delta y_2(\hat{\pi}_2) = c_1 + \delta c_2 + \delta^2 c_3 \quad (1)$$

It should be noted that although utility in each period is uncertain due to the probability of death, it is assumed, for simplicity, that there is certainty over income. Therefore, there are no added complications involved in transferring income from one period to another, or more precisely, distributing consumption among periods. Also, r is assumed to be known and constant throughout all periods.

We can now set up the individual's maximization decision which is made at the beginning of period one. It is as follows:

$$\max \quad E(U^L) \text{ with respect to } c_1, c_2, c_3, \hat{\pi}_2$$

$$\text{subject to} \quad WLTH(\hat{\pi}_2) = c_1 + \delta c_2 + \delta^2 c_3$$

At this point the assumptions on the expected lifetime utility function, $E(U^L)$, should be explained. The type of structure to impose on the utility function is controversial. One must weigh the benefits of greater generality with the costs of possible intractability. There are basically three types of general structures that have been imposed on intertemporal models of utility. First, one can express lifetime utility, U^L, in the following most general manner:

$$U^L = U^L(c_1, c_2, \ldots, c_n) \qquad \frac{\partial^2 U^L}{\partial c_i \partial c_j} \neq 0 . \tag{2}$$

The second structure often imposed is to assume a separable U^L but allow the utility functions from one period to another to be different. This structure allows for the fact that individual characteristics, or tastes, may change from one period to another. Within this structure we express U^L as

$$U^L = U_1(c_1) + U_2(c_2) + U_3(c_3) . \tag{3}$$

The third assumption often used is that the utility function is the same in each period and only the arguments change. That is:

$$U^L = U(c_1) + U(c_2) + U(c_3) . \tag{4}$$

Often when structure (4) is used, the individual is also assumed to be myopic. In other words, the individual is assumed to have a rate of time preference with respect to utility. This suggests that people discount future utility since they may prefer present utility to future utility. This modifies (4) in the following manner:

$$U^L = U(c_1) + \left(\frac{1}{1+\rho}\right)U(c_2) + \left(\frac{1}{1+\rho}\right)^2 U(c_3) \tag{4'}$$

where ρ = rate of time preference.

Immediately one can see the advantages of using (3) over (4'). That is, the utility functions in (3) can differ from period to period either because the functional form changes from period to period or they can change merely because people are myopic. In other words, since (3) is more general than (4') the former could employ the same assumptions as the latter by assuming that:

$$U_1 = U(c_1)$$

$$U_2 = (\frac{1}{1-\rho})U(c_2)$$

$$U_3 = (\frac{1}{1+\rho})^2 U(c_3)$$

The model in this section assumes that U^L takes the form of (3); that is, U^L is separable with different utility functions across periods. In this manner utility in each period is assumed to be independent of the arguments in the other periods' utility functions. This loss of generality makes the problem tractable, makes the first order conditions relatively easy to interpret, and, for this model, is a realistic assumption. In this model separability is a realistic assumption for two reasons: (1) the three periods are distinctly different in nature, and (2) each period covers a relatively long period of time. With respect to the second, if each period were one day (or even one year) it might be questionable to assume, for example, that the utility of eating a steak today is independent of whether or not a steak was eaten yesterday. However, it is not as controversial to say that the utility of eating a steak today is independent of whether or not a steak was eaten five years ago.

Also, this model assumes no bequest value. In other words, it would be more precise to say that expected utility in a given period, E(U), is actually:

$$E(U) = (1-\pi)U + \pi\bar{U}$$

where π = risk of death

U = utility in life

$\bar{U}$ = utility in death.

Assuming that $\bar{U}$ is very small relative to U, $\bar{U}$ can be said to be approximately equal to zero. Thus, E(U) reduces to:

$$E(U) = (1-\pi)U.$$

Further, the following typical assumptions on each period's utility function are also made:

$$\frac{\partial E(U_i)}{\partial c_i} > 0 \qquad \frac{\partial^2 E(U_i)}{\partial c_i^2} <$$

Finally, one need not feel uneasy about the fact that there is the possibility that the individual may borrow money on future earnings and then die before he or she pays back the loan. This is a risk incurred on the bank not the individual and is incorporated in the interest rate.

With this information in hand we can formally state the individual's maximization problem as follows:

$$\max \quad E(U^L) = (1-\pi_1)U_1(c_1) + (1-\pi_1)(1-\pi_2)U_2(c_2) + (1-\pi_1)(1-\pi_2)(1-\pi_3)U_3(c_3)$$

subject to: $WLTH(\hat{\pi}_2) = c_1 + \delta c_2 + \delta\ c_3^2$

The lagrangian is therefore:

$$L = E(U^L) + \lambda[WLTH(\hat{\pi}_2) - c_1 - \delta c_2 - \delta^2 c_3].$$

The first order conditions from this maximization problem are as follows:

$$\frac{\partial L}{\partial c_1} = (1-\pi_1)U'_1 - \lambda = 0 \tag{5}$$

$$\frac{\partial L}{\partial c_2} = (1-\pi_1)(1-\pi_2)U'_2 - \delta\lambda = 0 \tag{6}$$

$$\frac{\partial L}{\partial c_3} = (1-\pi_1)(1-\pi_2)(1-\pi_3)U'_3 - \delta^2\lambda = 0 \tag{7}$$

$$\frac{\partial L}{\partial \hat{\pi}_2} = -(1-\pi_1)U_2 - (1-\pi_1)(1-\pi_3)U_3 + \lambda \frac{dWLTH}{d\hat{\pi}_2} = 0 \tag{8}$$

where $U'_i \equiv \dfrac{dU_i}{dc_i}$

conditions (5)-(7) imply respectively:

$$\lambda = (1-\pi_1)U'_1 \tag{5'}$$

$$\frac{\lambda}{(1+r)} = (1-\pi_1)(1-\pi_2)U'_2 \tag{6'}$$

$$\frac{\lambda}{(1+r)^2} = (1-\pi_1)(1-\pi_2)(1-\pi_3)U'_3 \tag{7'}$$

These are standard utility conditions put into an intertemporal expected utility framework. By the envelope theorem, λ is the marginal utility of wealth. Therefore, conditions (5')-(7') imply that, at the optimum, the discounted marginal utility of wealth equals the expected marginal utility of consumption. This is nothing more than a marginal cost equals marginal benefit condition. The right-hand-side in (5')-(7') is the expected marginal utility (benefit) of consumption; that is, an increase in wealth leads to an increase in consumption and hence utility. The left-hand-side in (5')-(7') is the discounted shadow price of wealth. This price must be discounted and is, therefore, highest in the first period (as shown by (5')) since the opportunity cost of consumption in the first period is the highest. This is because a unit of consumption in the first period could have been in the bank for the longest period of time and thus could have rendered a higher level of consumption in the future.

Solving for λ in the first order conditions implies yet another standard utility maximization condition. If we then equate (5) and (6), (6) and (7), and then (5) and (7) respectively, we get the following conditions:

$$\frac{E[U'_1]}{E[U'_2]} = (1+r) \tag{9}$$

$$\frac{E[U'_2]}{E[U'_3]} = (1+r) \tag{10}$$

$$\frac{E[U'_1]}{E[U'_3]} = (1+r)^2 \tag{11}$$

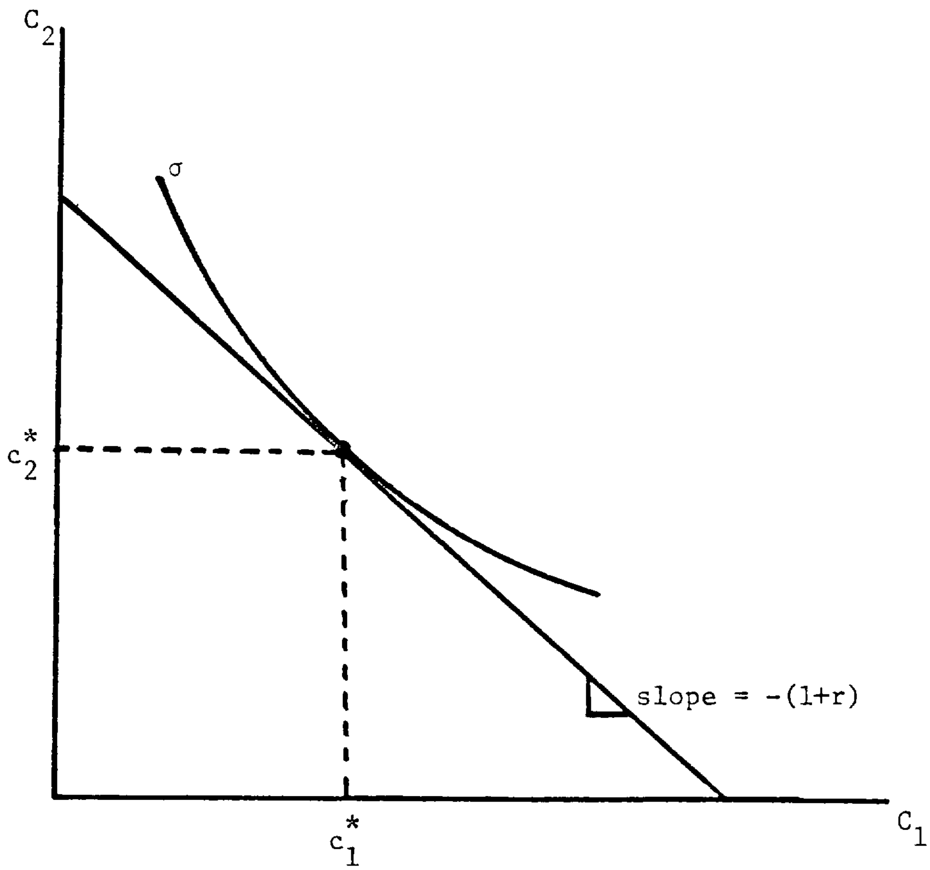
where $E[U'_j] = \prod_{i=1}^{j}(1-\pi_i)U_j$

and E is the expectations operator.

The left-hand side of (9)-(11) is the marginal rate of substitution of c_i for c_j ($i \neq j$; i, j = 1, 2, 3) expressed in expected value terms. This denotes the subjective manner in which the individual would like to substitute a unit of c_i for a unit of c_j. The right-hand side of (9)-(11), on the other hand, represents the marginal rate of transformation of c_i for c_j, MRT_{ij}. MRT_{ij} expresses the objective manner in which the individual can transform a unit of c_i for a unit of c_j. Given convex indifference curves, when these conditions are met, interior solutions for maximum expected utility are obtained.

Figure 3.2 graphically represents condition (9). In this figure the expression (l+r) implies that the individual can transform one unit of c_2 into one unit of c_1 at (l+r). In other words, every unit of cl must be paid back, with interest, during period two. This implies that in total $c_1(1+r)$ must be paid back leaving this same amount unavailable for consumption in period two. Similarly, the individual can postpone a unit of c_2, put it in the bank, and render (l+r) available for consumption in period three. In Figure 3.2, given a convex indifference curve, σ, the optimal values are described by c_1^* and c_2^*.

Figure 3.2: Intertemporal Equilibrium



That these standard intertemporal utility maximization conditions (in expected value terms) fall from the model suggests that the model is correctly set up. Although these conditions are not in themselves earthshattering, they lend credibility to other conditions which follow from the maximization procedure. In particular, we are interested in the type of job (defined above as the level of job-related risk of death) the individual chooses. Recall from the maximization problem that:

$$\frac{\partial L}{\partial \hat{\pi}_2} = -(1-\pi_1)U_2 - (1-\pi_1)U_3 + \lambda \frac{dWLTH}{d\hat{\pi}_2} = 0$$

which implies: $\lambda\frac{dWLTH}{d\hat{\pi}_2} = (1-\pi_1)U_2 + (1-\pi_1)(1-\pi_3)U_3$

$$\frac{dWLTH}{d\hat{\pi}_2} = \frac{(1-\pi_1)U_2 + (1-\pi_1)(1-\pi_3)U_3}{\lambda}$$

$$WLTH'(\hat{\pi}_2) = \frac{(1-\pi_1)(1-\pi_2)U_2 + (1-\pi_1)(1-\pi_2)(1-\pi_3)U_3}{\lambda(1-\pi_2)} \qquad (8')$$

The left-hand side of (8') is the marginal benefit of taking on more risk: the amount present discounted earnings (earnings in period two) increase with an increase in π_2. Remember that since the individual is making the career decision at the beginning of period one, income from period two will be discounted. The left-hand side of (8') is merely the slope of the hedonic wage-risk gradient. In order to interpret the right-hand-side of (8') we must return to the objective function, $E(U^L)$. Totally differentiating $E(U^L)$ and combining like terms yields:

$$E(U'_1)dc_1 + E(U'_2)U'_2dc_2 + E(U'_3)U'_3dc_3$$
$$- [(1-\pi_1)U_2 + (1-\pi_1)(1-\pi_3)U_3]d\hat{\pi}_2 = dE(U^L) \qquad (12)$$

Suppose we ask the question how much must we change the present discounted value of income from period two, given a change in π_2, in order to keep $E(U^L)$ at the same level (i.e. $dE(U^L) = 0$). This is nothing more than a compensating variation measure given a change in π_2. In deriving this compensating variation it is assumed that the individual distributes the additional wealth needed to maintain a given $E(U^L)$ optimally between the three periods. Returning to our first order conditions and solving for U'_i in (5), (6) and (7) we find that an optimal allocation of a change in wealth requires that:

$$U'_1 = \frac{\lambda}{(1-\pi_1)} \qquad (5")$$

$$U'_2 = \frac{\lambda}{(1-\pi_1)(1-\pi_2)(1+r)} \qquad (6")$$

$$U'_3 = \frac{\lambda}{(1-\pi_1)(1-\pi_2)(1-\pi_3)(1+r)^2} \quad (7")$$

substituting (5"), (6"), and (7") into (12), setting $dE(U^L) = 0$, and combining like terms implies that:

$$\lambda[dc_1+\delta dc_2+\delta^2 dc_3] = [(1-\pi_1)U_2+(1-\pi_1)(1-\pi_3)U_3]d\hat{\pi}_2 \quad (13)$$

Recall the intertemporal budget constraint from equation (1):

$$\delta y_2(\hat{\pi}_2) = c_1 + \delta c_2 + \delta^2 c_3$$

or $$WLTH = c_1 + \delta c_2 + \delta^2 c_3$$

totally differentiating (1) yields:

$$dWLTH = dc_1 + \delta dc_2 + \delta^2 dc_3 \quad (14)$$

substituting (14) into (13) yields:

$$\lambda dWLTH = [(1-\pi_1)U_2 + (1-\pi_1)(1-\pi_3)U_3]d\hat{\pi}_2$$

$$\frac{dWLTH}{d\hat{\pi}_2} = \frac{[(1-\pi_1)U_2 + (1-\pi_1)(1-\pi_3)U_3]}{\lambda}$$

$$\frac{dWLTH}{d\hat{\pi}_2} = \frac{[(1-\pi_1)(1-\pi_2)U_2 + (1-\pi_1)(1-\pi_2)(1-\pi_3)U_3]}{\lambda(1-\pi_2)} = MVS_1 \quad (15)$$

$$MVS_1 = \frac{E(U_2) + E(U_3)}{\lambda(1-\pi_2)} \quad (15')$$

This compensating variation, therefore, measures the individual's marginal value of safety, MVS_1. MVS_1 is the amount of wealth an individual will subjectively require in order to take on an additional amount of risk in period two as seen from a period one perspective. As was shown in chapter 2, Mvs > 0. A relatively low value of MVS_1 implies that the individual exhibits a relatively low risk-averse preference and therefore does not require much compensation for taking on π_2.

