AN EMPIRICAL INVESTIGATION INTO THE EFFECT OF PSYCHOLOGICAL PERCEPTIONS ON THE WILLINGNESS-TO-PAY TO REDUCE RISK

by

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ABSTRACT

A large sample of the residents of metropolitan Chicago were interviewed to investigate whether psychometric attributes by which people view hazards are related to their willingness-to-pay to reduce the hazard. One of the hazards, stomach cancer, is found to engender fear and a high willingness-to-pay. Among the other hazards willingness-to-pay increases with the dread of the hazard but declines with degree of knowledge people have about the risk they are exposed to. When adjustment is made for perceived probability of occurrence, one can conclude that the implied valuation of life varies across hazards according to psychometric risk perceptions. This result has practical implication for policy makers when making decisions regarding spending to reduce hazards.

KEYWORDS: Risk, Value of life, Psychometric characteristics

JEL CODE: D61, J17

In the past two decades, economists have studied a variety of consumer, technological and workplace hazards to determine the value of life (see Viscusi, 1992). These studies have produced widely different results, which has been discouraging to economists who undertake cost-benefit analysis to evaluate projects involving safety hazards. This paper investigates empirically whether the diversity has partly occurred because researchers have been studying many different hazards, and peoples' inherent valuation of life varies dependent on the nature of the hazard being addressed. Furthermore, the contention of this paper is that the diversity of valuation of life across hazards is explained by the psychometric cognitive characteristics of the hazards.

Psychologists have been very active in investigating and cataloging people's attitudes to different types of hazards (see for example, Fischhoff et al.; 1978; Slovic, Fischhoff and Lichtenstein, 1980, 1985; Johnson and Tversky, 1984). They have postulated, and empirically tested, various cognitive dimensions by which people assess risk. Such risk dimensions include (with their commonly referred to names underlined): whether death is immediate or <u>delayed</u>; whether victims are exposed to this risk <u>involuntarily</u>; if exposed to the risk, the extent to which the victim can, by personal skill or diligence, avoid death, i.e., <u>controllability</u>; and whether it is a <u>dread</u> risk or one that can be thought of in a calm and reasonable way. Empirical testing, for up to ninety consumer and technological hazards, has found these dimensions to be highly collinear so factor analysis has been used to produce a two composite "dread" and "unknown" scores.

Economists concerned with cost-benefit analysis and the value of life have, of course, noted the possibility of inter-risk differences in valuation before. However, in my search of the literature I have found that the issue is either downplayed or swept aside, often citing difficulties in evaluation. Mooney (1977) is typical when he observes

> "... it could be `rational' to have different implied values emerging in different circumstances. However, without some empirical research it is difficult to judge the extent of the differentials likely to emerge".

It is symptomatic that there is no discussion of this issue in standard cost-benefit textbooks. This is despite the evidence from public finance economists. Graham (1982) analyzed the spending by two United States government agencies and found a wide variety of implied values of life from different programs. In explaining this diversity he postulates that risk perceptions as well as "political" factors may be important. However, there is evidence that economists are starting to become concerned with this issue. In the concluding chapter of his most recent book Jones-Lee (1989) prominently raises the research issue, but provides no answer to the question:

> "How should the value of statistical life for more emotive, involuntary "dread" risks, such as those that are a consequence of nuclear power generation, relate to values for everyday risks which are, on the whole, more or less voluntary."

However Jones-Lee is mainly concerned with the special nature of nuclear power and similar potential societal catastrophes, rather than seriously suggesting there may be differential valuation for "everyday" risks.

This paper makes use of a large, professionally conducted, survey of a wide cross-section of the residents of metropolitan Chicago to investigate whether the willingness to pay to reduce four common hazards is related to the psychometric perceptions people have of those hazards. One thousand adults were interviewed in a random-digit dial telephone survey, producing a useable dataset of about 800. Respondents are from the full range of socioeconomic groups. This contrasts with earlier economic and psychometric researchers who have had to use small sample sizes drawn from specific subgroups of society.

Data on the psychological dread and unknown metrics, and an indication of personal exposure to risk were obtained on the standard seven point scale for four common hazards: aviation accidents, fires in the home, automobile accidents and stomach cancer. Respondents were then asked to allocate $100 between the four hazards for the purpose of research to reduce the risks posed by the hazards. Thus the survey collected data on the relative willingness to pay to reduce the four hazards rather than find a true, unconstrained, willingness to pay.

