Journal of Risk and Uncertainty, 1: 185–199 (1988)

The Marginal Value of Job Safety: A Contingent Valuation Study

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Key words: Contingent valuation, hedonic price method, marginal value of safety, perceived risk

Abstract

This article estimates the marginal value of safety based on contingent values obtained in a labor-market-oriented national random-sample mail survey. Thus, worker preferences for safety are assessed directly, in contrast to the hedonic price method that has been used almost exclusively in related studies. Key aspects of this article are that (1) contingent values are obtained for small changes in risks of job-related fatal accidents *perceived* by respondents, and (2) relationships are analyzed between respondents' marginal safety values and their income, socioeconomic/demographic characteristics, union membership status, and initial levels of risk faced.

Marginal value of safety estimates from labor market data generally have been obtained using empirical hedonic wage models. As discussed more fully in reviews by Smith (1979), Marin and Psacharopoulos (1982), Dickens (1984), and Dillingham (1985), these estimates are marked by wide divergence and conspicuous anomalies. Reasons cited for this outcome include problems of measuring fatal and nonfatal job-related accident risks, failure to adequately control for human capital and workplace characteristics, and differential bargaining strength of unionized workers. While the importance of such factors should not be minimized, exclusive focus on them draws attention away from another serious issue. Gegax, Gerking, and Schulze (1987) argue that there are many types of jobs in which fatal accident risks do not enter the production function. In this situation, the marginal product of risk is zero, no hedonic gradient exists, and the value of alterations in safety must be assessed in settings other than the labor market and/or using alternatives to the hedonic price method.

This article estimates the marginal value of safety by directly asking respondents in a national random-sample mail survey about their willingness to substitute money for changes in job-related fatal accident risks. Two versions of this approach, referred to as contingent valuation, are considered: respondents stated either willingness to pay for a specified reduction in job-related fatal accident risks, or additional compensation required to willingly accept an increase in such risks. Thus, worker preferences for safety are directly measured, in contrast to the hedonic price method which focuses on the locus of tangency points between worker indifference curves and firm isoprofit curves in the wage-risk plane. Viscusi and O'Connor (1984) previously elicited willingness to accept contingent values for nonfatal job accident risks in their study of chemical workers. The present study apparently is the first to obtain in a labor market context (1) contingent values for fatal risks, and (2) willingness to pay, as contrasted with willingness to accept, values to avoid those risks. Numerous contingent valuation studies, however, recently have been conducted in related settings such as traffic safety (Jones-Lee, Hammerton, and Philips, 1985), water quality (Desvousges, Smith, and Fisher, 1987) and exposure to toxic wastes (Smith and Desvousges, 1987). Cummings, Brookshire, and Schulze (1986) critically evaluate uses of contingent valuation in environmental benefit assessment.

The following discussion also considers three aspects of the contingent valuation data to sharpen interpretation of the marginal value of safety estimates. First, contingent values are obtained for small changes in risks of job-related fatal accidents *perceived* by respondents. Measurement of perceived risk is a central issue in computing marginal value of safety estimates—one that has failed, with few exceptions (see, for example, Viscusi and O'Connor, 1984), to receive sufficient attention in existing literature. Psychologists have long argued that the cognitive process used to form risk beliefs is complex and often leads to perceptions that are inconsistent with objective measures of risk (Kahneman and Tversky, 1979, 1984; Lichtenstein et al., 1978). Second, relationships are analyzed between respondents' marginal safety values and their income and socioeconomic/demographic characteristics (e.g., race, gender, union membership status, education). Parallel analyses often are undertaken in hedonic wage-risk studies (see, for example, Thaler and Rosen, 1976; Viscusi, 1978; Olson, 1981; and Worrall and Butler, 1983). Yet, the present study provides a unique opportunity to examine these interactions from the standpoint of worker preferences alone. Third, relationships are analyzed between marginal safety values and initial levels of risk faced. In contrast to Smith and Desvousges (1987), results presented below show a significant positive association between these two variables.

The remainder of the article is divided into three sections. Section 1 discusses the mail survey data. Section 2 analyzes contingent values in detail and shows their relationship to other variables measured in the mail survey. Implications and conclusions are drawn out in section 3.

1. Mail survey data

Empirical work in this study uses data collected by national mail survey during summer, 1984. Implementation of the mail survey closely followed Dillman's

(1978) total design method. For example, care was taken in preparing cover letters and survey materials sent to respondents. Postcard reminders were sent eight days after the initial mailing. A replacement questionnaire and cover letter was sent to everyone who had not responded within three weeks. A more complete description of the survey methodology, questionnaire pretesting, and copies of all materials can be found in Gegax et al. (1985).

