The Econometric Basis for Estimates of the Value of Life

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I. Frames of Reference

Over two centuries ago in his book, The Wealth of Nations, Adam Smith developed the basic theory of compensating differentials for hazardous jobs. The theory can be put in terms of the basic elements of individual preferences. If a job is made unattractive by a higher risk level or some other negative characteristic, there must be some offsetting advantage of the job, such as a higher wage rate, to compensate the worker for this added risk. The focus of the economics literature has been on estimating these compensating differentials for job risk, where the rate of tradeoff between money and risk gives the value attached to the statistical lives at stake.

The basic elements of this theory are not controversial. Although empirical estimation of the tradeoff between risk and wages is continuing to be refined, there is general acceptance of the existence and importance of such a linkage. Indeed, every major labor economics textbook includes an extensive discussion of this analysis of compensating differentials for risk within the context of the theory of labor supply.1 As with empirical estimates of other economic relationships, there will be some error involved in the process. The empirical task is to continually refine our analysis of these relationships so that we can better understand their magnitude.

The focus of this paper will be on exploring the various sources of uncertainty and the problems involved in estimating the premiums for risk that govern values of life. Particular attention will be devoted to the succession of steps that have been taken within the context of the literature to resolve these issues.

Before engaging in this assessment, it is useful to keep in mind our reference point, which is the current procedures predominantly used to assess damages for personal injury. In the case of earnings loss, an analyst generally calculates the present value of earnings lost by the decedent, where this value may be adjusted by taking into account consumption and taxes, depending on the jurisdiction. Such exercises always involve some error. Future earnings growth throughout the rest of an individual's lifetime is not known with certainty. Future inflation rates and interest rates are also uncertain. This uncertainty may be particularly great in the case of children who are injured since they have no earnings record whatsoever to use in making this projection.

The fact that there are such uncertainties does not mean that one cannot

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prepare meaningful estimates for use in the courtroom. In particular, the task of the analyst in these instances is to provide the appropriate assessment of the expected present value of the future losses taking into account the full range of the uncertainty that may be present. In doing so, however, one should also place appropriate weight on the outcomes that are more likely to occur.

When considering whether we should move to a legal regime in which deterrence value of life numbers are used rather than earnings values, we should keep in mind that current procedures also involve error. Upon close examination, it is likely that almost the entire class of potential problems associated with value of life estimates also pertain to earnings projections as well. Sound economic analyses will ensure as much as possible that this error is random and that there is no systematic bias in the results. There is an important component of the analysis that will continue to draw upon the expertise and good judgment of the analyst.

II. Basic Elements of the Estimation Approach

The theory of compensating differentials is in terms of individual behavior as it interacts with firms' demand for labor. Most studies of compensating differentials rely upon labor market data, for which we observe the outcome of the interaction between workers' supply of labor and the demand for labor by firms. Because of the greater cost of making the workplace safer, firms will be willing to offer workers a higher wage for jobs of greater riskiness if the costs of added safety exceed the compensating differential for risk. Workers will select the desired wage-risk combination from the available job offers, where workers will demand a higher wage rate for the added risk imposed by a hazardous position.

The great majority of studies of labor market risk bearing focus on the wage-risk combinations generated by this set of choices. Although there are differences in approach, the principal emphasis is on the average rate of tradeoff in the market for death risks and wages.

The essential elements of the procedure are illustrated by a simple formulation of the equation that is estimated statistically using labor market data. In particular, one hypothesizes that for each worker the wage is some function of the worker's personal characteristics and job characteristics, including the job risk, so that the wage equation takes the form:

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Wage = \alpha_0 + \sum_{i=1}^{k} \beta_i \text{ Personal Characteristics} + \sum_{i=1}^{m} \gamma_i \text{ Job Characteristics} + \tau \text{ Risk} + \text{error.}
\]

With any statistical relationship there will be some source of error, which is indicated as the final term in equation 1. The main task from the standpoint of sound statistical analysis is to ensure that this error is random.

What is most noteworthy is that the compensating differential for risk is not determined by looking up the risk premium in a labor market contract. Rather,

\footnote{For further discussion of the approach discussed below, see Rosen (1988).}
one must obtain statistical estimates that disentangle the premium for job risk from other attributes of either the worker or his job.