Regression analysis was then conducted to relate the willingness to pay to perceived personal exposure, and psychological perception of dread and the unknown factor. I conducted regressions on each hazard separately; and also by pooling, and then using a panel analysis, on all of the data (i.e., the responses of each respondent to each of the four hazards). The most striking result was that stomach cancer appeared to be in a class apart from the other hazards. Previous work by me and by psychologists has found that nuclear power is another risk which is viewed quite distinctly. Stomach cancer shares with nuclear power the fact that people feel that the threat is unknown.

Amongst the other three hazards considered - commercial aviation, fires in the home, and automobiles - a more consistent pattern emerged. Hazards which make people become nervous when thinking about them (i.e., dread) are generally associated with a higher willingness-to-pay to reduce that hazard. However for hazards about which the risk is considered unknown engender a lower willingness-to-pay. This latter result need not be regarded as being counter-intuitive. When people think that a hazard is unpredictable in occurrence, and that scientists do not have a good understanding of the risks, then people would prefer to spend their income on research into other hazards where there is a greater chance that preventive measures may be discovered.

While the data collected for this analysis does not permit calculation of a numerical value of life, it is possible to obtain some measure of the relative valuation across hazards. This can be done by adjusting the calculated willingness-to-pay for each hazard by the perceived probability of occurrence. Having done this we find that the implied underlying valuations of life vary across the hazards studied, and is explained by the statistically significant effects of the dread and unknown variables.

The implications of the findings are firstly that researchers should not be disappointed at the wide variation in the valuation of life found in empirical studies. Different hazards will produce different values of life. Secondly, practitioners should not strive for, and use, a common valuation of life when making policy decisions regarding priorities for spending to reduce hazards.

Practical examples of the relevance of the research can be illustrated by the area of transportation. Until recently Transport Canada used a valuation of C$280,000 for a fatality in a road accident and C$2.5 million in the case of an aviation fatality, when comparing the return on projects. However, the Canadian government recently decreed that a common value of C$1.5 million be used for all transportation projects. Similarly in the United States the Federal Aviation Administration recommended a value slightly higher than that used by the Federal Highway Administration. As in Canada recent rulemaking has imposed a common valuation across all branches of the Department of Transportation. My results would suggest that such action is regrettable. Yet based on the data in my survey, the higher dread and lower unknown aspects of automobile accidents compared with aviation accidents might suggest that it is highway rather than aviation projects that should be evaluated with a higher valuation of life.

The structure of the paper is as follows. Section 1 hypothesizes the consumer theory that underlies my propositions. Section 2 describes one previous analysis of this type. The objectives of designing the survey are described in section 3, and discussion of the actual design and implementation are in section 4. Section 5 contains the econometric analysis, with conclusions being drawn in section 6.

1. THEORY

It is postulated that the willingness-to-pay (WTP) to avoid a certain hazard can be defined as:

$$WTP_i = \mathbf{P_i} \cdot [\mathbf{E_i} + \mathbf{U_i}] \tag{1}$$

where: $\mathbf{P_i}$ is a matrix of the assumed probabilities of various levels of harm (death, disability etc.);

$\mathbf{E_i}$ is a matrix of the assumed consequences of a death or injury in traditional economic terms (loss of potential earnings, bereavement etc.);

$\mathbf{U_i}$ is a matrix of the value of the disutility associated with the occurrence of harm (ie. certain forms of death or injury have a greater disutility attached to them).

The valuation of life (VOL) will be defined as $[\mathbf{E_i} + \mathbf{U_i}]$. In this simple model the pecuniary and non-pecuniary losses are additive. It is worth noting that while the term "valuation of life" will be used in this paper, the wording of the empirical questions leaves it open for respondents to consider the full gamut of possible harms that may occur.

It is my hypothesis that the valuation of life will vary because of the existence of the **U** matrix. The subscript **i** in this case can either refer to individuals or to different types of hazards. It is also my hypothesis that this variability over individuals or over risks can be explained by cognitive psychometric dimensions by which people assess risk.

2. PREVIOUS LITERATURE

The author is aware of only one prior investigation that brings together economic and psychometric data. McDaniels (1988) administered a questionnaire to 53 respondents regarding ten common hazards, asking for psychometric risk assessment in eight dimensions, and a WTP to reduce the annual fatalities from that hazard by 20%. He found that while the psychometric dimensions were statistically related to the WTP to save one life (found by dividing the answer given to his questionnaire by the number lives a 20% fatality reduction represents), the R^2 for the equation was low. However, McDaniels admits himself that his study could be flawed because a 20% reduction in annual fatalities represents 10,000 lives saved in automobile accidents but only one life in the case of certain workplace chemical hazards. Psychologists have noted that people are particularly fearful of multiple fatality hazards.