Survey materials were sent to (1) a simple random sample of 3000 U.S. households, and (2) 3000 additional households randomly selected from 105 counties that have disproportionately large concentrations of high-risk industries. In the second component, the sample included an equal number of households (750) from the northeast, northcentral, south, and west regions of the U.S.[1] Of 6000 questionnaries mailed, 749 (12.5%) were returned as undeliverable and 2103 were returned in completed form. Thus, the net response rate was about 40%.

Although the response rate was reasonably good in light of length and complexity of the questionnaire, it does raise questions about possible biases in the resulting sample. A general problem with mail surveys is that better-educated, higher-income individuals tend to respond with greater frequency than other groups. The present survey is no exception. Dickie and Gerking (1988), who use these data to test for interregional wage equality, note that in a restricted sample of full-time workers very similar to the one analyzed in section 2, 6.8% did not complete high school, as compared with 16.5% of employed civilians aged 25 or older in the U.S. Also, 43.9% of workers were employed as managers or professionals as compared with 26.4% in the general U.S. population. Therefore, a cost of using the mail survey approach may be an undersampling of low-human-capital-low-income workers. If job safety is a normal good, then workers in high-risk jobs may be underrepresented in the present sample.

Three types of information were obtained from the head of each responding household. First, the survey developed two measures of each household head's perceived risk of a fatal accident at work. With respect to the first measure, respondents were shown a list of 13 major causes of death at work (e.g., motor vehicle accident, electrocution, gun shot, explosion) and asked to rank the likelihood of each occurring to them on an ordinal integer scale with 1 labeled "Could Never Happen" and 5 labeled "Most Likely to Happen." This exercise encouraged respondents to review various sources of accidental death risk on their own job and to evaluate which, if any, of these sources posed a credible threat. The variable RISK1 then was computed for each respondent by averaging his rankings across sources of perceived job-related fatality risk. Immediately after providing information needed for RISK1, respondents were shown an illustration of a ladder (see figure 1) with ten equally spaced steps. For reasons elaborated below, each step denoted the number of annual job-related fatal accidents per 4000 workers. Seven example occupations were placed on the ladder according to their average levels of job-related risk of death ranging from relatively safe jobs such as schoolteachers to more dangerous jobs such as lumberjacks. Respondents then specified the step number, which defined the variable RISK2, that most closely described their risk of job-related accidental death. It is worth emphasizing that both RISK1

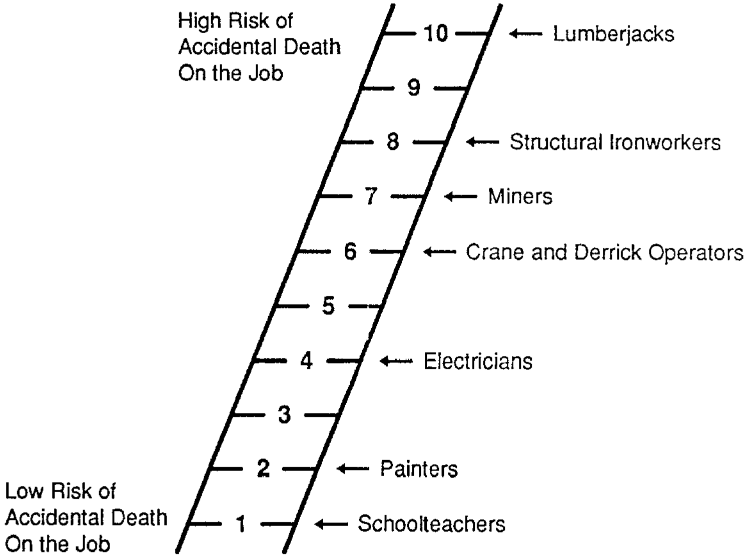

Fig. 1. Risk ladder shown to survey respondents.

and RISK2 measure *perceived* risks of accidental death on the job and may be viewed as disaggregated versions of the DANGER variable used by Viscusi (1979).

Procedures used to construct RISK2 are worth further elaboration. The risk ladder scale and six of the seven example occupations are based on data presented in Thaler and Rosen (1976, p. 288). These data measure extra deaths per 100,000 policy years of life insurance underwriting experience after subtracting expected deaths by age and occupation based on sample records and standard life tables. For example, in the Thaler and Rosen sample, lumbermen had 256 extra deaths per 100,000 policy years (or approximately ten extra deaths per 4000 policy years). Consequently, this example occupation was placed on the tenth rung of the risk ladder. Similar calculations were made for structural ironworkers, miners, cranemen and derrickmen, electricians, and painters, and these occupations were appropriately placed on the ladder. Schoolteachers, an occupational group not considered by Thaler and Rosen, were arbitrarily assigned to the first rung of the ladder.