Therefore, from conditions (8') and (15) we can conclude that:

$$WLTH'(\hat{\pi}_2) = MVS_1 \quad (16)$$

From equation (15') we can see that the magnitude of MVS_1 depends on the levels of $E(U_2)$ and $E(U_3)$ (which in turn depend on U_2, U_3 and on π_1, π_2, and π_3) and λ: the marginal utility of wealth.

This suggests that if an individual expects high levels of utility in the future (i.e., periods two and three) this person will have a relatively high MVS and may be adverse towards entering high risk careers. Also, a low marginal utility of wealth means that for a given level of $WLTH'(\pi_2)$, the amount by which this increases $E(U^1)$ is relatively low. It is, therefore not surprising that this person will be more adverse towards taking a risky career since the benefits are relatively low. This is reflected in a high MVS_1.

Figure 3.3 shows the hedonic wage gradient, $WLTH(\pi_2)$, the individual faces in the above maximization problem. Further, the indifference curves for two different individuals are given as Θ^{**} (for a risk-averse individual) and Θ^{*} (for a risk-loving individual). The risk averse worker consumer satisfies condition (16) by choosing to train for a low risk career, π_2^{**} while the risk-loving worker-consumer chooses to train for the higher risk career π_2^{*}.

The results obtained to this point suggest that MVS estimates from hedonic wage-risk studies, if modified to measure perceived risk, accurately reflect subjective evaluations of risk reductions (as shown by the similarity between Figure 3.3 and Figure 2.4). However, since this is a life cycle model, the question naturally arises will the choice of an optimal job-related risk made at the beginning of period one remain optimal throughout the individual's life?

If the individual at some future point in time re-evaluates the above maximization problem and the optimal level of job-related risk does not change, this individual is said to exhibit dynamic consistency. If, after re-evaluating, the optimal level of risk changes, dynamic inconsistency is said to be observed.

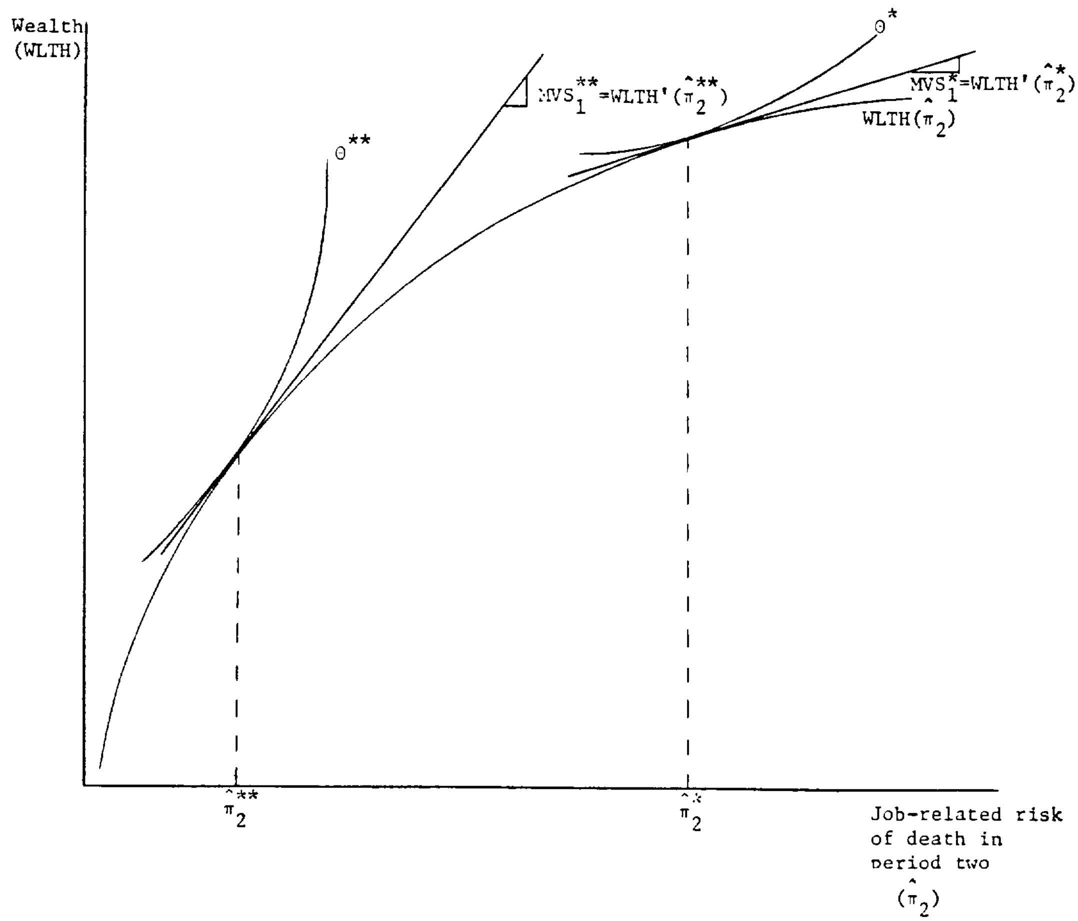
It will be shown in the next section that dynamic consistency will only result under extremely heroic assumptions. Therefore, the worker-consumer is eventually faced with the decision of whether or not to train for a different career.

3.1.2. Problems of Dynamic Inconsistency and Risk Rigidities

The dynamic inconsistency problem stems from the fact that if the individual is to re-evaluate the maximization problem at the beginning of some future period (e.g., at the beginning of the work period), the original "lifetime plan" with respect to optimal risk acceptance is no longer optimal. The results here are similar to Robert Strotz's problem of consistent planning in his 1955 article entitled "Myopia and Inconsistency in Dynamic Utility maximization." Strotz showed that inconsistency arises if the individual discounts utility with a nonexponential discount function.

Strotz's result when applied to this model suggests that, unless the perceived risk of death is constant throughout an individual's life so that the odds of being alive decline exponentially over time, the "optimal" degree of job-related risk may be different when evaluated from some future

Figure 3.3: Hedonic Gradient and Indifference Curves for Risk Averse and Risk Loving Individuals



perspective. If people become more risk averse as they get older, the new optimal level of job-related risk of death will be lower. If this inconsistency is recognized, the individual can either retrain for a lower risk job or stay in the "high" risk job ("high" relative to what is now optimal). At some point in time the transaction costs of retraining and/or relocating will be too high relative to the benefits of shifting into an optimal risk job. Therefore the individual will be forced to stay in a "high risk" job.

Re-evaluating at the beginning of period two, this new problem is formulated as follows:

$$\max_{c_2,\, c_3,\, \hat{\pi}_2} E(U\ ) = (1-\pi_2)U_2(c_2) + (1-\pi_2)(1-\pi_3)U_3(c_3)$$

$$\text{subject to } WLTH(\hat{\pi}_2) - \bar{c}_1(1+r) = c_2 + \delta c_3$$

where: $\bar{c}_1$ = optimal consumption level from period one derived from the original maximization problem

The new first order conditions become:

$$\frac{\partial L}{\partial c_2} = (1-\pi_2)U'_2 - \lambda = 0 \tag{17}$$

$$\frac{\partial L}{\partial c_3} = (1-\pi_2)(1-\pi_3)U'_3 - \delta\lambda = 0 \tag{18}$$

$$\frac{\partial L}{\partial \hat{\pi}_2} = -U_2 - (1-\pi_3)U_2 + \lambda\frac{dWLTH}{d\hat{\pi}_2} = 0 \tag{19}$$

Conditions (17) and (18) again imply the standard utility maximization conditions put in expected utility terms like those derived above. Rewriting (19) we get:

$$WLTH'(\hat{\pi}_2) = \frac{(1-\pi_2)U_2 + (1-\pi_2)(1-\pi_3)U_3}{\lambda(1-\pi_2)} \tag{19'}$$

Where, once again, $WLTH'(\hat{\pi}\ )$, describes the slope of the hedonic wage-risk gradient. Following the same procedure as above to find MVS_2 we find that

$$MVS_2 = \frac{(1-\pi_2)U_2 + (1-\pi_2)(1-\pi_3)U_3}{\lambda(1-\pi_2)} \tag{20}$$

where MVS_2 is the individual's subjective evaluation of a reduction in $\hat{\pi}_2$ from a period two perspective. Conditions (19') and (20) imply that

$$WLTH'(\hat{\pi}_2) = MVS_2 \tag{21}$$

The optimal condition for risk in this problem (i.e., when evaluated at the beginning of period two) is similar to that in the above problem (i.e., when evaluated at the beginning of period one) in that they both describe a tangency between the hedonic gradient and the worker's indifference curve. However, the value for MVS has now changed.

The fact that living through period one is no longer uncertain gives the individual added information (i.e., that $\pi = 0$). Comparing (20) with with (15) we see that the difference between them is that condition (15) has the added term, $(1-\pi_1)$, multiplied to the numerator. Further, the value for λ is different because the maximization problem has changed. Since $0 < (1-\pi_1) < 1$, the numerator in (20) has increased from that in (15). However, the value for λ in (20) cannot be readily compared with the value for λ in (15) and, therefore, it cannot be determined from the calculus whether the denominator in (20) has increased or decreased from that in (15). On the other hand, there is no reason to believe, given these two changes, that MVS_1 equals MVS_2. If, however, individuals do in fact become more risk averse as they get older MVS_2 would be larger than MVS_1. If this is the case, the optimal level of risk derived at the beginning of period one is no longer optimal; in fact it is too high. Combining the tangency condition from (21) along with the fact that the individual's MVS has increased, suggests that their entire preference map has changed. Specifically, the individual now exhibits more risk-averse preferences (i.e., the indifference curves have become more steep).

Figure 3.4.1 represents this situation. $\hat{\pi}_2^*$ is the optimal level of risk when the individual evaluates the maximization problem at the beginning of period 1. $\hat{\pi}_2^{**}$, on the other hand, is the optimal level of risk when the individual re-evaluates the maximization problem at the beginning of period two. Note that Θ^* is a member of the old (less risk averse) preference map while Θ^{**} is a member of the new (more risk averse) preference map.

The costs of retraining for and shifting into a lower risk job are prohibitively high, the individual is locked into the "high risk" job, $\hat{\pi}_2^*$. Since the individual's indifference map is now changed, $\hat{\pi}_2^*$ is now associated with a point on an indifference curve such as Θ^{**} in Figure 3.4.2.

Figure 3.4.2 shows that the individual would like to be in a job with a risk level $\hat{\pi}_2^{**}$ which renders a maximum level of expected utility, Θ^{**}. However, since the person is locked into a job with risk $\hat{\pi}_2^{**}$ this person is at the sub-optimal level of utility, Θ^{**}. At $\hat{\pi}_2^{**}$ the slope of the hedonic wage gradient is less than the slope of the individuals indifference curve. That is, a "wedge" is placed between these two slopes. Therefore, if the hedonic approach is used to measure an individual's MVS (as interpreted by the slope of the hedonic wage gradient) this approach will underestimate peoples' true valuations of safety. The difference between these two slopes is the amount by which the hedonic approach underestimates an individual's MVS.

Figure 3.4.1: Indifference Map Between Wealth and Risk (1)

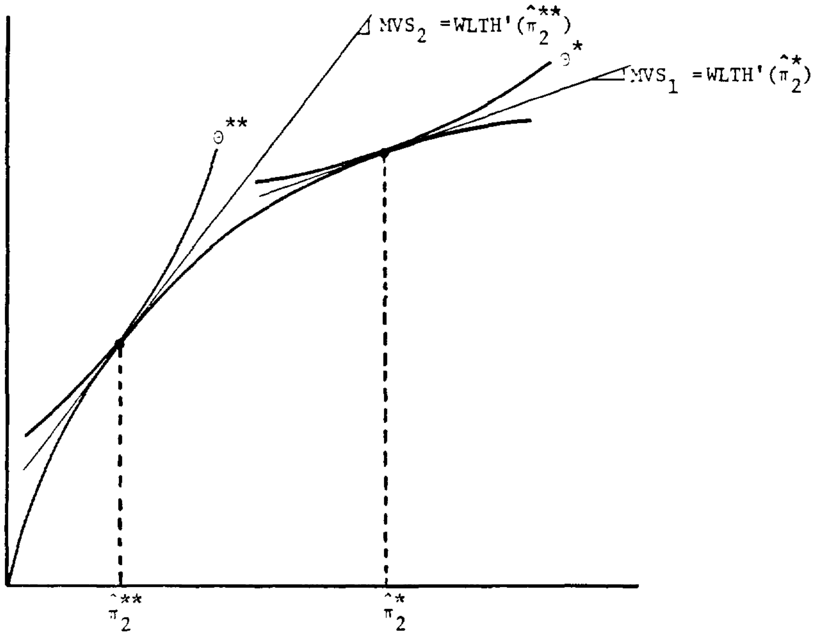
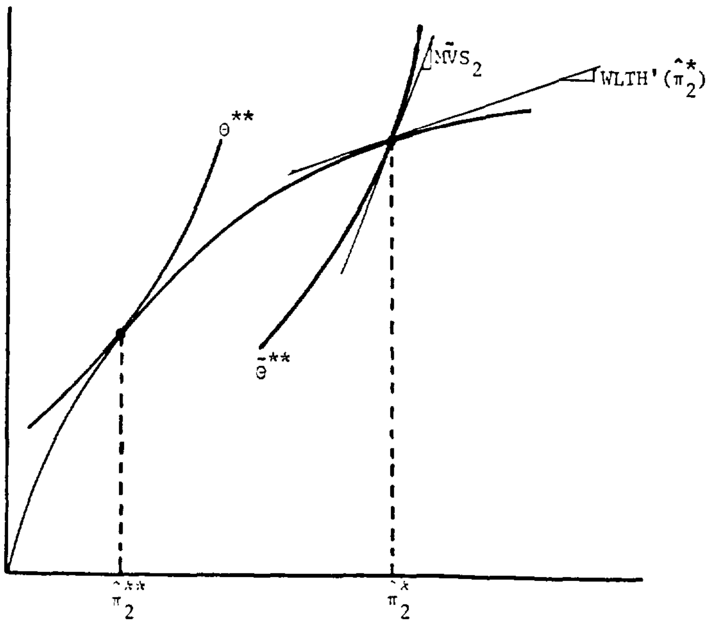


Figure 3.4.2: Indifference Map Between Wealth and Risk (2)



3.2 NON-SYMMETRIC CAPITAL MOBILITY

In the previous two sections a typical intertemporal budget constraint was employed wherein the interest rate at which an individual can borrow on future earnings was identical to the rate earned on savings. Once this assumption is dropped, however, the results of the model presented above are changed and another "wedge" between the slope of the hedonic wage gradient and an individual's MVS is rendered.