Because of the difficulty of sorting out these differences, compensating differentials for risk were not reliably estimated until the 1970s. Before that time, labor market studies primarily utilized data by industry. At the industry-wide level, the sources of variation are too great to isolate aspects of the compensation mix such as this. With the advent of large data sets on individual workers, it became possible to obtain information on a variety of aspects of the individual and his job, making it feasible to isolate the risk premium.

Before considering the specific aspects of the estimation process in detail, we should at least note the similarity of the statistical task for estimating the value of life to that of estimating the present value of lost earnings. Implicit in a lost earnings calculation is a wage equation of a form similar to equation 1. The difference is that the analysis focuses on the relationship of wages to personal characteristics, principally the age and experience of the individual injured. In contrast, the value of life estimates focus on the wage-risk tradeoff. In each case, the estimates of the damages are derived from an implicit or an explicit wage equation. A principal issue is whether the risk-wage tradeoff results are less meaningful than the other implications of the wage-equation analysis.

Dickens (1990) identifies a variety of sources of error that may affect the equation. These include, for example, errors with respect to the measurement of the job risk variable. However, errors of this type affect estimates of all aspects of such equations, not simply the risk variable. Similarly, omitted variables bias problems contaminate the entire equation, not simply the job risk coefficient. Thus, many of these same classes of problems that affect our understanding of compensating differentials also are present in the context of projecting earnings loss. They are also present in the wage equations estimated in the efficiency wage literature cited by Dickens (1990).

III. Choice of the Risk Variable

Ideally, one would want to use a risk variable that reflects the subjective risk perceptions of the individual bearing the risk. Risks include fatal and nonfatal hazards posed by the job. The value-of-life literature necessarily focuses on fatality risks, although ideally one would also want to include nonfatal risks in the equation so as not to capture these premiums as part of the estimate of the value of life.

The first measure of death risks used in the literature is that of the total fatality rates associated with different occupations based on data from the Society of Actuaries. This analysis by Thaler and Rosen (1976) captured overall risks associated with people in different occupations and did not distinguish the portion of the risk due to the job per se. Moreover, since this sample consisted disproportionately of people in high risk jobs, the average risk level of 1/1,000 was almost an order of magnitude greater than the average for the U.S. workforce. As a result, their estimated value of life (in 1987 dollars) of $700,000 will be lower than the appropriate estimate for the population at large. These estimates

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3 As we indicate below, these too may be sensitive to individual income levels.
are in no way wrong. Rather, they simply reflect the value-of-life preferences of the particular population group that was the focus of their estimation.


These studies consequently used a risk measure that was more representative of risks throughout the U.S. economy. The BLS has long collected data pertaining to industry fatality rates, and these risk levels can be matched to workers in a sample using information on the workers’ industry. The studies by Smith (1976) and Viscusi (1978a, 1979a) were the first published analyses to utilize these data.

Reliance on the BLS death risk data for which the average worker risk is 1/10,000 annually yields higher values of life on the order of several million dollars. These estimates exceed those in the original Thaler and Rosen (1976) study since the mix of workers in the samples differ.

One would expect there to be such substantial heterogeneity in the value of life since the preferences of the individuals bearing the risk will differ depending on the mix of workers included in the sample. The value of life is not a natural constant, but is simply a rate of tradeoff that reflects the character of the individual’s attitude toward the risk.

The Bureau of Labor statistics and the Society of Actuaries results were reconciled in Viscusi (1981) in which I explicitly estimated the heterogeneity in the value of life. These results yielded results that were consistent with the findings of Thaler and Rosen for BLS risk levels comparable to those in their study, but they indicated that a value of life may range as high as $10,000,000 for workers in very low risk jobs.

Because of perceived inadequacies in measures of death risks generated by BLS and the National Safety Council, the National Institute of Occupational Safety and Health launched a project known as the National Traumatic Occupational Fatality Project. This effort consisted of a census of all job-related fatalities in order to reduce the measurement error in the death risk index. Although Dickens (1990) alludes to “some recent studies” using these NIOSH data, to the best of my knowledge the only published studies are those that have been undertaken by Michael Moore and myself. The number of studies we have written using these data now total six, and one of them is a book that addresses a wide variety of issues relating to the role of job risks in the economy (Moore and Viscusi, 1988a, 1989, 1990a, 1990b, forthcoming 1990c). Estimates using the NIOSH data yield value-of-life estimates roughly double those obtained with BLS data, as they are on the order of $5 million dollars or more for the typical worker.