The mean of RISK2 in the sample analyzed in the following section is 2.64. Thus, the average perceived risk of death was less than one in 2000. This comparatively large figure may be partly an outcome of using the Thaler and Rosen data to calibrate the risk ladder. Marin and Psacharopoulos (1982) point out that if occupational and nonoccupational death risks are positively correlated, then the Thaler and Rosen data would overestimate occupational death risks. Also, the comparatively high mean value may indicate that respondents overperceived fatal accident risks. Bureau of Labor Statistics (U.S. Department of Labor, 1986) data on actual fatal accidents by industry indicate average death probabilities on the order of one worker in 5000 to 10,000 per year. Reinforcing the point on overperception of risk is the fact that, as previously noted, high-income, high-human-capital individuals are overrepresented in the sample, implying an underrepresentation of workers in high-risk jobs.

The second type of information collected pertains to the contingent valuation analysis. Half of the surveys asked how large an increase in annual wages would induce repondents to voluntarily work at the same job if risk of accidental death were one step higher on the ladder than where they placed their initial assessment. The other half of the surveys asked how large a decrease in annual wages respondents willingly would forego if their job-related risk of death were moved one step lower on the ladder. Thus, the former question asks for willingness to accept, the latter asks for willingness to pay, and both make use of the ladder used to construct RISK2. For the contingent valuation questions, then, respondents had to assess for themselves how much incremental risk was involved in a one-step move on the ladder. The only subjective way they would have to understand this change in risk would be to *imagine* the threats involved to workers in the various example jobs used on the ladder. Therefore, the quality of marginal value of safety estimates obtained from the survey depends critically on an understanding of the change in risk presented.[2]

To answer the valuation question, respondents marked one of 37 boxes denoting dollar amounts ranging from $0 to more than $6000 that most closely approximated willingness to pay or willingness to accept for a one-step movement on the risk ladder. However, individuals receiving the willingness-to-pay version whose initial job risk assessment was placed on the first rung of the ladder, and individuals receiving the willingness-to-accept version whose initial job risk assessment was placed on the tenth rung, were unable to make this one-step move. As a consequence, these willingness-to-pay respondents were instructed to bid on movement from the second to the first rung and willingness-to-accept respondents were asked how much money they would require to induce them to move from rung nine to rung ten. Of the willingness-to-pay respondents included in the final data set (the composition of which is discussed below), 50.9% placed their initial level of job risk on the first rung of the ladder—a result that indicates that the range of risks depicted may have been too narrow. Correspondingly, 1.2% of the willingness to accept respondents placed their initial risk level on the tenth rung of the ladder.

Third, the survey also measures respondents' human capital, workplace, and socioeconomic characteristics. Key variables used in this study are (1) years of schooling, (2) whether head is a union member, (3) years of age, (4) race, (5) gender, and (6) annual labor earnings. More precise definitions of variables used in the analysis are presented in table 1 in section 2.

As previously indicated, completed questionnaires were received from 2103 respondents. For several reasons, however, not all of this information could be used

Table 1. Two-Limit Tobit Estimates from Two Subsamples: Dependent Variable is the Contingent Valuation Bid

Explanatory Variable	Definition	Subsample Estimates			
		Willingness to Pay		Willingness to Accept	
CONSTANT		−2570.28 (−2.469)	−788.66 (−0.955)	448.63 (0.386)	2218.71 (2.065)
EARN	Labor earnings from respondent's main job in 1983	0.0217 (2.885)	0.0272 (3.055)	0.0228 (2.982)	0.0249 (3.249)
RISK1	Perceived risk of job-related fatal accidents from 13 causes	630.38 (2.462)	—	690.36 (2.850)	—
LOWRISK	1 if RISK1 is less than or equal to its mean value; 0 otherwise	—	−783.99 (−2.228)	—	−597.51 (−1.708)
RACE	1 if white; 0 otherwise	−1257.20 (−2.212)	−1281.24 (−2.269)	−546.04 (−0.656)	−612.92 (−0.739)
AGE	Years of age	22.35 (1.602)	22.72 (1.621)	−13.98 (−0.909)	−17.19 (−1.103)