The budget constraint employed here takes into account that the interest rate on borrowed funds, r_b, may well differ from the rate on savings, r_s; the former taking into account the risk that the individual may not survive to pay back the loan.

Recall that the intertemporal budget constraint used above, re-written, was in the form:

$$\frac{WLTH(\hat{\pi}_2)}{\delta} = (1 + r)c_1 + c_2 + \frac{c_3}{(1 + r)} \tag{22}$$

If we assume that the real rate of interest which the individual can borrow on future earnings, r_b, differs from the real rate of interest on savings, r_S, equation (21) is modified as

$$\frac{WLTH(\hat{\pi}_2)}{\delta} = (1 + r_b)c_1 + c_2 + \frac{c_3}{(1 + r_s)} \tag{23}$$

It will be assumed, however, that there exist some relationship between r_b and r_S and that $r_b \geq r_s$. Specifically the assumption is made that:

$$(1 + r_b) = \gamma(1 + r_s) \tag{24}$$

where $1 < \gamma < \infty$.

In the above life cycle model the individual borrows on future earnings in order to finance consumption during his training period. Depending on the specific job the individual is training for, the risk associated with his particular job will affect the probability that he will live to pay back the loan. While r_b is influenced by other job-related factors, as well as non-job-related factors, it is reasonable to assume that r_b will increase, ceteris paribus, with the risk level of the job the individual is training for, specifically,

$$\gamma = \gamma(\hat{\pi}_2) \tag{25}$$

where $\gamma' > 0$.

Assuming that money is discounted at the opportunity cost of savings, equation (22) can now be re-written as:

$$WLTH(\hat{\pi}_2) = \gamma(\hat{\pi}_2)c_1 + \delta c_2 + \delta^2 c_3 \tag{26}$$

where $\delta = 1/(1 + r_s)$. The individual's beginning of the first period maximization problem now becomes:

$$\max_{c_1,\, c_2,\, c_3,\, \hat{\pi}_2} \quad E(U^L)$$

$$\text{subject to: } WLTH(\hat{\pi}_2) = \gamma(\hat{\pi}_2)c_1 + \delta c_2 + \delta^2 c_3$$

From the first order conditions the optimal level of job-related risk is described by the condition:

$$WLTH'(\hat{\pi}_2) = MVS_1 - \gamma' c_1 \tag{27}$$

where again the left hand side of (27) is the slope of the hedonic wage gradient.

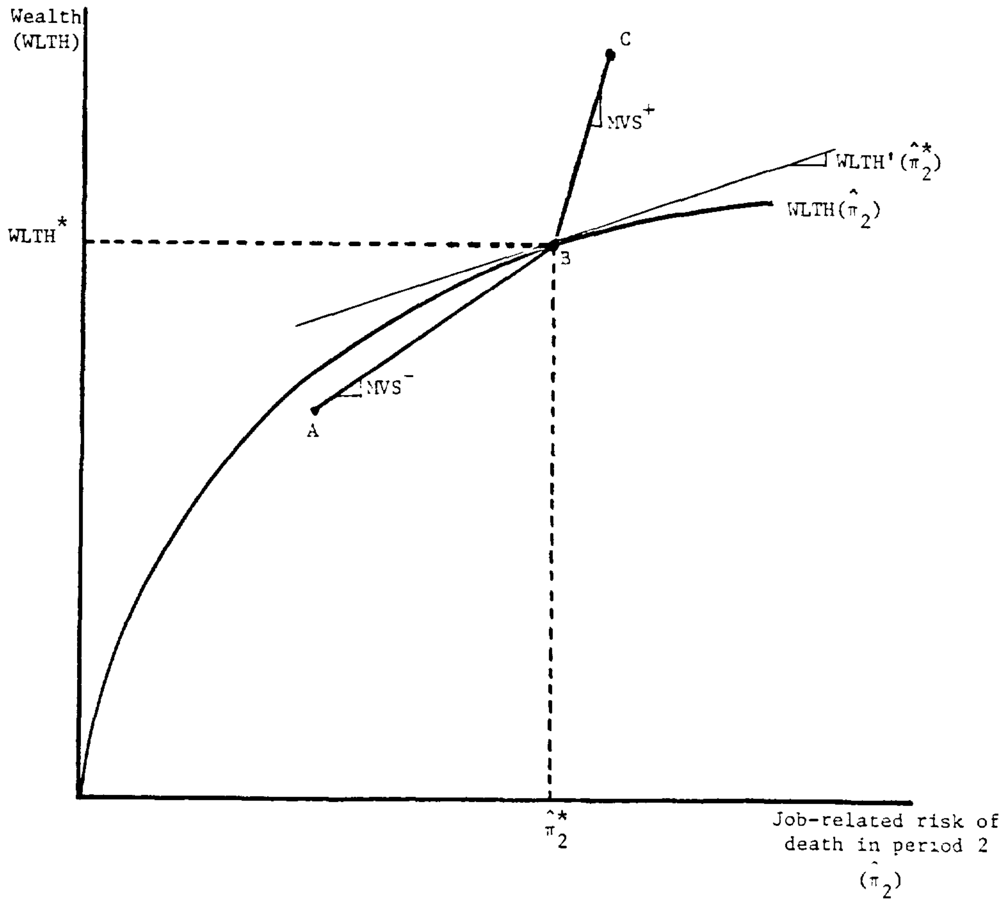
From equation (27) it is clear that the rate of which the market compensates the worker does not equal his subjective MVS: specifically, $WLTH'(\pi) < MVS_1$. Therefore in this situation hedonic wage-risk studies would underestimate workers' true evaluations of risk reduction.

3.3 HEDONIC ESTIMATES AND WTP VS. WTA

The theoretical model presented above offers two reasons why one might expect, a priori, hedonic estimates of valuations of an expected life saved to underestimate the "true" subjective MVS measure. This hypothesis is tested in Chapter 5. Further the theoretical results in Section 2.4 suggest another testable hypothesis that WTA measures should exceed WTP measures of the MVS: The difference being explained by individual's conservative tendency to overestimate losses in wealth and underestimate gains in wealth.

These two theoretical results are brought together here and are shown in Figure 3.5. This figure shows the hedonic wage gradient, $WLTH(\pi_2)$, as intersecting the worker-consumer's indifference curve, ABC as suggested by the results in Sections 3.1 and 3.2. For illustrative purposes, the curve ABC has been linearized about the initial (optimal) levels of job-related risk of death and wealth, $\hat{\pi}_2^*$ and WLTH* respectively. Similar to the curve, ABC has a steep segment, BC (which corresponds to the individual underestimating gains in wealth), and a flat segment, AB (which corresponds to the individual overestimating losses in wealth). Further, the slope of AB, MVS^-, corresponds to the subjective MVS for a reduction in period two's job-related risk of death (i.e., WTP) while the slope of BC, MVS^+, corresponds to the subjective MVS for an increase in such risk (i.e., WTA). This figure suggests that, while estimates from hedonic wage-risk studies underestimate an individual's true MVS (since MVS^+ 7 MVS^- 7 $WLTH'(\hat{\pi}_2^*)$), these studies may yield estimates which are statistically similar for WTP measures (since $MVS^{-} - WLTH'(\hat{\pi}_2^*)$ is relatively small). On the other hand one would expect hedonic estimates to grossly underestimate true WTA measures of the MVS (since $MVS^{+} - WLTH'(\hat{\pi}_2^*)$ is relatively large). These hypotheses are tested in Chapter 5.

Figure 3.5: Hedonic Wealth-Risk Gradient



CHAPTER 4
SURVEY METHODOLOGY

4.1 OVERVIEW

The data analyzed in this report are drawn from a national mail survey conducted in the summer of 1984. The data collected measure

(1) individual perceptions of respondents job-related risk of death,

(2) willingness to pay and willingness to accept measures for hypothetical changes in these risks (i.e., the contingent valuation), and

(3) all socio-economic earnings, hours, work place, and human capital characteristics needed for estimating a hedonic wage equation.

The intertemporal expected utility model developed in chapter three would suggest that the market does not correctly compensate individuals for the risk they face on the job. Hence, the hypothesis is that standard hedonic wage-risk models fail to accurately measure marginal value of safety. A comparison of the contingent valuation method for measuring marginal value of safety with the hedonic wage equation derived from the same subjects provides a test for this hypothesis.

The decision to conduct a mail survey (rather than face-to-face interviews) was determined primarily by cost. The mail survey is less expensive by at least a factor of ten, however, there are difficulties associated with mail surveys. The type of information required for this study is difficult for the respondent to fully understand, and the quantity of information needed was large. Both of these factors would tend to decrease response rates and the reliability of responses. For these reasons every possible effort was made to implement the best possible survey techniques to minimize these effects. In fact, a secondary objective of this study is to test whether complex data of this type can be obtained via a mail survey.

Since both willingness to pay and willingness to accept measures of individuals' marginal values of safety were sought, two forms of the questionnaire were developed. These two forms were identical except for the one contingent valuation question, and the language used to ask these two questions were made as similar as possible. Both forms of this question are presented in Appendix A.

The total design method for mail surveys, as discussed in Dillman (1978), was used for this study. This method includes the design of the questionnaire, the procedures for mailing the questionnaires, and all follow-up procedures. Dr. Dillman served as a consultant to this project to further insure quality survey technique.

4.2 QUESTIONNAIRE DEVELOPMENT

The form of the questionnaire is of critical importance in any mail survey. It must be attractive in appearance, the information needed by the respondents must be clearly worded, the questions and response categories must be clearly stated, and there should be a natural flow which encourages the respondent to complete all the questions. Most of all, the questions must be carefully worded to avoid any bias in response. The length of the questionnaire is also important; and any more than ten pages often results in significant reduction in response rates.

A complete list of information required for the study objectives was compiled, and tentative question formats were prepared. In this process, the researchers were guided by an extensive review of the literature and other surveys dealing with estimating the marginal value of safety. A maximum length of ten pages was set. Several revisions of the individual questions and order of questions were made. General principles guiding this development include:

- The early questions should be simple, applicable to all respondents, interesting, and a sense of neutrality should be conveyed.
- Questions should be ordered along a descending gradient of importance, and questions with similar content should be grouped together.
- Questions which might be objectionable to most respondents should be placed after less objectionable ones.

The questionnaire form was a booklet made from 8½" x 12¼" sheets. The cover contained the study title, a graphic illustration related to risk, name and address of study group, and directions as to who should answer the questionnaire. The back page had only an invitation for additional comments, a thank you, and an offer to send results of the study. Lower case letters were reserved for questions and upper case for answers. Answer categories were identified on the left with numbers, and a vertical flow was established throughout. Some graphics were used to explain concepts, such as risk of death, and to identify question flow.

Three methods were used to pretest the questionnaire. The purpose of the pretesting was to uncover any problems in wording or format that would be difficult for the respondent to understand or would result in bias in the answer. The first pretest involved several persons on the University of Wyoming campus knowledgeable about survey design and/or the area of risk, for example the University safety officer completed the questionnaire and made comments relative to wording and completeness. The second pretest involved 30 University employees in buildings and grounds. Their occupations were in construction, clerical, mechanics, grounds keepers, and maintenance. The final pretest involved mailing 250 questionnaires to 250 households randomly selected from the Denver, Colorado Springs, and Pueblo phone books. Researchers pursuing other related research projects funded by current USEPA cooperative agreements also reviewed the questionnaire. Responses to questions and comments made on all three of these pretests were incorporated into the final form of the questionnaire.

Dr. Don Dillman, acknowledged expert on sample survey design and founder of the total design method, was employed as consultant to review the questionnaire. This review resulted in a number of improvements in the form, particularly in terms of the graphics used and explanation of risk concepts. Copies of the final questionnaire form are found in Appendix A.

4.3 SAMPLE DESIGN

Two conditions imposed on the sample design were that: (1) it be national in scope and (2) efforts be made to insure adequate response in the high risk categories. It was also recognized that persons unemployed, retired, part-time worker only, self-employed, or for whom a substantial portion of their income was made up of government assistance would not be useful respondents. (This point is treated more fully in Chapter 5). Therefore, some deliberate over sampling was required to insure an adequate number of useable responses.

The first component of the sample consisted of a simple random sample of 3,000 households from the entire United States. The second component was more complex. Four regions, Northeast, South, West, and North Central were identified. States within each of the four regions that were known to have concentrations of high risk industries (lumbering, mining, oil, steel mills, construction, heavy industry, etc.) were selected. Within these states, counties with highest concentrations of these industries were selected (a total of 105 counties). Finally, 750 households were randomly drawn from the selected counties in each of the four regions. Thus, the second part of the sample consisted of 3,000 households randomly selected from 105 counties known to have high concentrations of high risk industries. Tables 4.2 and 4.3 contain a summary comparison of the demographic characteristics of these two samples.

The actual sample was generated by Survey Sampling, Inc., 180 Post Road East, Westport, CT 06880. This firm maintains and regularly updates computer tapes of census data, and they have the capability of generating random samples from a wide variety of specifications. In particular, they were able to generate one national random sample of size 3,000, and random samples of size 750 each from the four lists of counties we provided. Their updating of files is such that they guarantee less than 15 percent of the addresses undeliverable. In our study, that figure was about 12 percent.

4.4 SURVEY PROCEDURES

On Monday, July 9, all 6,000 households in the sample were mailed a cover letter, a copy of the questionnaire, and a stamped return envelope. The cover letters were individually addressed, typed on monarch stationery, and hand-signed in blue ink. This letter was designed to explain the nature and usefulness of the study, that all respondents are important, and to assure confidentiality (see copy in Appendix B). An identification number was stamped on each questionnaire for follow-up procedures. Each of the two samples of 3,000 were ordered by zip code. Willingness to pay and willingness to accept questionnaires were alternated through the samples.

Eight days after the initial mailing, July 16, post cards were sent to all persons in the sample. The first follow-up was designed as a thank you and a reminder, the post card included the mail-out date and an individual signature in blue ink of the project director. The person's name and address was typed on the card as opposed to mailing labels. A copy of the post card is given in Appendix C.

Twenty-two days after the original mail-out, July 30, a second follow-up consisting of a replacement questionnaire, a stamped return envelope, and a cover letter were sent to everyone who had not yet responded. This cover letter, also individually typed and signed, was designed to encourage the respondent to complete and return the questionnaire (see copy in Appendix D). No further follow-ups were planned or implemented, however, the total design method does include one more by certified mail or phone.