Moreover, Dickens’ (1990) observation that measurement error is an issue is also not new. The source of the difference in the BLS and NIOSH results has been explored extensively in Moore and Viscusi (1988a) in which we address the measurement error issue in substantial detail. Because of the more detailed character of the NIOSH data and its utilization of data that is averaged over a 5-year period, there should be less random error than in the BLS death risk measure. The NIOSH measure of the risk is based on a sample that includes almost 35,000 worker fatalities over a 5-year period so that limitations of death risk variables due to the smallness of the sample size are not of major consequence.
Moreover, the data are available by industry and by state, making possible a more precise match-up of the reported risk level with the particular worker. If this measurement error were random, the NIOSH estimates should yield higher estimated values of life. There is also, however, a difference in the level of the risk measures. In particular, the NIOSH death risk level is larger than that implied by the BLS death risk measure. Nation-wide, the Bureau of Labor Statistics reported only 3,750 job-related fatalities in 1984, as contrasted with an annual death rate of 6,901 workers over the 1980–1984 period for NIOSH. This scale effect should lead the estimated values of life from the BLS data to be greater than those obtained with the NIOSH data. The estimated results indicate that the random measurement error effect dominates the influence of the bias in the scale of the variables. Moreover, the extent of the change in the estimates for otherwise identical equations indicates the substantial role of measurement error in influencing the earlier results in the literature.

Even an ideal measure of the industry risk level will not be perfect. Jobs within an industry differ in their riskiness, and the resulting measurement error will tend to bias the results downward if it is random. Even an accurate industry-occupation measure of the job risks will not be free of error because what drives worker decisions is not the objective measure of the risk but rather their subjective perception of the hazard, which may differ from the measured risk.

One mechanism for taking into account workers’ subjective perceptions is to utilize information reported in surveys regarding risk perception levels. In Viscusi (1978a, 1979a), I introduce this approach by interacting the subjective risk perception measure with the objective risk index. The University of Michigan Survey of Working Conditions includes a question ascertaining whether a worker believes his job is dangerous. Workers indicating that their job was hazardous in some respect received as their risk measure the BLS risk level, and workers who did not believe their jobs were dangerous received a risk value of zero. A similar approach has been employed by Moore and Viscusi (1988b). In each case, the estimated value of life is similar to that obtained using the objective risk measure, although the results do differ in modest ways.

A final possibility is to rely exclusively on the worker’s subjective risk assessment. This is done in Viscusi (1978a, 1979a) for the worker’s subjective danger perception variable.

In Viscusi and O’Connor (1984), we introduced a subjective risk perception scale in which the worker recorded his or her perception of the risk, which was then used in a wage equation. A similar approach has also been employed more recently in Hersch and Viscusi (1990). In each case, the estimates and results are similar in magnitude to those obtained using objective risk measures of the injury rate. A similar methodology employed within a survey study by Gerking, de Haan, and Schulze (1988) also generated estimates of the value of life similar in magnitude to those obtained using market data.

IV. Imperfect Information and the Rationality of Choice

The above discussion of measurement error with respect to the risk variable is based on the underlying assumption that workers have full information about the job risk and act upon this knowledge in a fully rational manner. The only
difficulty for economists is in gathering data on how this full information world operates. This idealized situation, of course, may not always prevail.

The observation that workers may lack full knowledge about the risks they face is not a new one for the compensating differential literature. The inadequate nature of information was a central theme of my 1976 dissertation, which was subsequently published as Viscusi (1979a). In that and subsequent related work (Viscusi, 1979a,b,c; 1980a,b,c; and 1983a), I constructed models to reflect the fact that workers may lack full details when they initially begin work on the job, but there are often opportunities for information acquisition after work on it. Workers can learn about the fatality risks of their jobs in a number of ways. They do not have to die or rely upon observing deaths in the workplace to obtain some basis for making a risk assessment. The presence of worker injuries, the character of the workplace operations, the speed of work, the noise levels, the presence of noxious fumes, and other observable attributes of the job all contribute to worker risk perceptions.