GENDER	1 if male; 0 if female	−387.33 (−0.880)	−357.61 (−0.826)	419.58 (0.678)	513.69 (0.823)
SCHOOL1	1 if formal schooling ended with completion of high school (or vocational program), or before; 0 otherwise	739.96 (1.624)	693.55 (1.498)	−496.59 (−1.009)	−402.67 (−0.810)
SCHOOL2	1 if formal schooling ended with some college or completion of bachelor's degree; 0 otherwise	676.47 (1.725)	657.22 (1.683)	−533.48 (−1.205)	−426.75 (−0.967)
SCHOOL3	1 if formal schooling ended post-graduate training or completion of post-graduate degree; 0 otherwise	—	—	—	—
UNION	1 if respondent is a union member; 0 otherwise	−3.46 (−0.011)	43.98 (0.139)	−314.014 (−.815)	−179.13 (−0.462)
STEP1	1 if RISK2 equals 1; 0 otherwise	486.22 (1.382)	458.99 (1.261)	—	—
SUMMARY STATISTICS					
Standard Error		2643.17	2649.50	3293.64	3311.28
Log of Likelihood		−2570.28	−2031.70	−2471.00	−2472.90
Number of Observations		444	444	417	417

in the analysis. Responses from 872 retired or unemployed individuals were excluded, since the job risk and labor earnings questions did not apply to them. Additionally, responses from 32 individuals who did not answer the contingent valuation questions were dropped. Also excluded were 338 individuals who did not supply key information related to contingent values, such as labor earnings and initial level of job risk faced. These restrictions reduced the original number of respondents to a sample size of 861 observations.

2. Analyzing contingent values

Mean contingent valuation bids for a one-step move on the risk ladder are \$665 for the willingness-to-pay questionnaires and \$1705 for the willingness-to-accept version. Multiplying these values by 4000 yields marginal value of safety estimates of \$2.66 million and \$6.82 million for the two subsamples. Both values are significantly greater than zero using a *t*-test. Thus, the contingent values should not be automatically dismissed as purely random or ill-considered responses to a hypothetical question. Also, the distribution of both willingness-to-pay and willingness-to-accept responses are positively skewed with medians less than means. Partially responsible for this outcome is the comparatively large number of zero bids: 47.4% of the willingness-to-pay contingent values were zero and the corresponding figure for willingness-to-accept contingent values was 23.2%. This clustering of bids at zero may reflect the previously mentioned narrow range of risks shown on the ladder. Alternatively, it may mean that some workers do not bother to calculate small positive bids and simply report zero instead. A decision to edit or deny the value of small risk reductions in certain situations is in fact a rational response to the innumerable risks which are present in daily life. Only some risks can receive attention given limited resources. Thus, the many zero bids likely reflect a prior decision by respondents to edit their own job-related risks.

Notice that the mean willingness-to-accept estimate of the marginal value of safety exceeds that obtained using the willingness-to-pay approach by a factor of approximately 2.5. This finding is similar to results reported by Knetsch and Sinden (1984), Brookshire and Coursey (1987), Coursey, Hovis, and Schulze (1987), and Viscusi, Magat, and Huber (1987) showing that willingness-to-accept contingent values are larger than those obtained in a willingness-to-pay framework. Additionally, it is consistent with the observation that people are reluctant to accept involuntary risks. Since labor markets are voluntary institutions, it may well be the case that hedonic studies of wages and risk reveal willingness-to-pay values.

The contingent valuation willingness-to-pay estimate (\$2.66 million) is close to Viscusi's (1978) widely cited \$3.4 million estimate (in 1984 dollars) and lies within Dillingham's (1985) "best-guess" range of marginal safety values (\$1.3–\$2.7 million in 1984 dollars) based on his analysis of labor market studies. Thus, the contingent valuation willingness-to-pay estimate of the marginal value of safety is not implausible in light of results from previous labor market studies.

Further analysis of both willingness-to-pay and willingness-to-accept contingent values reveals interesting relationships with other variables. This analysis was undertaken by estimating the effects of explanatory variables including annual labor earnings, race, gender, age, union membership, schooling, and initial level of risk faced in the contingent valuation bid to move one step on the risk ladder. Estimates of this relationship were obtained using a two-limit tobit procedure because of the large proportion of zero bids and the truncation of the bid distribution at $6000. All observations in each subsample are used in the regression analysis.

Use of all observations represents a departure from practices often followed in contingent valuation studies in which attempts are made to eliminate protest and/or outlier bids prior to statistical analysis. As noted by Smith and Desvousges (1987), protest bids can be defined as zero bids given by respondents for reasons *other than* as a reflection of the value of alteration in risk or as an indication of budget limitations. Outlier bids, on the other hand, can be defined as influential or implausible bids and identified using both statistical and nonstatistical procedures. Both types of troublesome bids, however, are more easily defined than identified, and methods used to determine which bids to ignore are arbitrary. For example, Rowe and Chestnut (1987) suggest throwing out bids that violate prespecified consistency checks based on income or the cost of obtaining by other means the good for which the bid was obtained. Jones-Lee, Hammerton, and Philips (1985) trimmed bid distributions by removing upper tail responses that displayed discontinuity in terms of order of magnitude in relation to other responses. Also, Smith and Desvousges analyze only positive bids using Heckman's (1979) two-step estimator to correct for the sample selection effects that result from dropping the zero bids. This latter approach may well eliminate some valid bids that simply happen to be zero, and does not identify outlier bids. In any case, rather than resort to bid elimination procedures that would end up being difficult to defend, all usable observations were included in the data set.[3]