4.5 RESPONSE RATES

Of the 6,000 questionnaires mailed, 749 (12.5 percent) were returned by the post office as undeliverable. A total of 2,103 were returned complete for a response rate of 40 percent of delivered or 35 percent of total mailed. Of these returns, only 1,231 were employed and therefore useable in this study. Thus the actual useable returns are only 20.5 percent of the original mailing, or 23.4 percent of those delivered. Figure 4.1 is a graphical display of the responses by time from the first mailing.

The motivation for splitting the sample was to obtain more responses from individuals in high risk jobs. Table 4.1 gives the numbers in each (perceived) risk category for the two samples. The sample from selected counties did in fact have significantly more (α = .037) respondents in higher risk categories, however the difference in actual numbers is not great. For example, there were only 31 more respondents from the random sample of selected counties in the risk categories 6 through 10 as compared to the simple random sample. This is a difference of 15 percent compared to 9.5 percent.

Table 4.2 contains a comparison of job related characteristics between the national random sample and the random sample drawn from selected

FIGURE 4.1 CUMULATIVE RESPONSES BY DAY

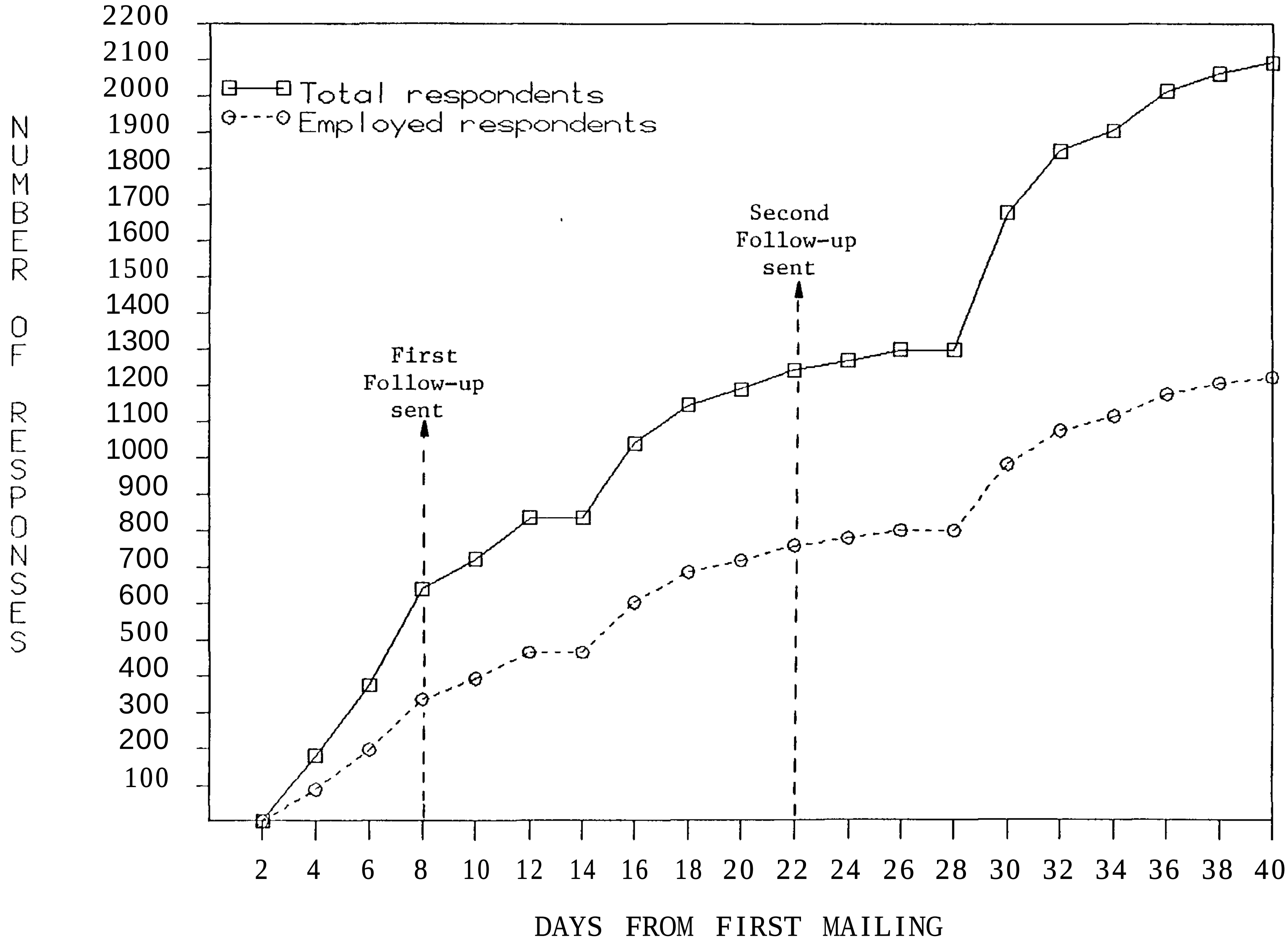


TABLE 4.1: LEVEL OF RISK

Sample Type	12	3	4	5	6	7	8	9	10	Total
National Random	285	72	58	41	39	21	8	13	6	7	572
Random from Selected Counties	244	81	71	36	37	26	23	23	3	11	575
Total	529	153	129	77	76	74	31	36	9	18	1147

Number of missing values = 71
Completed returns not in this run = 84.

counties. The p values listed are for the tests of the null hypothesis that the two populations are the same. None of these job characteristics were significantly different at the .05 level of significance. The three that were significant at the .10 level were the level education required for the job, whether or not special training was needed, and the type of special training needed. It was interesting that occupation classification was not significantly different even though that characteristic is more directly related to the selection of counties.

Table 4.3 contains a similar comparison for personal characteristics of the respondents. The only two that show significant differences were type of living area and type of work area. This is to be expected since property is directly related to the counties selected and the fact that samples of equal size were drawn from the four regions of the United States. None of the other personal characteristics were anywhere near significant.

The similarity of the two samples with respect to demographic characteristics would tend to indicate that weighted regression estimates will be almost identical to unweighted. Further analysis will be completed using weighted regressions to either confirm or contradict this statement, and these results will appear in the final draft. Further analysis will also consider regional differences in the wage equation as well as the impact of air pollution measures.

The actual cost for completing the data collection for this study was approximately $14.00 per completed questionnaire, or nearly five dollars for each sampled household. This figure does not include the time of principal investigators directly related to the questionnaire design, the sample design, and data preparation. It also does not include such activities as the theoretical formulation of the problem, the analysis and interpretation of the data, and the writing of reports and research papers. Face-to-face interviews for a study of this type would likely be in excess of $100.00 per completed interview, exclusive of transportation costs which would be enormous for a national sample.

TABLE 4.2: COMPARISON OF JOB CHARACTERISTICS FOR NATIONAL AND SELECTED COUNTIES RANDOM SAMPLES

Characteristics	National Random Sample	Selected Random Sample	p value
Occupation Type:			
Service Worker	8.7	8.0	.286
Laborer	6.6	8.7	
Transportation Operator	3.3	4.8	
Equipment Operator	4.2	5.8	
Craft Worker	15.5	16.6	
Clerical Worker	6.1	5.3	
Sales Worker	6.3	7.3	
Manager or Administrator	16.3	12.8	
Professional or Technical	31.1	29.9	
Farmworker	1.9	.9	
Education Required for the Job:			
0-8 Grades	4.9	4.5	0.63
6-9 Grades; Finish Grade School	1.4	2.1	
9-11 Grades; Some High School	4.5	6.3	
12 Grades; Finish High School	31.6	34.1	
Some College, No Degree Necessary	19.4	19.3	
College Degree; BA or BS	25.9	18.1	
Some Graduate Work	3.3	4.7	
Advanced College Degree or Professional Degree	8.9	11.0	
Special Training Needed for the Job:			
Yes	80.6	84.8	0.61
No	19.4	15.2	
Type of Training Needed for the Job:			
None	17.1	15.1	.097
Apprenticeship	5.0	7.4	
Vocational Trade School	3.2	2.9	
On-The-Job Training	29.3	30.6	
Work Experience from Another Job	22.9	17.6	
Other	22.6	26.3	

(continued)

Table 4.2, continued

Characteristics	National Random Sample	Selected Random Sample	p value
Type of Employment:			
Self Employed	15.9	16.5	.626
Government	17.0	17.9	
Other	67.1	65.6	
Do You Supervise Others:			
Yes	59.4	60.4	.719
No	40.6	39.6	
Is Your Job Covered by a Union Contract:			
Yes (Member)	24.7	30.5	
Yes (Not Member)	4.9	5.8	
No	70.5	63.7	
Way Paid:			
Salary	50.8	46.9	.296
Hourly Wage	37.2	41.7	
Other	12.0	11.4	
Number of Years Training Needed	3.32	3.51	.399
Years Worked for Current Employer	11.39	12.09	.231
Years this Type of Work	13.18	13.79	.320
Number Employed where You Work	669.41	588.93	.355

TABLE 4.3: COMPARISON OF PERSONAL CHARACTERISTICS FOR NATIONAL AND SELECTED COUNTIES RANDOM SAMPLES

Characteristics	National Random Sample	Selected Random Sample	p value
Sex:			
Male	82.7	85.2	.249
Female	17.3	14.8	
Race:			
White	93.2	95.4	
Nonwhite	6.8	4.6	
Education:			
0-5 Grades	.5	.5	.387
6-8 Grades; Finished Grade School	1.7	3.6	
9-11 Grades; Some High School	4.2	5.1	
12 Grades; Finished High School	9.6	20.9	
Trade School	8.8	6.3	
Some College	24.3	25.1	
College Degree; BA or BS	19.2	16.2	
Some Graduate Work	7.5	7.5	
Advanced College Degree or Professional Degree			
Living Area Type:			
Rural	26.0	34.7	.005
Suburban	56.0	49.8	
Central City	18.0	15.5	
Work Area Type:			
Rural	21.8	31.0	.001
Suburban	38.0	36.1	
Central City	40.2	32.9	

(continued)

Table 4.3, continued

Characteristics	National Random Sample	Selected Random Sample	p value
Veteran:			
Yes	39.0	38.3	.802
No	61.0	61.7	
Age:			
Mean	42.15	42.60	.533
Years Worked Since 18:			
Full or Part Time	22.49	22.72	.739
Full Time	20.91	21.13	.759

CHAPTER 5

EMPIRICAL MARGINAL VALUE OF SAFETY ESTIMATES

Empirical estimates of the marginal value of safety (MVS) from both hedonic studies and contingent valuation studies have been summarized in the economics literature (e.g. Violette and Chestnut, 1983). As a result, there may be a natural inclination to compare the safety valuations implied by these two methods. However, the MVS estimates from studies which utilize the hedonic technique are not directly comparable to those derived from contingent valuation studies primarily because different measures of risk, as well as different types of risk, are employed. As a result the two approaches can not be directly compared.

In Chapter 4 a particular survey design was described whose goal was to directly compare the hedonic and contingent valuation approaches. Information was obtained from each respondent which rendered two separate MVS estimates: one from an estimated hedonic wage-risk equation and another through a contingent valuation process. Since both procedures utilized the same risk measure (perceived job-related risk of death and data set, some insight on how one technique compares to the other can be drawn. Moreover, since each respondent was directly asked the perceptions of his specific occupation, the type of error in variables problems mentioned in chapter two are presumed to be circumvented.

The remainder of this chapter is organized as follows: in Section 5.1 the hedonic wage equation to be estimated is specified with the empirical results reported in Section 5.2. Section 5.3 compares the MVS measures obtained from both the hedonic wage equation and the contingent valuation with the resulting implications and conclusions in Section 5.4.

5.1 SPECIFICATION OF THE WAGE EQUATION

The general form of the hedonic wage equation considered here is based on that used by Gerking and Weirick (1983) and is in the following form:

$$LWAGE = f(H, P, W) \qquad (1)$$

where LWAGE denotes the natural logarithm of the wage rate paid, H denotes a vector of human capital variables, P denotes a vector of personal characteristics, and W denotes a vector of work environmental variables. The natural logarithm of the wage rate is employed in order to compensate for the non-normal distribution of income. By forcing the distribution of income to be roughly normal, equation (1) can be estimated via an ordinary least squares (OLS) procedure. Further, the vectors H, P. and W pertain to the household head, and his or her primary job in 1983, from families across the entire United States. Further, the wage rate paid, WAGE, was adjusted for regional price differences.

Within equation (1) the vector H measures: (1) the highest level of formal schooling completed (CED), (2) years worked in the present occupation (YWO), (3) years of full time work experience (WEXP), and (4) years worked for present employer (YREMP).

Personal characteristics, P, are described by measurements on : (1) age (AGE), (2) race (RACE), (3) sex (SEX), (4) physical limitations or disabilities (PHYS), (5) whether or not the household head has moved in the last three years (MOVE), and (6) whether or not the individual lives in a rural area (LIVEA).

The vector W measures: (1) the individual's perceived level of job-related risk (RISK), (2) the highest level of formal schooling required to work on the present job (RED), (3) the number of people the individual supervises (SUP), (4) whether or not the individual works in the public sector (PUB), (5) whether or not some work experience or special training is required to get a job like the present one (REXP), (6) union membership (UNI), (7) years required for the average new person to become fully qualified in the head's present job (QUAL), (8) the type of occupation the individual is employed in (OCC), (9) miles traveled from the head's home to his job (DIST), (10) whether or not the job is located in a rural area (JOBA), and (11) the number of people employed at the head's work (NUM).

While the variables contained in vectors H, P, and W are expected to explain variations in the wage rate, cross effects between some variables might also be expected to be significant. Since this research effort concentrates on risk, the following cross terms are analyzed: (1) risk with age (RXAGE), (2) risk with union status (RXUNI), (3) risk with sex (RXSEX), and (4) risk with race (RXRACE).

Similar cross terms to those described above have been employed in other hedonic wage-risk studies (e.g., Thaler and Rosen, 1975; Viscusi, 1978a; Olson, 1981). In this study, both RXSEX and RXRACE were continually found to be highly insignificant; therefore, only RXAGE and RXUNI were included in the final estimate wage equation.

Exact descriptions for these data are contained in Table 5.1 with their sample means reported in Table 5.2. Further, all the variables above were obtained from the survey described in chapter four (see Appendix A).