3. OBJECTIVES AND SURVEY PHILOSOPHY

The principal objective of this study is to find out if psychometric factors influence willingness to pay to reduce risk. That is to say, are there systematic variations in the willingness-to-pay across individuals depending on their psychometric responses, and across different types of hazards?

As a consequence of this objective the interest was in peoples' rankings of psychometric and economic variables across hazards, and not in the absolute values of these variables. This both considerably simplified the questionnaire and meant that the survey would not produce numerical "values of life".

A secondary objective of the study was to collect data from a large sample of people with varying socioeconomic backgrounds. Previous psychometric studies have typically had sample sizes well under 100, composed of well-informed upper-middle class people (the League of Women Voters in Eugene, Oregon being particularly well represented).

To achieve this objective it was decided to make the questionnaire as short, and as easily intelligible as possible. Budgetary considerations also limited the scope of the work. It was therefore decided (a) to only seek information on four hazards, and (b) research only two cognitive psychometric risk dimensions.

The four hazards were chosen based on prior evidence from the work of Slovic, Fischhoff and Lichtenstein (1980) that these hazards were cognitively viewed has having very different characteristics. The hazards chosen were commercial airplane accidents, fires in the home, automobile accidents and stomach cancer.

It was also decided that it would be counter-productive to ask for responses to the eight or nine risk dimensions typically used by psychologists. In any event, many of these dimensions are found to be highly collinear, and hence unsuitable for econometric analysis, and were anyway often consolidated by factor analysis into two factors (Slovic, Fischhoff and Lichtenstein, 1980). It was therefore decided that it would be much simpler to ask people directly about these two factors: "dread" and "unknown". People appear to have a great "dread" of a hazard when it is catastrophic; if death is a long draw out event (eg cancer); if victims are exposed to the hazard involuntarily; and if, when exposed to the hazard, the victim cannot by personal skill or diligence avoid harm. The "unknown" factor is relatively self-explanatory comprising the fact that victims may not observe the hazard when it occurs, do not personally know the risk, or that the probability or consequences of the hazard are not even known to scientists.

4. SURVEY DESIGN AND IMPLEMENTATION

The data were collected as part of Northwestern University Survey Laboratory's annual *Chicago Area Survey Project (CASP-91). CASP-91* is a random-digit dial telephone survey of the adult population in Cook, Lake and DuPage counties of northeastern Illinois, which covers the greater part of the City of Chicago and its surrounding suburbs. It is a multi-issue survey gathering information on a large number of issues including quality of life measures, race relations, media performance, political attitudes, and also other topic areas which the faculty of Northwestern University could pay to have included. Additionally, many standard demographic items were included. The questionnaire ran to some 108 questions, and produced a maximum usable sample size of 1,027.

In addition to administering the questionnaire, the Survey Laboratory also provided advice on the structuring and wording of questions, pre-testing, and data input verification and "cleaning". The survey was conducted in May 1991 using professionally trained and supervised staff. Over 10% of the completed interviews were validated by call-backs to the original respondents. No problem was found during the validation process. Extensive efforts were made to avoid bias by repeat calls to selected telephone numbers (over 20% of selected numbers required over 10 calls to complete the interview) and by training interviewers to minimize the number of refused interviews.

Reference to equation (1) suggests that three pieces of information are required to make the necessary calculations: a measure of relative WTP, subjective probabilities of exposure, and psychometric attitudes. The questions to obtain these data were numbered 42-45 on the 108 question interview.

The first question related to the individual's psychological dread for each of the hazards. Of interest to other researchers in the field is that originally the word "dread" was used in this question. However, during the pre-testing (on 50 respondents) it was reported that respondents had great difficulty understanding what the term meant. Therefore, it was decided to use the definition of whether respondents could think about a risk in a calm way or whether they became nervous about it. Although the term "dread" will be used in the description of the results, it is worth noting that this is a term which is widely understood by professionals working in the area, but is not in common usage amongst lay people. The form of this question and the following questions on the unknown factor and personal exposure is similar to that adopted by previous psychometric researchers. Respondents had to indicate their feeling on a 1 - 7 scale. This scale is the standard form used in all the psychometric work.

Q42 The following group of questions asks your opinions about four types of health hazards: commercial airplane accidents, household fires, automobile accidents, and stomach cancer.