Table 1 presents two-limit tobit estimates from the willingness-to-pay and willingness-to-accept subsamples. The dependent variable in each regression is the contingent valuation bid to move one rung up, in the case of willingness to accept, or down, in the case of willingness to pay, on the risk ladder. The t-statistics are shown in parentheses beneath the coefficient estimates, and summary statistics provided at the bottom of the table indicate that the null hypothesis of no relationship between the dependent variables and all explanatory variables would be rejected at conventional significance levels. Also, previously promised definitions of explanatory variables are given in the second column.

Most of these variable definitions are straightforward; however, RISK1 and STEP1 require further elaboration. RISK1 was created by adding the ordinal 1-to-5 rankings of perceived likelihood of death from each major accidental cause and dividing by number of causes considered (13). STEP1 reflects whether a willingness-to-pay respondent initially placed his job on the first rung of the risk ladder. Recall that because these respondents could not then move down a step, they were asked to bid on a move from the second rung to the first. A variable corresponding to STEP1 was not included in the willingness-to-accept regressions because only 1.2% of respondents in this subsample placed their initial level of risk on the tenth rung of the risk ladder.

Results presented in table 1 use RISK1 rather than RISK2. RISK2 performed poorly in all regressions (both for willingness-to-pay and willingness-to-accept subsamples) in which it was included. Coefficients of RISK2 (not presented) occasionally were negative and seldom had t-statistics exceeding .50 in absolute value. As discussed more fully below, coefficients of RISK1 are positive and significant at conventional levels. The Pearson correlation between RISK1 and RISK2 is approximately .46 in each of the two subsamples. One explanation for the difference in performance of these two variables is that the question on which RISK1 is based provided respondents with more perceptual cues or reminders of risk than did the risk ladder. In other words, they found it easier to subjectively assess the chance of occurrence of specific causes of accidental death than to place their job on a risk ladder in comparison with seven example occupations. A second explanation may be that the small number of rungs on the risk ladder prevented precise coefficient estimation. Yet the risk ladder still may have aided respondents in thinking through how much a unit change in risk is worth to them.

Estimates presented in table 1 show effects of earnings, perceived initial risk levels, race, age, gender, union membership status, and schooling on willingness-to-pay and willingness-to-accept contingent valuation bids for a small change in job safety. The first willingness-to-pay regression (see column 3 of table 1) shows strong positive relationships between the contingent valuation bid and EARN and RISK1. Thus, higher bids were obtained from respondents with higher levels of 1983 labor earnings and who perceived greater likelihoods of accidental death on their jobs. The positive coefficient of EARN was expected given the presumption that a reduction in the probability of a job-related fatal accident is a normal good. Additionally, the positive coefficient of RISK1 suggests that respondent indifference curves are upward sloping in the money–risk plane. This result sharply contrasts with the negative association between option price bids and baseline risk levels found by Smith and Desvousges (1987). Moreover, it supports theoretical analyses of Jones-Lee (1974) and Weinstein, Shepard, and Pliskin (1980) which demonstrate that under plausible assumptions, individuals would be willing to pay larger amounts to avoid a unit of risk reduction, the higher the initial level of risk faced.

The relationship between willingness to pay and perceived initial risk levels is further analyzed in the regression shown in the fourth column of table 1. There is only one difference in specification between this regression and the one shown in column 3: RISK1 has been dropped and the dummy variable LOWRISK has been added. As indicated in the table, LOWRISK measures whether RISK1 is less than its mean value of 2.23. Thus, the negative coefficient of LOWRISK indicates that respondents facing below-average perceived risk levels are willing to pay less for a one-step movement down the risk ladder than are respondents facing above-average perceived risk levels. This finding is consistent with contingent valuation willingness-to-pay results in the Jones-Lee, Hammerton, and Philips (1985) study suggesting that willingness to pay to avoid risk of death in a traffic safety context is an increasing, concave function of risk reduction.