Before equation (1) was estimated, a few theoretical problems in using the complete data set had to be addressed. Gerking and Weirick (1983) note that households which receive a significant percentage of their income in the form of transfer payments face non-convex budget constraints. To

TABLE 5.1
VARIABLE DEFINITIONS

A. DEPENDENT VARIABLE

WAGE = (Head's average hourly wage rate from primary job)[1]

LWAGE = In (WAGE)

B. HUMAN CAPITAL VARIABLES

CED1 = 1 if (CED) = 0 to 5 grades, otherwise = 0

CED2 = 1 if (CED) = finished grade school, otherwise = 0

CED3 = 1 if (CED) = some high school, otherwise = 0

CED4 = 1 if (CED) = finished high school, otherwise = 0

CED5 = 1 if (CED) = finished high school and some trade school, otherwise = 0

CED6 = 1 if (CED) = some college, otherwise = 0

CED7 = 1 if (CED) = college degree; BA or BS, otherwise = 0

LEDB = 1 if (CED) = some graduate work, otherwise = 0.[2]

YWO = (Years worked in present occupation)

WEXP = (Years of full time work experience)

YREMP = (Years worked for present employer)

C. PERSONAL CHARACTERISTIC VARIABLES

AGE = (Age in years)

RACE = 1 if white, otherwise = 0

SEX = 1 if male, otherwise = 0

PHYS = 1 the individual has any physical or nervous conditions that would limit the type or amount of work he could do, otherwise = 0

MOVE = 1 if the individual has moved in the last three years, otherwise = 0

LIVEA = 1 if the individual lives in a rural area, otherwise = 0

(continued)

Table 5.1 (continued)

D. WORK ENVIRONMENT VARIABLES

RISK = (the individuals perceived level of job-related risk of death) Risk takes on an integer value from 1 (one job-related death per year per 4,000 workers in the individual's occupation) to 10 (ten job-related deaths per year per 4,000)

RED1 = 1 if (RED) = 1 to 8 grades, otherwise = 0

RED2 = 1 if (RED) = finish grade school, otherwise = 0

RED3 = 1 if (RED) = some high school, otherwise = 0

RED4 = 1 if (RED) = some college; no degree necessary, otherwise = 0

RED5 = 1 if (RED) = some college; no degree necessary, otherwise = 0

RED6 = 1 if (RED) = college degree; BA or BS, otherwise = 0

RED7 = 1 if (RED) = some graduate work, otherwise = 0.[3]

SUP = (the number of people the individual supervises)

PUB = 1 if the individual is employed in the public section, otherwise = 0

REXP = 1 if some work experience or special training is required to get a job like the individual's, otherwise = 0

UNI = 1 if the individual has a union contract, otherwise = 0

QUAL = (the number of years it would take the average person to become fully trained and qualified on the present job)

OCC1 = 1 if (OCC) = service worker, otherwise = 0

OCC2 = 1 if (OCC) = laborer, otherwise = 0

OCC3 = 1 if OCC = transportation operator, otherwise = 0

OCC4 = 1 if (OCC) = equipment operator, otherwise = 0

OCC5 = 1 if (OCC) = craft worker, otherwise = 0

OCC6 = 1 if (OCC) = clerical worker, otherwise = 0

OCC7 = 1 if (OCC) = sales worker, otherwise = 0

(continued)

Table 5.1 (continued)

OCC8 = 1 if (OCC) = manager or administrator, otherwise = 0[4]

OCC9 = 1 if (OCC) - farmer, otherwise = 0

NUM = (the number of people employed at the head's workplace)

DIST = (the miles from the individual's home to his work)

JOBA = 1 if the job is located in a rural area, otherwise = 0

E. CROSS TERMS

RXUNI = (RISK) x (UNI)

RXAGE = (RISK) x (AGE)

TABLE 5.2: MEANS AND STANDARD DEVIATIONS OF VARIABLES MEASURED

Variable	Mean	Standard Error
LWAGE	2.411	.017
CED1	.007	.003
CED2	.020	.005
CED3	.048	.007
CED4	.213	.014
CED5	.076	.009
CED6	.244	.015
CED7	.183	.014
YWO	12.509	.336
WEXP	20.650	.412
YREMP	11.838	.341
AGE	41.595	.403
RACE	.945	.008
SEX	.837	.013
PHYS	.115	.014
MOVE	.220	.015
LIVEA	.331	.016
RISK	2.605	.075
RED1	.029	.006
RED2	.010	.003
RED3	.050	.008
RED4	.362	.017
RED5	.191	.014
RED6	.227	.015
RED7	.042	.007
SUP	13.637	2.606
PUB	.212	.014
REXP	.839	.013
UN1	.390	.017
QUAL	3.215	.115
OCC1	.091	.010
OCC2	.069	.009
OCC3	.037	.007
OCC4	.059	.008
OCC5	.164	.013
OCC6	.058	.008
OCC7	.050	.008
OCC8	.150	.013
OCC9	.004	.002
DIST	11.625	.470
JOBA	.246	.015
RXUNI	.255	.054
RXAGE	-23.537	114.096

circumvent this problem, those household heads which received more than 20 percent of their total income from transfer payments were eliminated from the sample. Further, Gerking and Weirick state that "casual workers ... may be out of equilibrium because their asking wage may exceed their offered wage." In light of this potential problem, those household heads who worked less than 1,250 hours in 1983 were also eliminated from the sample.

In addition to these two sets of exclusions, individuals who were self-employed were also eliminated from the data set. The justification for this centers around the difficulty these individuals might have in estimating their total number of 1983 working hours. Without a reliable measure for hours, an accurate wage rate cannot be imputed for those who are self-employed.

As is usually the case with large data sets, missing values were present in the original data. A reasonable method commonly employed in econometric studies is to assign means (for continuous variables) and modes (for discrete variables) in situations where an observation on a particular variable is missing. This method was employed in this study except for the risk, wage, and occupation variables. Since an individual's wage rate is the variable which equation (1) is attempting to explain, it was felt that substituting the mean for WAGE in situations where this variable was missing would be inappropriate. Consequently, individuals who did not report their 1983 wage were eliminated from the data set.

With respect to risk, another method was employed to deal with missing values. This procedure entailed regressing perceived risk on occupation for the subset of total respondents who gave information on these two variables. Then, this regression equation was utilized for the purpose of predicting a perceived risk measure for those individuals who did not report such a measure. By doing this, it was felt that a more accurate representation of their perceived risk would be rendered than if merely the mean of RISK was used. Of course for the few people who did not report an occupation (this amounted to 12 observations) this could not be done; therefore, these observations were eliminated from the data set.

With respect to the variables in which a mean or mode was assigned to a missing value, the total number of these cases was not significant. Depending on the particular variable, and after the above sets of exclusions were made, missing values ranged from 0 to 20. Further, after the above sets of exclusions were made, the data set was reduced from 1,351 observations originally available from the survey to 888. Therefore, at worst, the number of missing values for any specific variable amounted to only 2 percent of the final data set.

5.2 EMPIRICAL ESTIMATES

The exact specification of equation (1) is shown in Table 5.3 along with the resulting ordinary least squares (OLS) estimates. Because the dependent variable is in logarithmic form, the coefficients are interpreted

TABLE 5.3: REGRESSION RESULTS

Dependent Variable: LWAGE
Number of Observations: 888
Sum of Squared Residuals: 105.54
R-Squared: .495
Adjusted R-Squared: .464

Explanatory Variable	Coefficient	Standard Error	t-Statistic
CED1	-.277 E-0	.166 E-0	-1.665
CED2	-.342 E-0	.115 E-0	-2.951
CED3	-.264 E-0	.852 E-1	-3.101
CED4	-.204 E-0	.653 E-1	-3.129
CED5	-.153 E-0	.721 E-1	-2.116
CED6	-.129 E-0	.608 E-1	-2.138
CED7	-.631 E-1	.564 E-1	-1.118
CED8	.115 E-0	.659 E-1	1.750
YWO	.369 E-2	.274 E-2	1.346
YWO**2	-.318 E-3	.158 E-3	-2.022
WEXP	.106 E-1	.310 E-2	3.403
WEXP**2	-.189 E-3	.786 E-4	-2.411
YREMP	.103 E-1	.229 E-2	4.462
YREMP**2	-.187 E-3	.126 E-3	-1.485
AGE	-.518 E-2	.298 E-2	-1.740
RACE	.577 E-1	.577 E-1	1.115
SEX	.177 E-0	.375 E-1	4.725
PHYS	-.474 E-1	.313 E-1	-1.512
MOVE	-.592 E-1	.316 E-1	-1.875
LIVEA	-.885 E-1	.301 E-1	-2.946
RISK	.756 E-1	.270 E-1	2.799
RISK**2	-.667 E-2	.259 E-2	-2.577
RXAGE	-.147 E-2	.579 E-3	-2.542
RXUNI	.273 E-1	.119 E-1	2.287
RED 1	-.323 E-0	.107 E-0	-3.004
RED2	-.274 E-0	.139 E-0	-1.966
RED3	-.276 E-0	.912 E-1	-3.030
RED4	-.228 E-0	.745 E-1	-3.025
RED5	-.202 E-0	.712 E-1	-2.836
RED6	-.879 E-1	.614 E-1	-1.434
RED 7	-.162 E-1	.814 E-1	-1.993

(continued)

Table 5.3 (continued)

Explanatory Variable	Coefficient	Standard Error	t-Statistic
SUP	.353 E-3	.174 E-3	2.027
PUB	-.502 E-1	.328 E-1	-1.529
REXP	.745 E-1	.356 E-1	2.090
UNI	.867 E-1	.293 E-1	2.965
NUM	.189 E-4	.835 E-5	2.259
QUAL	.184 E-1	.434 E-2	4.240
OCC1	-.194 E-0	.556 E-1	-3.491
OCC2	-.261 E-1	.643 E-1	- .406
OCC3	-.10l E-0	.781 E-1	-1.295
OCC4	-.619 E-1	.659 E-1	- .941
OCC5	-.104 E-0	.496 E-1	-2.098
OCC6	-.149 E-0	.647 E-1	-2.303
OCC7	-.974 E-1	.594 E-1	-1.640
OCC8	.332 E-1	.407 E-1	.813
OCC9	-.549 E-0	.186 E-0	-2.957
DIST	.275 E-2	.950 E-3	2.895
JOBA	-.660 E-1	.321 E-1	-2.057
CONSTANT	.244 E+1	.166 E-0	14.745

in percentage terms. For example, the coefficient on YREMP suggests that for an additional year of seniority, an individual is rewarded with a one percent increase in his wage rate. It should be noted, however, that the coefficients on the dummy variables lack this straightforward interpretation.

As described in Chapter 4 the data were made up of two separate sample spaces, both being random. Therefore, a chow-test was constructed in order to see if the two samples could be pooled. The results of this test are shown in Table 5.4. E_1 denotes the statistics from estimating equation (1) and using the national sample; E_2 using the selected, high risk, counties sample; and E_R using both samples. The computed F-statistic was .95, suggesting that the two samples could be pooled.

The results in Table 5.3 show that the estimated coefficients have the signs one would expect and most are significant. For example, individuals who live or work in rural areas or who work in the public sector receive a lower wage rate, ceteris paribus - as suggested by the negative coefficients on LIVEA, JOBA, and PUB respectively. The positive coefficients on WEXP and QUAL suggest, respectively, that those individuals with relatively more years of full-time work experience, or for jobs which require relatively more time for the average person to become fully qualified, wage rates are higher. The negative coefficients on YWO**2, YREMP**2 and WEXP**2 denote that there exists diminishing returns to occupational experience, seniority, and full-time work experience. Further, the coefficients on RED1 through RED2 illustrate that as less formal schooling is required for an occupation, wages are penalized at an increasing rate.

Such influences on wages are typically included in wage equations. However, since the goal of this research is to derive a marginal value of safety, the risk variables are of primary concern. The variables of interest are, therefore, RISK, RISK**2, RXAGE, and RXUNI.

Thaler and Rosen (1975) were the first to note the positive relationship between risk and wages; that is:

$$\frac{\partial WAGE}{\partial RISK} > 0 \qquad (2)$$

To derive an expression like equation (2) consider the following representation of the above estimated hedonic wage equation:

$$LWAGE = \alpha o + \alpha Z + \beta_1 \ RISK + \beta_2 (RISK)^2 + \beta_3 RXAGE + \beta_4 RXUNI \qquad (3)$$

where Z ≡ a vector containing all other variables specified in equation (1). Exponentiating both sides of (3) and then differentiating with respect to risk yields:

$$\frac{\partial WAGE}{\partial RISK} = (\beta_1 + \beta_2 \cdot 2 \cdot RISK + \beta_3 AGE + \beta_4 UNI) WAGE \qquad (4)$$

TABLE 5.4: STATISTICS FOR CHOW-TEST

Equation	Independent Variables	Sum of Squared Residuals	Degrees of Freedom
E_1	48	45.092	400
E_2	48	54.536	391
E_R	48	105.544	839

Computed F-statistic: .95

Critical $F_{.01}$: 1.59

Critical $F_{.05}$: 1.39

Equation (4) suggests that market risk premium depends on: (1) the initial levels of risk and wages, (2) age, and (3) union status. Therefore, in order to test the significance of risk in the hedonic wage equation one must look at the combined significance of the variables RISK, RISK**2, RXAGE, and RXUNI. RXAGE and RXUNI are significant at the .99 level of confidence while RISK and RISK**2 are significant at the .98 level of confidence respectively. Therefore, it is concluded that the market does in fact grant a premium based on perceived job-related risk of death. Further, due to the inclusion of occupational dummies in (1) a convincing argument could not be made that RISK is actually a proxy measure for other occupational characteristics - one of which may be risk. OCC accounts for other occupational characteristics not specified in (1). Therefore, it is concluded that the survey instrument did in fact measure individuals' perceptions of job-related risk of death as measured by RISK.

The positive sign on RXUNI suggests that union members get a larger risk premium than do their non-union counter parts. Three explanations for this result are offered. First, Thaler and Rosen suggest that "the lack of free entry into [union] markets renders the typical union member more risk averse than would be true in free markets, forcing firms to pay higher risk premiums in order to entice unwilling union members to work on the riskier jobs." Another explanation is that unions may supply their workers with additional information regarding risk (Olson, 1981). This would affect risk-perceptions. If workers in relatively high risk jobs under perceive job-related risk, due to such psychological factors as risk denial or cognitive dissonance, the added information granted to union workers may adjust their perceptions upwards rendering a larger risk premium demand. Finally, the stronger bargaining power of unions may enable them to receive larger premiums in general - including a premium on risk.

The negative sign on RXAGE may be attributed to the fact that younger workers, although lacking the caution and experience of their older co-workers, have "superior reflexes and recuperative ability" (Thaler and Rosen, p.295). As a result they may be more productive in riskier situations which would render a higher wage rate.

The decision to include variables RISK, RISK**2, RXAGE, and RXUNI in equation (3) was based on economic theory which suggests that the marginal value of safety is dependent on initial levels of risk and wealth, age, and union status. However, it should be pointed out that when RISK**2, RXAGE, and RXUNI were left out of equation (3), the variable RISK faired well by itself. In this situation, the coefficient on RISK was .013 with a t-statistic of 2.5.

The fact that the above cross terms in equation (3) are significant suggests that different risk premiums, according to personal and work environment characteristics, appear in the market. Further, an individual's MVS will also depend on his personal characteristics. In the next section the implied MVS relationship from the above hedonic equation is derived and compared to the MVS measures obtained from the contingent valuation approach used in the survey.