The two-armed bandit models I have developed to structure this process of learning and adaptive behavior yield quite explicit results with respect to the estimates of the compensating differential literature. In particular, if workers have unbiased risk perceptions which are imprecise, they will demand too little wage compensation in return for the risks they face. The theoretical predictions are unambiguous. Compensating differentials will be understated. Moreover, there will be an additional worker response through quitting. My empirical estimates in Viscusi (1983b) suggest that manufacturing quit rates are almost one-third greater than they would be in the absence of learning about job risks, which is consistent with this learning model.

The results in Viscusi and O'Connor (1984) explicitly test some of the specific and distinctive propositions generated by this learning model. Whereas my earlier work on the job hazard–quit relationship is suggestive, it is not as refined a test of the theory as one might like. The test in Viscusi and O'Connor is quite explicit and deals with an aspect that is quite specific to the theory. In particular, an optimal sequential decision model predicts that workers will display a systematic preference for jobs that are dimly understood. Viewed somewhat differently, imprecisely understood risks should lead workers to be willing to accept a lower wage premium for bearing the risks. The prediction that there should be a positive relationship between the required wage rate and the precision of the risk assessment is a novel prediction of the model. This result is borne out empirically, thus corroborating this model of optimal worker experimentation.

A second source of irrationality pertains to systematic biases in risk perception. In an early study of catastrophe insurance, Kunreuther (1976) found that individuals failed to purchase insurance against risks of floods and earthquakes even though this insurance was often subsidized by the government. However, the fact that people do not purchase such insurance does not necessarily imply that they misassess the risks. Learning about subsidized insurance and expending

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4 Dickens (1990) apparently uses a model from classical statistics rather than a Bayesian learning model as his reference point.

5 Dickens (1990) has interpreted this phenomenon as reflecting a systematic tendency to underestimate risks.
the effort to obtain such insurance is often a costly process. Moreover, individuals may anticipate that they will be bailed out by a disaster relief program so that purchase of insurance is not needed. Finally, even if subsidized insurance is available, for the risk faced in a particular location of the household (e.g., a house on high ground), the purchase of such insurance may not be actuarially attractive.

Rather than rely on such indirect evidence of risk perception bias, researchers developed a substantial literature in the 1980s addressing the character of risk perceptions. One study of fatality risk perceptions that currently reflects the consensus in the literature is that of Fischhoff, et al. (1981). Fischhoff and his group of psychologist colleagues demonstrated that there is a systematic tendency to overestimate low probability risks and to underestimate the large risks. For example, people overestimate the risk of being killed by a tornado, a flood, or an earthquake, but they underestimate the overall risk that they face from heart disease and strokes. In Viscusi (1990), I analyze how perception biases such as this affect responses to risk. The net effect from the standpoint of risk valuation is that such biases tend to flatten out individuals' responses to changes in risks except when there are incremental jumps from a zero risk situation to a finite risk level. These and similar modifications do not require that the compensating differential model be abandoned, only that it be generalized to reflect such concerns.

V. Other Estimation Issues

Although there are a variety of issues that arise with respect to appropriate estimation of compensating differential equations, here I will emphasize two of them. First, the equations should include other measures of the character of the job other than the fatality risk. The purpose of the compensating differential equation is to disentangle the job risk compensation for compensation from other job attributes unrelated to fatality risk, such as having an unpleasant supervisor.

Studies differ greatly in terms of how adequately they take these factors into account, and as a result the meaningfulness of the estimates also differs considerably. Because of such differences, it is inappropriate to simply average studies in the literature without also ensuring that the equations estimated were comparable.

This familiar omitted variables problem has been recently noted by Dickens (1990): "Dirty jobs, fast-paced jobs, jobs involving heavy lifting, exposure to extreme temperatures, or noxious chemicals were also more likely to be dangerous jobs. This is just a partial list of such characteristics. Most studies cannot control for any of these characteristics. None can control for all of them."