Returning to the column 3 regression, other results of interest are that willingness to pay to avoid job-related fatal accident risks tends to be larger for older workers. The coefficient of AGE, however, with t-statistic of approximately 1.60, is not significantly different from zero at the 10% level using a two-tail test. Yet, this positive coefficient does provide weak evidence that workers may become increasingly averse to job-related fatal accidents as they age. Additionally, the coefficient of UNION has a particularly small t-statistic of -0.011. Thus, preferences of union members for job safety are not different from those of nonunion members—a result that at first may be surprising in light of most previous labor market studies. Viscusi (1978), Dickens (1984), Olson (1981), and Worrall and Butler (1983), for example, note significant wage premiums earned by union members who work at riskier jobs and zero (even occasionally negative) wage premiums for nonunion members who work at riskier jobs.[4]

One explanation for these results may be that unions alter the wage–risk tradeoff even though union members' preferences for risk do not differ from those of nonunion members. This alteration in the wage–risk relationship may reflect a mechanism through which unions capture their economic rents. Another possible explanation may lie in differences in risk perceptions between union and nonunion workers. As demonstrated by Viscusi (1983), unions play a key role in collecting and disseminating job-related risk information, thus increasing their members' awareness of safety hazards. Moreover, unionized jobs may be riskier than jobs in the nonunion sector. In the mail survey data, unionized workers perceived somewhat greater levels of risk on their jobs than did nonunionized workers. Averages of RISK1 and RISK2 were 2.44 and 3.30 for unionized workers and 2.11 and 2.23, respectively, for nonunion members. More jobs in the nonunion sector, therefore, may have low odds of a fatal accident and for a larger share of these jobs, fatal accident risks may not enter the production function. Thus, the marginal product of increased job-related fatal accidents is zero and no hedonic wage–risk gradient exists. Yet, as reflected in the insignificant coefficient of UNION, there may be little difference between union and nonunion worker preferences to avoid fatal accident hazards while on the job.

The coefficient of RACE is negative and significant at the 5% level using a two-tail test, indicating that nonwhites are willing to pay more for safety than are whites. Additionally, the positive, but barely significant, coefficients of SCHOOL1 and SCHOOL2 suggest that willingness to pay for safety decreases with formal education levels (note that SCHOOL3 is the omitted schooling dummy) and the small t-statistic on the coefficient of GENDER indicates no difference in preferences for safety between males and females. Although results for these socioeconomic characteristics are not totally implausible, they may occur, in part, because of confounding with the perceived risk measure. Nonwhites and individuals with lower levels of schooling may work at riskier jobs than do more highly educated whites. Thus, the negative coefficient of RACE and the positive coefficients of SCHOOL1 and SCHOOL2 simply may reflect effects of perceived risk on contingent valuation willingness to pay bids. Finally, the positive coefficient of STEP1 is significantly different from zero only at the 20% level using a two-tail test. Thus, workers who rated their initial level of job safety on the lowest rung of the risk ladder do not appear to have a strong tendency to give different contingent valuation willingness-to-pay bids than other workers.

Willingness-to-accept contingent valuation estimates, shown in the fifth and sixth columns of table 1, are similar to those for willingness to pay in two respects. First, coefficients of EARN and RISK1 are positive with t-statistics of 2.85 or greater. Also, the coefficient of LOWRISK (see column 6) is negative and significant at the 10% level using a two-tail test, thus providing additional evidence that indifference curves increase at an increasing rate in the money–risk plane. Second, coefficients of UNION and GENDER are not significantly different from zero at conventional levels, again implying that preferences for safety do not differ between union and nonunion workers or between males and females. Key differences between the willingness-to-pay and willingness-to-accept regressions are that, in the latter, coefficients of RACE, SCHOOL1, and SCHOOL2 have small t-statistics. Additionally, the constant terms in the willingness-to-accept regressions are larger, thus reflecting the larger mean bid obtained when using this method as compared with willingness to pay. Using a χ^2 test, the null hypothesis of no difference between the coefficients in the willingness-to-pay and willingness-to-accept regressions is rejected at the 1% level.

3. Conclusions

This article has presented marginal value of safety estimates obtained in a labor market context using the contingent valuation method. This method has the virtue of focusing directly on how workers substitute job risk for money. Data collected from a national random sample mail survey were used to measure both willingness-to-accept and willingness-to-pay values to avoid job-related fatal accident risks. Thus, the analysis is similar to that in Viscusi and O'Connor (1984) who measured the willingness of chemical workers to accept small increases in nonfatal job-related risk. Yet this study is the first to examine (1) contingent values for job-related fatal accidents, and (2) willingness to pay for increased job safety. The distinction between willingness-to-accept and willingness-to-pay values is important because, on average, the former are about 2.5 times the latter. Moreover, the average willingness-to-pay estimate of \$2.66 million is roughly consistent with marginal value of safety estimates obtained by applying the hedonic price method to unionized and/or blue-collar workers.