5.3 THE ESTIMATED MVS MEASURES

Equation (4) specifies the slope of the hedonic wage-risk equation. In order to interpret (4) as the marginal value of safety, the following modifications must be made for unit consistency and in order to render an MVS term which is measured in dollars per expected death. First, because R is in terms of deaths per year while W is in terms of dollars per hour, both sides of (4) must be multiplied by total hours per year worked, H. In this fashion, for example, (5) will be transformed in (6)

$$\frac{\partial W \text{ (dollars/hour)}}{\partial R \text{ (deaths/year)}} \qquad (5)$$

$$\frac{\partial W \text{ (dollars/hour)}}{\partial R \text{ (deaths/year)}} \cdot \left(\frac{\text{hours}}{\text{year}}\right) = \frac{\partial W \text{ (dollars)}}{\partial R \text{ (deaths)}} \qquad (6)$$

Further, since the unit change in deaths is one out of every 4,000 workers employed in the given occupation (6) is actually:

$$\frac{\partial W\text{(dollars)}}{\partial R\text{(death/4,000)}} \qquad (7)$$

After being multiplied by 4,000, equation (6) will be in terms of dollars per death; or

$$\frac{\partial W\text{(dollars)}}{\partial R\text{(death/4,000)}} \cdot (4{,}000) = \frac{\partial W\text{(dollars}}{\partial R\text{(death)}}$$

Therefore, in order to interpret (4) as a MVS measure both sides must be multiplied by 4000 l H. In doing this, and utilizing the assumptions made by hedonic studies (specifically that the hedonic wage-risk gradient is formed by a locus of tangencies to the worker-consumer' indifference curves), it can be concluded that:

$$MVS = (\beta_1 + \beta_2 2RISK + \beta_3 AGE \ \beta_4 UNI)WAGE(4000H) \qquad (8)$$

Notice that this specification suggests that an individual's MVS depends on initial levels of risk and wealth, age, and union status. This is consistent with the theory in Chapter 2.

Appealing to the estimated coefficients in Table 5.3, equation (8) is estimated to be:

$$MVSH = [.075 - .0066\ (2)RISK - .0015AGE + .027UNI](WAGE)(H)(4000)$$

where MVSH = the implied marginal value of safety from the estimated hedonic equation.

A value for MVSH was then calculated for every individual in the data set. The mean value for MVSH was $2,148,461 and was normally distributed.

In the contingent valuation section of the survey (see question 6 in Appendix A), half of the individuals sampled were asked directly for their willingness to pay for a hypothetical one-unit reduction in job-related risk of death from their initial perceived levels. The other half of the sample was asked there willingness to accept for a hypothetical one-unit increase in job-related risk of death from their initial perceived levels. Since both involve subjective evaluations, it is assumed that the information received in Question 6 reflects individuals' indifference curves. From these WTP and WTA measures two different MVS measures were obtained. Since each step on the ladder in Question 6 is associated with an additional one in 4,000 risk of death from the previous step, multiplying these "bids" by 4,000 yields the marginal value of safety from the CVM. This measure is denoted by MVSS. The results of the contingent valuation are summarized in Table 5.5.

In Table 5.5 $MVSC^{+}$ denotes the implied marginal value of safety from the contingent valuation for an increase in risk (i.e. willingness to accept-WTA) while $MVSC^{-}$ denotes the implied willingness to pay (WTP) measure of the marginal value of safety.

TABLE 5.5: CONTINGENT VALUATION ESTIMATES OF MVS

	$MVSC^{+}$	$MVSC^{-}$
Mean	5,906,934	2,135,972

Because this approach directly estimates a subjective MVS estimate and since it is assumed that MVS is non-negative,[14] the respondents were constrained to choose from bids ranging from zero to infinity. For $MVSC^{-}$, the bids in fact ranged from zero to $6,000 (implying MVS estimates ranging from zero to $24 million) with the mean of MVSC equal to $2,135,972. Although the mean values for MVSH and $MVSC^{-}$ were approximately equal, unlike the distribution of MVSH, $MVSC^{-}$ was not distributed normally. Specifically, $MVSC^{-}$ was skewed to the right.

5.4 CONCLUSIONS

The empirical results from the national survey suggest that the distribution of MVS estimates across the sample are quite different depending on the technique employed. Therefore, for a specific individual the implied safety valuation will be different depending on which method policymakers use. However, in order to derive social benefits from some environmental policy, the policymaker is forced to aggregate individual preferences.

In this situation, taking the mean of these individual evaluation is as good a method as any for the purpose of deriving social benefits.[5]

Therefore, the appropriate measure for comparison purposes is the mean of these distributions.

In this study the mean of individual MVS measures from the hedonic technique (MVSH) was found to be approximately the same as the mean of the willingness to pay measure from the contingent valuation ($MVSC^-$). That the mean of $MVSC^+$ (i.e. willingness to accept) is significantly larger, is consistent with the above theory. Further, since most environmental-risk regulation deals with reductions in risk, willingness to pay estimates are the appropriate measures to examine.

By directly comparing the hedonic approach and the contingent valuation method, the results of this study suggest that the two approaches may, in fact, render mean values of the marginal value of safety which are quite similar.[6] Moreover, the $2.1 million MVS figure implied by the hedonic technique in this study is similar to the MVS estimates from other hedonic studies, although slightly higher.[7] Due to the aforementioned error in variables problem found in other hedonic studies, and presuming that this study circumvented such a problem by utilizing a perceived risk measure, one would expect the mean value for MVSH to be different in this study.

To the extent that the results from hedonic studies accurately depict individuals' safety valuations, the results of this study are encouraging for the contingent valuation method because the two methods yielded similar results for this particular risk type (i.e. job-related risk of death.)

If individuals' safety valuations vary across risk types, then the practice of imputing benefits from reductions in environmental risk from job-related risk compensations may be suspect.[8] In this case, one option may be to apply the contingent valuation approach to reductions in specific environmental risk such as exposure to toxic wastes. Valuations in reducing risk types other than job-related risk can be obtained directly from contingent valuation methods due to their flexibility, i.e., they can be applied to a wide spectrum of risk types. The same cannot be said about hedonic techniques.

Although the contingent valuation method appears to fair well when directly compared to the hedonic method, there are some important caveats which should be pointed out with respect to applying this approach to other risk types. As Brookshire et al. (1982) point out:

> [s]ituations where no well-developed hedonic market exists may not be amenable to survey valuation. Biases due to lack of experience must be considered a possibility.

However, they also point out that:

> [e]xisting studies by Randall et al. and Brookshire, Ives, and Schulze, and Rowe et al. of remote recreation areas certainly suggest that survey approaches provide replicable estimates of consumers'

willingness to pay to prevent environmental deterioration, without prior valuation experience.

Therefore, although the hedonic approach cannot be applied to non-job-related risk types while the survey can, much work must be made to ensure that the survey design gives the respondent adequate information regarding the hypothetical market. In Chapter 2 it was noted, however, that the manner in which the survey is designed may affect the survey results. While this dilemma may well be compounded for a risk type where there is no market, it should be pointed out that this is essentially a public good problem, i.e., a reduction in some environmental risk is a public good. The contingent valuation method is one approach towards valuing public goods, including environment risk.

While the criticism aimed at the contingent valuation method are valid, the difficulties involved in evaluating public goods, in general, do not disappear by merely criticizing a particular method aimed at retrieving these valuations. The options are to either improve the existing methods, develop new methods, or simply give up. It is the opinion of this author that an efficient allocation of resources into the production of public goods is crucial as to render the third option a non-option.

Therefore we are left with developing new methods of evaluating public goods in general, and safety in particular, or improving the existing methods. The latter includes a close examination of how the existing approaches compare to each other. This study suggests that, within the realm of safety evaluations, the hedonic approach and the contingent valuation method, when directly compared, yield similar results. While this does not validate the contingent valuation approach as a general method of valuing public goods, it does offer evidence that attempts at improving this method may be a worthy step towards the public goods problem.

REFERENCES

1. If an individual was paid in the form of a salary, WAGE was computed by dividing the individual's yearly salary by his reported total hours work for 1983.

2. The highest education level category, "Advanced College Degree or Profession Degree" has been left out.

3. The highest education level category, "Advanced College Degree or Profession Degree" has been left out.

4. The occupational category "Professional or Technical" has been left out.

5. This amounts to a Benthamite Social Welfare function where each individual is weighted the same. Although the decision to employ any weighting scheme over another involves making normative statements, an equal weighting scheme may be less controversial then, for example, weighting risk-averse preferences more heavily.

6. It should be noted that this result also held for the following subsets of the date file: households with (1) low income levels, (2) middle income levels, (3) high income levels, (4) low π_p levels, (5) middle π_p levels, (6) high π_p levels.

7. These estimates range from $400,000 to $7.5 million, and tend to center around $1.5 million (see Violette and Chestnut, 1983).

8. It has been shown that individuals have different evaluations for different types or risks. See, for example, Starr (1969) and Litai (1980).

BIBLIOGRAPHY

Acton, Jan P. 1973. Evaluating Public Programs to Save Lives: The Case of Heart Attacks. Research Report R-73-02, Rand Corp., Santa Monica, CA.

Akerlof, G. A. and W. T. Dickens. 1982. "The Economic Consequences of Cognitive Dissonance." American Economic Review 72 (June): 307-319.

Ando, A. and F. Modigliani. 1963. "The 'Life Cycle' Hypothesis of Savings: Aggregate Implications and Tests," American Economic Review (March).

Arthur, W. B. 1984. "The Economics of Risks to Life." American Economic Review 71 (March): 54-64.

Bacharach, M. 1977. Economics and the Theory of Games (Boulder: Westview Press).

Bernoulli, J. 1899. Ars Conjectandi, 1713. Translated into German by R. H. Aussner as "Wahrscheinlichkeitsrechnung," Ostwald's Klassiker der Exakten Wissenschaften 107 and 108 (Liepzig: W. Englemann).

Bishop, R. C. and T. A. Heberlein. 1979. "Measuring Values of Extra-Market Goods: Are Indirect Measures Biased?," American Journal of Agricultural Economics: 926-30.

Bishop, R. C., T R. Heberlein and M. J. Kealy. 1983. "Contingent Valuation of Environmental Assets: Comparison With A Simulated Market," Natural Resources Journal, 23(3) (July): 619-34.

Blomquist, G. 1982. "Estimating the Value of Life and Safety: Recent Developments," in J. W. Jones-Lee (ed.) The Value of Life and Safety (Geneva: North-Holland Publishing Co.).

Blomquist, G. 1979. "Value of Life Saving: Implications of Consumption Activity." Journal of Political Economy 87 (June): 540-558.

Bodily, S. E. 1980. "Analysis of Risks to Life and Limb." Operations Research 28 (January-February): 156-175.

Brookshire, D. S., M. A. Thayer, J. Tschirhart and W. D. Schulze. 1985. "A Test of the Expected Utility Model: Evidence from Earthquake Risks," Journal of Political Economy 93(2): 369-389.

Brookshire, D. S., M. A. Thayer, W. D. Schulze and R. C. d'Arge. 1982. "Valuating Public Goods: A Comparison of Survey and Hedonic Approaches." American Economic Review 72 (March): 165-177.

Brookshire, D. S., R. C. d'Arge, W. D. Schulze and M. A. Thayer. 1981. "Experiments in Valuing Public Goods," Advances in Applied Microeconomics, Vol. 1, V. K. Smith, ed., Connecticut, JAI Press, Inc. 123-172.

Coursey, D. L., J. J. Hovis and W. D. Schulze. 1985. "On the Supposed Disparity Between Willingness to Accept and Willingness to Pay Measures of Value," manuscript, Department of Economics, University of Wyoming.

Cronin, F. J. 1982. Valuing Nonmarket Goods Through Contingent Markets, prepared for the U.S. Environmental Protection Agency under Related Services Agreement with the U.S. Department of Energy under Contract DE-AC06-76RL0 1830 (September).

Cropper, M. L. 1977. "Health, Investment in Health, and Occupational Choice," Journal of Political Economy 85(6) (December): 1273-1294.

Cummings, R. G., D. S. Brookshire and W. D. Schulze. 1984. "Valuing Environmental Goods: A State of the Arts Assessment of the Contingent Valuation Method," Volume I in Experimental Methods for Assessing Environmental Benefits, U.S. Environmental Protection Agency, Contract #CR-811077-01-0.

Dardis, R. 1980. "The Value of a Life: New Evidence from the Marketplace." American Economic Review 70 (December): 1077-1082.

Dillman, Don A. Mail and Telephone Surveys: The Total Design Method. Wiley-Interscience NY, 1978.

Dublin, L. I. and A. J. Lotka. 1946. The Money Value of Man (New York: The Ronald Press, Co.).

Feenberg, D. and E. S. Mills. 1980. Measuring the Benefits of Water Pollution Abatement, Academic Press, New York.

Fischhoff, B. and D. MacGregor. 1980. Judged Lethality, Decision Research Report 80/84.

Fischhoff, B., P. Slovic and S. Lichtenstein. 1982. "Lay Foibles and Expert Judgements About Risk," The American Statistician 36(3) (August): 240-255.

Freeman, A. M., III. 1979. The Benefits of Environmental Improvement: Theory and Practice. Baltimore: John Hopkins University Press for Resources for the Future.

Fromm, G. 1968. "Comment on T. C. Schelling's paper, 'The Life You Save May Be Your Own,"' in S. B. Chase (ed.) Problems in Public Expenditures (Washington, D.C.: Brookings Institute).

Gerking, S. D. and W. N. Weirick. 1983. "Compensating Differences and Interregional Wage Differentials," Review of Economics and Statistics 65: 483-87.

Ghosh, D., D. Lees and W. Seal. 1975. "Optimal Motorway Speed and Some Valuations of Time and Life." Manchester School of Economic and Social Studies 43 (June): 134-143.

Hershey, R. C. and P. J. H. Schoemaker. 1980. "Risk-Taking and Problem Context in the Domain of Losses--An Expected Utility Analysis," Journal of Risk Insurance 47(1): 111-132.

Jones-Lee, M. W. 1976. The Value of Life: An Economic Analysis. Chicago: The University of Chicago Press.

Jones-Lee, M. 1974. "The Value of Changes in the Probability of Death or Injury," Journal of Political Economy 82(4) (July/August).

Kahneman, D. and A. Tversky. 1982. "The Psychology of Preferences," Scientific American, (January) pp. 160-73.

Kahneman, D. and A. Tversky. 1979. "Prospect Theory: An Analysis of Decision Under Risk," Econometrica 47(2) (March): 263-291.

Kunreuther, H., R. Grinsberg and L. Miller et al. 1978. Disaster Insurance Protection: Public Policy Lessons. New York: Wiley and Sons.

Lichtenstein, S., P. Slovic, B. Fischhoff, M. Layman and B. Combs. 1978. "Judged Frequency of Lethal Events," Journal of Experimental Psychology: Human Learning and Memory 4: 551-578.

Linnerooth, J. 1979. "The Value of Human Life: A Review of the Models." Economic Inquiry 17 (January): 52-74.

Lipsey. R. E. 1975. "Comments on The Value of Saving a Life: Evidence from the Labor Market." In Nestor E. Terleckyj, ed., Household Production and Consumption. New York: Columbia University Press for NBER.