To see how well such studies can control for these features, it is useful to examine the results reported in Viscusi (1979a). That study includes not only a fatality measure and a non-fatal job risk measure, but also an extensive set of variables pertaining to the nature of the job, including: the size of the firm, whether the firm is unionized, whether the worker is a supervisor, the speed of work, whether the job permits the worker to make decisions, whether the job requires that the worker not make mistakes, the presence of overtime work, worker training, a set of 25 industry variables, and a series of three occupational variables. In addition, variables pertaining to the speed of work, the physical
effort involved, and the pleasantness of physical conditions entered a quit equation in Viscusi (1979a), but were not statistically significant in the wage equation. Taking such factors into account is largely an issue of appropriate care on the part of the economic analyst rather than a question of feasibility.

One of the most important variables to be included but which has typically been omitted is that of workers' compensation. Moreover, when this variable is included it should be in an economically correct form, as indicated in Viscusi and Moore (1987), so that the higher value of such benefits to workers in risky jobs is recognized. The workers' compensation program imposes premiums in excess of $20 billion dollars per year to fund a compensation insurance system for workers injured on the job. Not unexpectedly, the levels of workers' compensation benefits should also influence other aspects of the compensation mix, such as wage premiums for risk.

One area where recognition of the role of workers' compensation has proved to be particularly important is with respect to unions. The early unions-job risk literature omitted the role of workers' compensation and generated mixed results. If, however, one takes into account the effect of workers' compensation and the influence of unions on affecting the wage-workers' compensation tradeoff, one finds that workers receive a positive premium for risk—both in union and non-union sectors. Moreover, the major role of unions is to reduce the wage reduction from workers' compensation that workers otherwise would have incurred (Moore and Viscusi, 1990).

A second class of issues pertaining to estimation is the sample that will be used for the estimates. Ideally, one would like a set of variables that enables one to control perfectly for variations in job attributes so that one can successfully disentangle premiums for job risks from other labor market premiums. However, this task is complicated by the fact that there is a strong positive income elasticity of demand for good health. As a result, the highest paid jobs in society are also the most attractive. The overall relationship between income and risk is negative.

Economists using data sets that do not provide adequate controls to take full account of all the various factors determining income often focus on the portion of their samples for whom the job risk questions are most appropriate. Thus, many studies analyze blue-collar workers, production workers, or male workers in an effort to isolate the premiums provided to workers in hazardous jobs.

VI. Conclusion

Value-of-life issues are on the frontier of emerging judicial policy in the area, but they are not novelties from the standpoint of labor economics. The theory of compensating differentials has been established for over two centuries, and a substantial empirical literature on this topic has developed over the past two decades. The compensating differential analysis is featured in all major labor economics textbooks, and remains an active area of economics research. As in any area of economics, there will remain debates over the appropriate estimation of the relationships, as economists attempt to continually refine these values.

Although statistical estimation is by its very nature a process that involves some error, which ideally is random, courts are not faced with a situation in which they are moving from valuation techniques without error to techniques
that have error. Economists who prepare lost earnings analyses are not clairvoyant. They cannot foresee with perfect accuracy the expected future earnings of a person who is injured or killed. Nor is there complete foresight regarding prospective medical costs. The task of the economist is to provide his or her best estimate of these losses, where the actual outcome may lie either above or below these estimates.

Even if there were less error with the value-of-life estimates than with current loss procedures, one should not necessarily switch to this methodology in all cases. Indeed, the key decision facing the courts is the threshold decision of when value-of-life numbers should be employed in judicial contexts. Unfortunately, most individuals testifying on these issues have not been involved in the development of these estimates and, as a result, they often have little understanding of their economic foundations or how they should be utilized in the courtroom. Indeed, there are instances of some individuals who have not even read the specific studies generating the estimates before venturing forth to undertake damages calculations based upon this literature.

Selecting the correct value-of-life number requires just as much care as calculating appropriate damages under current methodologies. It makes no more sense to utilize a uniform value-of-life figure for all people than it does to assume that economic damages are the same for every wrongful death case. A substantial danger is that if value-of-life concepts are adopted, they will be misused by those who have little interest in their content beyond the price tag that will result from awards based on these procedures.

References