A key feature of mail survey data is the measurement of perceived job-related fatal accident risks. Psychologists have argued that risk beliefs may be inconsistent with objective measures of risk. Measurement of these beliefs, however, has received little attention to date in the safety literature except for the previously cited article by Viscusi and O'Connor. In any case, the relationship between contingent values, perceived risk and other variables is analyzed using a two-limit tobit procedure. Contingent values increase at an increasing rate with initial levels of perceived job-related fatal risk, a result that stands in contrast to findings of Smith and Desvousges (1987) in their study of toxic waste exposure hazards. Additionally, contingent values are unaffected by union membership status. Large differences between marginal safety values of union and nonunion workers represent a major source of controversy in the hedonic labor market safety literature. Thus, the present study suggests that nonunion workers have similar preferences for safety as do union workers, and that for public policy purposes, marginal value of safety estimates obtained for one group can be applied to the other.

Acknowledgments

This research was partially supported by the U.S. Environmental Protection Agency under cooperative assistance agreements CR-811077-01-0 and CR-812054-01-1. However, the article does not necessarily reflect the views of the sponsoring organization. We thank Kip Viscusi, David Brookshire, and Don Coursey for numerous helpful suggestions on earlier drafts and Karen Radosevich, George Cutts, Chari Pepin, Mark Dickie, and Doug Gegax for excellent research assistance.

Notes

1. Difference between means tests were performed for each variable measured in the two subsamples. None of these tests rejected the null hypothesis of no difference at the 5% level. Surprisingly, percentages of respondents in one-digit occupation and industry classifications were not significantly different between the two subsamples even though the latter characteristics were a basis for selecting counties with disproportionately high levels of employment in high-risk industries. As a consequence, the methods used here to identify potential respondents in risky jobs were judged to be ineffective. Yet, empirical work was simplified because unweighted data from the two subsamples simply could be pooled.
2. The situation for hedonic studies of wages and job safety is in reality quite similar in that workers must base their actual risk-motivated behavior on subjective assessments of job risks. These subjective assessments are based on perceptual cues or reminders of risk in the workplace (loud noises, fences, hardhats, warning signs, etc) as well as on experience (especially recent experience) with specific sources of danger. Thus, both contingent valuation and hedonic labor market studies are based on worker's perceptions of risk either based on information presented in the survey instrument or on available information presented in and around the workplace, respectively.

3. In preliminary work, the Smith and Desvousges adaptation of Heckman's two-step estimator was applied to both the willingness-to-pay and willingness-to-accept subsamples. However, ordinary least-squares coefficient estimates in the second step to explain the positive contingent valuation bids proved to be highly dependent on the variables selected for inclusion in the first-step probit regression. As a consequence, this approach was not pursued further.

4. Note that Dillingham and Smith (1984) found little support for this conclusion in their analysis of May, 1979 Current Population Survey data.

References

Brookshire, David S. & Coursey, Don L. Measuring the Value of a Public Good: An Empirical Comparison of Elicitation Procedures. *American Economic Review* (Vol. 77, No. 4, 1987), pp 554-566.

Coursey, Don L., Hovis, John J., & Schulze, William D. The Disparity Between Willingness to Accept and Willingness to Pay Measures of Value. *Quarterly Journal of Economics* (Vol. 102, No. 2, 1987), pp 679-690.

Cummings, Ronald G., Brookshire, David S., & Schulze, William D. *Valuing Environmental Goods: An Assessment of the Contingent Valuation Method.* Totowa, NJ: Rowman & Allanheld Publishers, 1986.

Desvousges, William H., Smith, V. Kerry, & Fisher, Ann. Option Price Estimates for Water Quality Improvements: A Contingent Valuation Study for the Monongahela River. *Journal of Environmental Economics and Management* (Vol. 14, No. 3, 1987), pp 248-267.

Dickens, William T. Differences Between Risk Premiums in Union and Nonunion Wages and the Case for Occupational Safety Regulation. *American Economic Review* (Vol. 74, No. 2, 1984), pp 320-323.

Dickie, Mark & Gerking, Shelby. Interregional Wage Differentials: An Equilibrium Perspective. *Journal of Regional Science* (1988), forthcoming.

Dillingham, Alan E. The Influence of Risk Variable Definition on Value-of-Life Estimates. *Economic Inquiry* (Vol. 23, No. 2, 1985), pp 277-294.

Dillingham, Alan E. & Smith, Robert S. Union Effects on the Valuation of Fatal Risk. *Industrial Relations Research Association.* Proceedings of the Thirty-Sixth Annual Meeting, December 28-30, 1983, San Francisco, (1984), pp 270-277.