Litai, D. 1980. "A Risk Comparison Methodology for the Assessment of Acceptable Risk." Ph.D. Dissertation. Massachusetts Institute of Technology. (January).

Markowitz, H. M. 1952. "Portfolio Selection," Journal of Finance 1 (March): 71-91.

Mishan, E. J. 1971. "Evaluation of Life and Limb: A Theoretical Approach." Journal of Political Economy 79 (July/August): 687-705.

Mulligan, P. J. 1977. "Willingness-to-Pay for Decreased Risk from Nuclear Plant Accidents." Working Paper No. 3, Energy Extension Programs, Pennsylvania State University. (November).

Olson, C. A. 1981. "An Analysis of Wage Differentials Received by Workers on Dangerous Jobs." Journal of Human Resources 16: 167-185.

Pindyck, R. S. and D. L. Rubinfeld. 1981. Econometric Models and Economic Forecasts (New York: McGraw Hill).

Pliskin, J. S., D. S. Shepard, and M. C. Weinstein. 1980. "Utility Functions for Life Years and Health Status," Operations Research 28(1) (January-February): 206-224.

Plott, C. R. and S. Sunder. 1982. "Efficiency of Experimental Security Markets with Insider Information: Application of Rational Expectation Models," Journal of Political Economy 90 (August): 663-698.

Pollock, F. and F. W. Maitland. 1968. The History of English Law (Cambridge: University Press).

Randall, A., J. P. Hoehn, and D. S. Brookshire. 1983. "Contingent Valuation Surveys for Evaluating Environmental Assets," Natural Economic Review, (June) 72, pp. 576-589.

Rosen, S. 1974. "Hedonic Prices and Implicit Markets." Journal of Political Economy 82 (January/February): 34-55.

Rowe, R., R. C. d'Arge and D. S. Brookshire. 1980. "Environmental Preferences and Effluent Charges," Chapter 4 of Progress in Resource Management and Environmental Planning, Vol. 2, T. O'Riordan and K. Turner, (eds), John Wiley and Sons, LTD., 89107

Schelling, T. C. 1968. "The Life You Save May Be Your Own." In Samuel B. Chase, Jr., ed. Problems in Public Expenditure Analysis. Washington, D. C.: Brookings Institution.

Schoemaker, P. J. H. 1982. "The expected Utility Model: Its Variants, Purposes, Evidence and Limitations," Journal of Economic Literature 20 (June): 529-563.

Schulze, W. D. and A. V. Kneese. 1981. "Risk in Benefit-Cost Analysis," Risk Analysis l(1): 81-88.

Simon, H. A. 1955. "A Behavior Model of Rational Choice," Quarterly Journal of Economics 69 (February): 174-83.

Smith, V. 1976. "Experimental Economics: Induced Value Theory," American Economic Review 66(2) (May): 274-79.

Starr, C. 1969. "Social Benefit vs. Technological Risk." Science 165: 1232-1238.

Strotz, R. H. 1955. "Myopia and Inconsistency in Dynamic Utility Maximization," Review of Economic Studies 23(3): 165-180.

Takayama, A. 1982. "On Consumer's Surplus," Economic Letters 10: 35-42.

Thaler, R. and S. Rosen. 1975. "The Value of Life Saving." In Nestor E. Terleckyj, ed., Household Production and Consumption. New York: Columbia University Press for NBER.

Violette, D. M. and L. G. Chestnut. 1983. "Valuing Reductions in Risk: A Review of the Empirical Estimates," report to the U.S. Environmental Protection Agency, Contract #68-01-6596 (June).

Viscusi, W. K. 1978a. "Health Effects and Earnings Premiums for Job Hazards." Review of Economics and Statistics 60: 408-16.

Viscusi, W. K. 1978b. "Labor Market Valuations of Life and Limb: Empirical Evidence and Policy Implications." Public Policy 26 (Summer): 359-386.

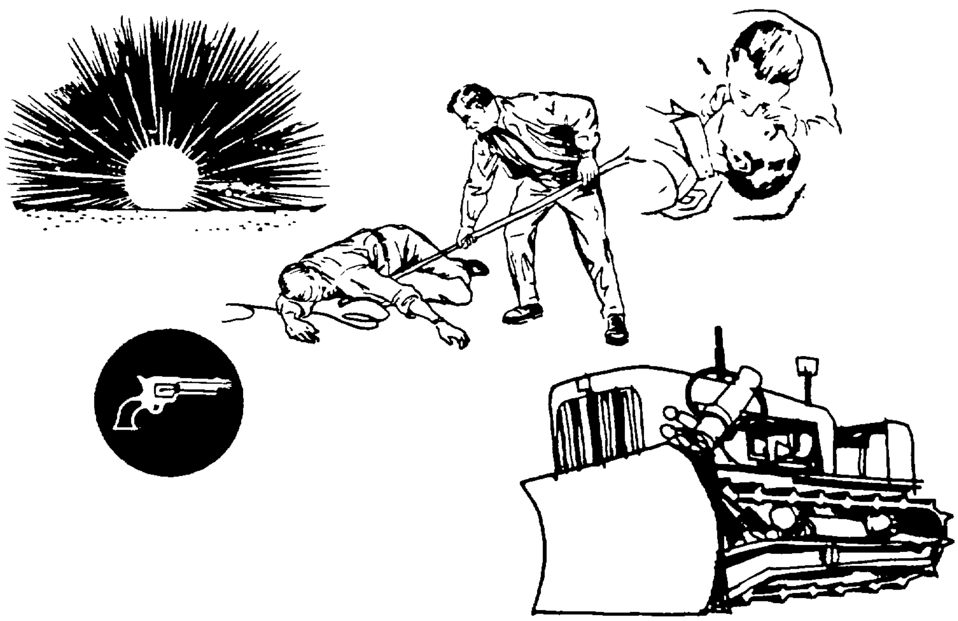
Weinstein, M. C. and R. J. Quinn. 1983. "Psychological Considerations in Valuing Health Risk Reductions," Natural Resources Journal 23(3) (July): 659-673.

Willig, R. D. 1976. "Consumer's Surplus Without Apology," American Economic Review 66 (December): 589-597.

APPENDIX A

SURVEY QUESTIONNAIRE

Job Safety In The United States
How Much Is Needed?



A Nationwide Survey on an Important Issue Facing Congress and the American People.

This questionnaire should be completed by the principle wage-earner in your household.

INSTITUTE FOR POLICY RESEARCH
University of Wyoming
Laramie, Wyoming 82070

(continued)

1

ABOUT YOUR JOB

Q-1 First, we would like to ask a few questions about the work you do. In 1983 were you: (Please circle the number of your answer)

1 EMPLOYED PART-TIME
2 EMPLOYED FULL-TIME
3 RETIRED
4 UNEMPLOYED

→ Inasmuch as the questions we need to ask only concern people's 1983 job, it won't be necessary for you to complete the rest of the questions. However, we would greatly appreciate your checking this box /__/ and returning the questionnaire so we can take your name off of the mailing list. Many thanks for your cooperation. We greatly appreciate it.

Q-2 Please describe your main job or position in 1983 (if you had more than one job in 1983 we only need to know about your main job).

TITLE OF JOB OR POSITION: ____________________

NATURE OF THE WORK YOU DO: ____________________

IN WHAT KIND OF BUSINESS OR INDUSTRY IS YOUR WORKPLACE: ____________________

Q-3 Which one of the following occupational categories most closely reflects the type of work you do in your job? A few examples are given to help you decide. (Please circle the number of your answer)

1	SERVICE WORKER	(Food service workers, Cleaning service workers, Dental assistants, Policemen)
2	LABORER	(Longshoremen, Construction workers, Loggers, Garbage collectors)
3	TRANSPORTATION OPERATOR	(Bus drivers, Taxicab drivers, Truck drivers, Railroad switch operators)
4	EQUIPMENT OPERATOR . .	(Textile workers, Drillers, Photographic processors, Smelters)
5	CRAFT WORKER	(Carpenters, Machinists, Bakers, Tailors, Repairmen, Mechanics)
6	CLERICAL WORKER	(Cashiers, Tellers, Secretaries, Receptionists, Telephone operators, Dispatchers)
7	SALES WORKER	(Advertising agents, Real estate agents, Sales clerks, Sales representatives, Vendors)
8	MANAGER OR ADMINISTRATOR	(Bank officers, Purchasing agents, Restaurant managers, School administrators)
9	PROFESSIONAL OR TECHNICAL	(Accountants, Engineers, Physicians, Teachers, Entertainers)
10	FARMWORKER	(Farmers, Farm laborers, Farm supervisors)

(continued)

HOW SAFE IS YOUR JOB

2

Q-4 Some people face a high risk of injury and death from accidents on the job and others face a very low risk. Compared to most other jobs, do you feel your main job in 1983 was: (Please circle the number of your answer)

1 MUCH SAFER
2 SOMEWHAT SAFER
3 ABOUT AVERAGE
4 SOMEWHAT RISKIER
5 MUCH RISKIER

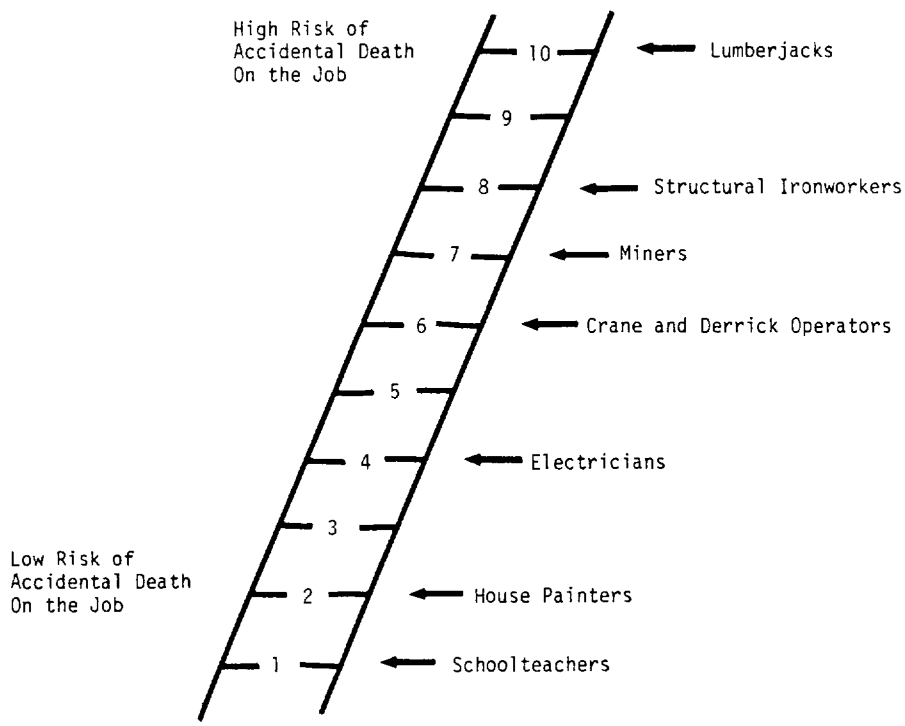
Q-5 Below are listed the major causes of how people die on the job. Depending on your particular job, some causes are not very likely to happen to you while others are more likely to happen. On a scale from 1 (could never happen) to 5 (most likely to happen), please circle the number which best indicates your feelings towards the chances of dying on a job like yours, as compared to other jobs, from each of the causes.

MAJOR CAUSES OF ACCIDENTAL DEATH AT WORK	Please circle one number for each cause: COULD NEVER HAPPEN				MOST LIKELY TO HAPPEN
A. On the road motor vehicle accident	1	2	3	4	5
B. A fall	1	2	3	4	5
C. Heart attack	1	2	3	4	5
D. Getting hit by industrial vehicle or equipment	1	2	3	4	5
E. Getting hit by object other than vehicle or equipment	1	2	3	4	5
F. Caught in, under or between objects other than vehicle or equipment	1	2	3	4	5
G. Electrocution	1	2	3	4	5
H. Gun shot	1	2	3	4	5
I. Airplane crash	1	2	3	4	5
J. Fire	1	2	3	4	5
K. Plant machinery operation	1	2	3	4	5
L. Explosion	1	2	3	4	5
M. Gas inhalation	1	2	3	4	5

(continued)

3 **JOB RELATED RISK**

The ladder below shows levels of job-related accidental risk of death. Each step shows the number of deaths per year for every 4,000 people in an occupation. The higher on the ladder, the more accidental "on the job" deaths there are each year for that occupation. A few example occupations are given and they are placed on the ladder according to their actual levels of risk. Note that schoolteachers have about one death per 4,000 workers and lumberjacks have about 10 deaths per 4,000 workers each year. Of course, your 1983 job does have a level of risk somewhere on the ladder even if it has not been listed as one of the examples. Questions 6 and 7 refer to this ladder.



(continued)

Q-6 Now, please think about your main job in 1983 for a minute. In your opinion, which step on the ladder comes closest to describing the risk of accidental death in your job. (Please circle the step number of your answer)

STEP 10
STEP 9
STEP 8
STEP 7
STEP 6
STEP 5
STEP 4
STEP 3
STEP 2
STEP 1

(IF you picked STEP 10)

Just suppose the actual risk of accidental death in your job was Step 9 (meaning 9 out of every 4,000 workers in this job die each year). What is the smallest increase in annual gross (i.e., before deductions and taxes) income from your job that you would have to be paid in order to accept an increase in the risk of accidental death from Step 9 up to Step 10 (i.e., one more death per year for every 4,000 workers)? (Please circle the number)

1 ($ 0)	20 ($ 380)
2 ($ 20)	21 ($ 400)
3 ($ 40)	22 ($ 420)
4 ($ 60)	23 ($ 440)
5 ($ 80)	24 ($ 460)
6 ($100)	25 ($ 480)
7 ($120)	26 ($ 500)
8 ($140)	27 ($ 600)
9 ($160)	28 ($ 700)
10 ($180)	29 ($ 800)
11 ($200)	30 ($ 900)
12 ($220)	31 ($1000)
13 ($240)	32 ($2000)
14 ($260)	33 ($3000)
15 ($280)	34 ($4000)
16 ($300)	35 ($5000)
17 ($320)	36 ($6000)
18 ($340)	37 (More than $6000)
19 ($360)	

(IF you picked a step from 1 to 9)

Consider a situation in which you were asked to face more risk on your job. What is the smallest increase in annual gross (i.e., before deductions and taxes) income from your job that you would have to be paid in order to accept an increase in the risk of accidental death by one step (i.e., one more death per year for every 4,000 workers)? (Please circle the number)

1 ($ 0)	20 ($ 380)
2 ($ 20)	21 ($ 400)
3 ($ 40)	22 ($ 420)
4 ($ 60)	23 ($ 440)
5 ($ 80)	24 ($ 460)
6 ($100)	25 ($ 480)
7 ($120)	26 ($ 500)
8 ($140)	27 ($ 600)
9 ($160)	28 ($ 700)
10 ($180)	29 ($ 800)
11 ($200)	30 ($ 900)
12 ($220)	31 ($1000)
13 ($240)	32 ($2000)
14 ($260)	33 ($3000)
15 ($280)	34 ($4000)
16 ($300)	35 ($5000)
17 ($320)	36 ($6000)
18 ($340)	37 (More than $6000)
19 ($360)	

Willingness to Accept

(continued)

Q-6 how, please think about your main job in 1983 for a minute. In your opinion, which step on the ladder comes closest to describing the risk of accidental death in your job? (Please circle the step number of your answer)

STEP 10
STEP 9
STEP 8
STEP 7
STEP 6
STEP 5
STEP 4
STEP 3
STEP 2
STEP 1

(IF you picked STEP 1)

Just suppose the actual risk of accidental death in your job was Step 2 (meaning 2 out of every 4,000 workers in this job die each year). What is the biggest decrease in annual gross (i.e., before deductions and taxes) income from your job that you would be willing to accept in order to have the risk of accidental death reduced from Step 2 down to Step 1 (i.e., one less death per year for every 4,000 workers)? (Please circle the number)

1 ($ 0)	20 ($ 380)
2 ($ 20)	21 ($ 400)
3 ($ 40)	22 ($ 420)
4 ($ 60)	23 ($ 440)
5 ($ 80)	24 ($ 460)
6 ($100)	25 ($ 480)
7 ($120)	26 ($ 500)
8 ($140)	27 ($ 600)
9 ($160)	28 ($ 700)
10 ($180)	29 ($ 800)
11 ($200)	30 ($ 900)
12 ($220)	31 ($1000)
13 ($240)	32 ($2000)
14 ($260)	33 ($3000)
15 ($280)	34 ($4000)
16 ($300)	35 ($5000)
17 ($320)	36 ($6000)
18 ($340)	37 (More than $6000)
19 ($360)	

(IF you picked a step from 2 to 10)

Consider a situation where you could face less risk on your job. What is the biggest decrease in annual gross (i.e., before deductions and taxes) income from your job that you would be willing to accept in order to have the risk of accidental death reduced by one step (i.e., one less death per year for every 4,000 workers)? (Please circle the number)

1 ($ 0)	20 ($ 380)
2 ($ 20)	21 ($ 400)
3 ($ 40)	22 ($ 420)
4 ($ 60)	23 ($ 440)
5 ($ 80)	24 ($ 460)
6 ($100)	25 ($ 480)
7 ($120)	26 ($ 500)
8 ($140)	27 ($ 600)
9 ($160)	28 ($ 700)
10 ($180)	29 ($ 800)
11 ($200)	30 ($ 900)
12 ($220)	31 ($1000)
13 ($240)	32 ($2000)
14 ($260)	33 ($3000)
15 ($280)	34 ($4000)
16 ($300)	35 ($5000)
17 ($320)	36 ($6000)
18 ($340)	37 (More than $6000)
19 ($360)	

Willingness to Pay

(continued)

5

Q-7 In this question several different jobs are listed (A through O). Each of the jobs are identical to your 1983 job except that their risk and salary levels are different than your 1983 job. The risk level for each job is one of the steps on the ladder (see page 3). The salary for each job is your 1983 salary, plus or minus some percentage of that salary. On a scale from 1 (much worse job) to 10 (much better job), please circle the number which best indicates your opinion of how each job would compare to your 1983 job. Thus, a job with risk level 1 and twice your 1983 salary might get a high number. A job with risk level 10 and half your 1983 salary might get a low number. Also, a job that you feel would be just as good as your 1983 job would get a 5. Please circle one number for each job.

			Circle one for each job								
JOB	RISK LEVEL	SALARY COMPARED TO 1983	MUCH WORSE JOB				YOUR 1983 JOB				MUCH BETTER JOB
A.	Step 2	10% more . . .	1	2	3	4	5	6	7	8	9
B.	Step 7	5% less . . .	1	2	3	4	5	6	7	8	9
C.	Step 3	the same . . .	1	2	3	4	5	6	7	8	9
D.	Step 9	10% less . . .	1	2	3	4	5	6	7	8	9
E.	Step 1	10% less . . .	1	2	3	4	5	6	7	8	9
F.	Step 4	5% more . . .	1	2	3	4	5	6	7	8	9
G.	Step 5	10% less . . .	1	2	3	4	5	6	7	8	9
H.	Step 8	the same . . .	1	2	3	4	5	6	7	8	9
I.	Step 6	10% more . . .	1	2	3	4	5	6	7	8	9
J.	Step 4	5% less . . .	1	2	3	4	5	6	7	8	9
K.	Step 10	the same . . .	1	2	3	4	5	6	7	8	9
L.	Step 5	the same . . .	1	2	3	4	5	6	7	8	9
M.	Step 7	5% more . . .	1	2	3	4	5	6	7	8	9
N.	Step 9	10% more . . .	1	2	3	4	5	6	7	8	9
O.	Step 2	10% less . . .	1	2	3	4	5	6	7	8	9

(continued)

MORE ABOUT YOUR JOB

6

Q-8 How much formal education is required to get a job like your 1983 job? (Please circle the number)

1 0- 8 GRADES
2 6- 9 GRADES; FINISH GRADE SCHOOL
3 9-11 GRADES; SOME HIGH SCHOOL
4 12 GRADES; FINISH HIGH SCHOOL
5 SOME COLLEGE, NO DEGREE NECESSARY
6 COLLEGE DEGREE; BA OR BS
7 SOME GRADUATE WORK
8 ADVANCED COLLEGE DEGREE OR PROFESSIONAL DEGREE

Q-9 Do you have to have some work experience or special training to get a job like your 1983 job? (Please circle the number)

1 YES →
2 NO

If YES, what kind of experience or special training is that? Please circle the number)

1 APPRENTICESHIP
2 VOCATIONAL TRADE SCHOOL
3 ON-THE-JOB TRAINING
4 WORK EXPERIENCE FROM ANOTHER JOB
5 OTHER (Please specify) ______________

____

Q-10 On a job like your 1983 job, how long would it take the average new person to become fully trained and qualified?

______ YEARS OR ______ MONTHS (IF LESS THAN A YEAR)

Q-11 How long have you worked for your present employer?

______ YEARS OR ______ MONTHS (IF LESS THAN A YEAR)

Q-12 How long have you done the type of work you do?

______ YEARS OR ______ MONTHS (IF LESS THAN A YEAR)

Q-13 Do you have any physical or nervous condition that limits the type of work or the amount of work you can do in your job? (Please circle the number)

1 YES
2 NO

Q-14 Do you have any physical or nervous condition that would limit the type of work or the amount of work you could do in another job you would like? (Please circle the number)

1 YES
2 NO

(continued)

7

Q-15 In 1983, did you work for yourself? (Please circle the number)

1 YES
2 NO →

> If NO, then did you work for the Federal, state or local government? (Please circle the number)
>
> 1 YES
> 2 NO

Q-16 Did you supervise the work of other employees, or tell them what to do? (Please circle the number

1 YES →
2 NO

> If YES, then did you have any say about their pay or promotion? (Please circle the number)
>
> 1 YES, ALL OF THEM
> 2 YES, SOME OF THEM
> 3 NO, NONE OF THEM
>
> About how many people did you supervise?
>
> ______________PEOPLE

Q-17 Approximately how many people are employed where you work?

______________NUMBER OF PEOPLE

Q-18 Is your job covered by a union contract? (Please circle the number)

1 YES →
2 NO

> If YES, do you belong to that union? (Please circle the number)
>
> 1 YES
> 2 NO

Q-19 How many weeks did you actually work on your job in 1983?

______________WEEKS

Q-20 On the average, how many hours a week did you work on your job in 1983?

______________HOURS

Q-21 Did you have any overtime which is not included in that? (Please circle the number)

1 YES →
2 NO

> If YES, then how many hours did that overtime amount to in 1983?
>
> ______________HOURS

(continued)

ABOUT YOU

8

Q-22 What is your age?

______ YEARS

Q-23 What is your sex? (Please circle the number)

1 MALE
2 FEMALE

Q-24 What is your race? (Please circle the number)

1 BLACK
2 ORIENTAL
3 HISPANIC OR PERSON OF MEXICAN DESCENT
4 WHITE
5 OTHER (Please specify) ______

Q-25 How much formal education have you completed? (Please circle the number)

1 0- 5 GRADES
2 6- 8 GRADES; FINISHED GRADE SCHOOL
3 9-11 GRADES; SOME HIGH SCHOOL
4 12 GRADES; FINISHED HIGH SCHOOL
5 TRADE SCHOOL
6 SOME COLLEGE
7 COLLEGE DEGREE; BA OR BS
8 SOME GRADUATE WORK
9 ADVANCED COLLEGE DEGREE OR PROFESSIONAL DEGREE

Q-26 In what type of area do you live? (Please circle the number)

1 RURAL
2 SUBURBAN
3 CENTRAL CITY

Q-27 Have you moved in the last three years? (Please circle the number)

1 YES
2 NO

Q-28 About how many miles is your job from where you live?

______ MILES

Q-29 On the average, how long does it take to travel from your home to your job?

______ HOUR OR ______ MINUTES (IF LESS THAN AN HOUR)

Q-30 In what type of area is your job located? (Please circle the number)

1 RURAL
2 SUBURBAN
3 CENTRAL CITY

(continued)

9

Q-31 How many years have you been employed since you were 18?

_____________ YEARS

Q-32 How many of these years were you employed full time for most of the year?

_____________ YEARS

Q-33 In general, how satisfied were you with your main job in 1983? (Please circle the number)

1 VERY SATISFIED
2 SATISFIED
3 NEUTRAL
4 DISSATISFIED
5 VERY DISSATISFIED

Q-34 Are you a veteran? (Please circle the number)

1 YES
2 NO

Q-35 Of the total fringe benefit package paid by your employer of your job in 1983 (e.g., workman's compensation, pension plan payments, health insurance payments, etc.), approximately what percentage of your gross annual earnings was this package worth? (Please circle the number)

1 0%-10%
2 11%-20%
3 21%-30%
4 31%-40%
5 41%-50%
6 DON'T KNOW

Q-36 Approximately what percentage of your total income received in 1983 was made up of government assistance payments (e.g., welfare, social security, veterans benefits, unemployment compensation, etc.)? (Please circle the number)

1 0%
2 1%-10%
3 11%-20%
4 21%-30%
5 31%-40%
6 41%-50%
7 51%-60%
8 61%-70%
9 71%-80%
10 81%-90%
11 91%-100%

(continued)

10

Q-37 How were you paid in your 1983 job? (Please circle one number)

1 SALARY
2 HOURLY WAGE
3 OTHER

(IF Other) How were you paid on your job in 1983? (Please circle the number)

1 PIECE WORK
2 COMMISSION ONLY
3 COMMISSION AND SALARY
4 TIPS ONLY
5 TIPS AND SALARY
6 OTHER (Please specify) ______________________

How much was the annual gross (i.e., before deductions and taxes) income you received from your main job in 1983?

$____________

If you worked more hours than average during some week, did you get paid for those extra hours? (Please circle the number)

1 YES → (IF Yes) About how much would you make, per hour, for that overtime?

$____________PER HOUR

2 NO

(IF Hourly) What was your hourly wage rate on your job for your regular or "straight" work time in 1983?

$____________PER HOUR

What was your hourly wage rate on your job for your overtime in 1983?

$____________PER HOUR

(IF Salary) How much was your annual gross (i.e., before deductions and taxes) income you received from your job in 1983?

$____________

If you worked more hours than average during some week, did you get paid extra for those extra hours? (Please circle the number)

1 YES → (IF Yes) About how much did you make, per hour, for that overtime?

$____________PER HOUR

2 NO

(continued)

Is there anything we may have overlooked? Please use this space for any additional comments you would like to make about the need for on-the-job safety in the United States.

Your contribution to this effort is very greatly appreciated. If you would like a summary of results, please print your name and address on the back of the return envelope (NOT on this questionnaire). We will see that you receive it.

APPENDIX B

ORIGINAL COVER LETTER

(Sample of letter sent to obtain information included in text)

THE UNIVERSITY OF WYOMING
INSTITUTE FOR POLICY RESEARCH
BOX 3925, UNIVERSITY STATION
LARAMIE, WYOMING 82071

July 9, 1984

¥Inside_Address¥

Safety on the job is a matter of concern to everyone yet little is really known about how much people value safety. Information of this type is essential in evaluating the benefits of safety-related government programs. In order to get this information, we need your help.

Your household is one of a few hundred selected at random from your region of the country. To truly represent the opinions of the entire population, it is important that each questionnaire be completed. Your answers and those of others from all walks of life will be summarized to form a profile of the American public's concern for job safety.

Since this survey concerns safety on the job, we ask that the enclosed questionnaire be filled out by the <u>principal wage earner</u> in your household whether male or female. You may be assured of complete confidentiality. Your name will never be associated with the information you provide. The number on the questionnaire is only so your name can be checked off the list when it is returned.

Since your responses are so important to the study, we hope that you will fill out the questionnaire and return it in the enclosed stamped envelope. However, it is completely voluntary, and if you do not wish to respond please let us know by returning the blank questionnaire.

If you would like a summary of the survey results (they are free). please write "send results" on the back of the envelope. I would be happy to answer any questions you might have. Please call or write. My telephone number is (307) 766-4890.

Many thanks for your help with this important effort.

Sincerely,

Shelby Gerking
Project Director

APPENDIX C

FIRST FOLLOW-UP

(Sample of post card sent to obtain information included in text)

July 16, 1984

Last week a questionnaire was mailed to you seeking information which is crucial in evaluating the benefits of safety-related Government programs.

If you have already completed and returned the questionnaire, accept our sincere thanks. If not, please do so today. Your household was drawn in a random sample of areas across the United States. The questionnaire was sent to only a small, but representative, sample of people throughout the country. Therefore, it is extremely important that your answers also be included in the study.

If by some chance you did not receive the questionnaire, or it was misplaced, please call me collect (307) 766-4890, and I will get another one in the mail to you immediately.

Sincerely,

Shelby Gerking
Project Director

APPENDIX D

COVER LETTER WITH SECOND FOLLOW-UP

(Sample of letter sent to obtain information included in text)

THE UNIVERSITY OF WYOMING
INSTITUTE FOR POLICY RESEARCH
BOX 3925, UNIVERSITY STATION
LARAMIE, WYOMING 82071

July 30, 1984

¥Inside_Address¥

About three weeks ago I sent you a questionnaire concerning on-the-job safety. As of today, I have not yet received your completed questionnaire.

This study has been undertaken as a national project in the belief that citizens' attitudes towards safety should be incorporated into policies concerning safety-related government programs. Your opinions will be extremely valuable towards evaluating the worth of such programs.

I am writing to you again to encourage you to complete the questionnaire. In the event that your questionnaire has been misplaced, a replacement is enclosed.

Your cooperation is greatly appreciated.

Cordially,

Shelby Gerking
Project Director