Dillman, Donald A. *Mail and Telephone Surveys: The Total Design Method,* New York: Wiley-Interscience, 1978.

Gegax, Douglas, Gerking, Shelby, & Schulze, William. Perceived Risk and the Marginal Value of Safety. Manuscript, Department of Economics, University of Wyoming, Laramie, WY, 1987.

Gegax, Douglas et al. Valuing Safety: Two Approaches. Volume IV in: *Experimental Methods for Assessing Environmental Benefits.* Washington, DC: U.S. Environmental Protection Agency, 1985.

Heckman, James J. Sample Selection Bias as a Specification Error. *Econometrica* (Vol. 47, No. 1, 1979), pp 153-161.

Jones-Lee, Michael W. The Value of Changes in the Probability of Death or Injury. *Journal of Political Economy* (Vol. 82, 1974), pp 835-849.

Jones-Lee, M.W., Hammerton, M., & Philips, P.R. The Value of Safety: Results of a National Sample Survey. *The Economic Journal* (Vol. 95, No. 377, 1985), pp 49-72.

Kahneman, Daniel & Tversky, Amos. Prospect Theory: An Analysis of Decision Under Risk. *Econometrica* (Vol. 47, No. 2, 1979), pp 263-291.

Kahneman, Daniel & Tversky, Amos. Choices, Values, and Frames. *American Psychologist* (Vol. 39, No. 4, 1984), pp 341-350.

Knetsch, Jack L. & Sinden, J.A. Willingness to Pay and Compensation Demanded: Experimental Evidence of an Unexpected Disparity in Measures of Value. *The Quarterly Journal of Economics* (Vol. 99, No. 3, 1984), pp 507-521.

Lichtenstein, S. et al. Judged Frequency of Lethal Events. *Journal of Experimental Psychology: Human Learning and Memory* (Vol. 4, No. 6, 1978), pp 551-578.

Marin, Alan & Psacharopoulos, George. The Reward for Risk in the Labor Market: Evidence from the United Kingdom and a Reconciliation with Other Studies. *Journal of Political Economy* (Vol. 90, No. 4, 1982), pp 827-853.

Olson, Craig A. An Analysis of Wage Differentials Received by Workers on Dangerous Jobs. *Journal of Human Resources* (Vol. 16, No. 2, 1981), pp 167-185.

Rowe, Robert D. & Chestnut, Lauraine G. Valuing Changes in Morbidity: WTP Versus COI Measures. Manuscript, Energy and Resource Consultants, Inc., Boulder, CO, 1987.

Smith, V. Kerry & Desvousges, William H. An Empirical Analysis of the Economic Value of Risk Changes. *Journal of Political Economy* (Vol. 95, No. 1, 1987), pp 89-114.

Smith, Robert S. Compensating Wage Differentials and Public Policy: A Review. *Industrial and Labor Relations Review* (Vol. 32, No. 3, 1979), pp 339-352.

Thaler, Richard & Rosen, Sherwin. 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, 1976.

Viscusi, W. Kip. Labor Market Valuations of Life and Limb: Empirical Evidence and Policy Implications. *Public Policy* (Vol. 26, No. 3, 1978), pp 359-386.

Viscusi, W. Kip. *Employment Hazards: An Investigation of Market Performance.* Cambridge, MA: Harvard University Press, 1979.

Viscusi, W. Kip. *Risk By Choice: Regulating Health and Safety in the Workplace.* Cambridge, MA: Harvard University Press, 1983.

Viscusi, W. Kip & O'Connor, Charles J. Adaptive Responses to Chemical Labeling: Are Workers Bayesian Decision Makers? *American Economic Review* (Vol. 74, No. 5, 1984), pp 942-956.

Viscusi, W. Kip, Magat, Wesley, & Huber, Joel. An Investigation of the Rationality of Consumer Valuations of Multiple Health Risks, *Rand Journal of Economics* (Vol. 18, No. 4, 1987).

Weinstein, Milton C., Shepard, Donald S., & Pliskin, Joseph S. The Economic Value of Changing Mortality Probabilities: A Decision-Theoretic Approach. *Quarterly Journal of Economics* (Vol. 94, No. 2, 1980), pp 373-396.

Worrall, John D. & Butler, Richard J. Health Conditions and Job Hazards: Union and Nonunion Jobs. *Journal of Labor Research* (Vol. 4, No. 4, 1983), pp 339-347.

U.S. Department of Labor, Bureau of Labor Statistics. *Occupational Injuries and Illnesses in the U.S., By Industry, 1984.* Bulletin 2259. Washington, DC: U.S. Government Printing Office, 1986.