For each of these hazards, please use a seven-point scale with "1" meaning you remain calm when thinking about it and "7" meaning you become nervous when thinking about it. Feel free to pick any number on the scale.

A. How do you feel when thinking about commercial airplane accidents?

Remain Calm 1 2 3 4 5 6 7 Become Nervous

And similarly for household fires, automobile accidents and stomach cancer.

Figure 1: **The "dread" question.**

Q43. Next, for each of the hazards, please tell me how informed you are about the risk and seriousness of each. For this use a seven-point scale with "1" meaning that you basically know nothing about the risk and seriousness and "7" meaning that you are well informed.

A. How informed are you about the risk and seriousness of commercial airplane accidents?

Don't know anything 1 2 3 4 5 6 7 Well informed

And similarly for household fires, automobile accidents and stomach cancer.

Figure 2: **The "unknown" Question**

The next question attempted to elicit the individual's knowledge of the risk which corresponds to the "unknown" factor described by psychologists. In devising the question we emphasized not only knowledge of the probability of the hazards but also the seriousness of the consequences in the event that the hazard occurs. Following pre-testing it was considered advisable to have "Don't know anything" correspond to the response 1, and "Well informed" to the response 7. This is the reverse of the other questions where the "worse" outcome corresponded to 7. We therefore transformed the data collected by subtracting from 8 in order to form the unknown variable used in the regression analysis.

The next question asked for a measure of the individual's subjective probability of being affected by the hazard. The question was phrased so as to elicit the threat felt by the individual and not the individual's opinion about the prevalence of the hazard in society in general. Interviewers were instructed to reinforce this objective. The ordinal risk scale of 1 to 7 was again employed here as we were interested in peoples' relative perceived risk in comparing the hazards rather than observing whether people could state some numerical probability of death (such as 1/10,000).

Q44. Next, for each of these hazards, please tell me how much actual threat each poses to you personally. For this please use a seven-point scale with "1" meaning that you feel no personal threat and "7" meaning you feel a high personal threat.

A. How much threat do you personally feel from commercial airplane accidents?

No threat 1 2 3 4 5 6 7 High threat

And similarly for household fires, automobile accidents and stomach cancer.

Figure 3: **The subjective probability question**

Q45. Imagine, you are going to give $100 in charitable contributions to scientific organizations that were doing research to lower the risks of commercial airplane accidents, household fires, automobile accidents, and stomach cancer. How much of the $100 would you give to each of the four groups? *[PROMPT GROUPS AS NEEDED. IF ASKED: "You should assume that each organization will be equally effective in spending the money to lower the specific risk.]*

A.	Commercial airplane accident research	$________
B.	Household fires research	$________
C.	Automobile accident research	$________
D.	Stomach cancer research	$________
	TOTAL:	$__100.00__

Figure 4: **The willingness-to-pay question**

The final question attempted to measure the relative willingness-to-pay to reduce each hazard. The form of this question requires some explanation. Respondents were asked to divide up a charitable donation of $100 between research into reducing the risks of the four hazards. To a large extent the project budget determined that just one question could be asked in this area rather than trying to elicit a true, unconstrained, valuation of life. As discussed already, this was not a problem as only relative valuations across hazards were being investigated. In addition, there are considerable practical problems in obtaining an unbiased unconstrained numerical answer (see Jones-Lee, Hammerton and Philips, 1985). As to the actual wording used, a number of different versions were considered. In the end it was decided to use a scenario familiar to most Americans, the decision on making (tax-deductible) charitable contributions. We were cognizant of two potential problems. The first is that respondents may have prior opinions on the effectiveness of the different organizations to reduce risk. The second is that the American Cancer Society regularly solicits for contributions, while the same cannot be said for organizations researching into the other three risks (if indeed such research organizations actually exist).

5. ANALYSIS OF THE DATA

The format of equation (1) suggests that the estimated equation should be multiplicative in nature. Therefore a log-linear or semi-log-linear estimation by OLS would appear appropriate. Given that the dependent variable can take the value zero, a semi-log form was used.

5.1 Analysis across Individuals for Each Hazard

The initial analysis looks at the variation over individuals for each hazard. There are therefore four regressions. As the economic valuation of a hazard in question 45 involves decisions on splitting $100 between four hazards, a correction must be made for perceptions and exposure to all the other risks. For each hazard was estimated:

$$WTP_i = \alpha_0 + ß_{1j}\ln(P_{ij}) + ß_{2j}\ln(D_{ij}) + ß_{3j}\ln(K_{ij}) \tag{2}$$

where: D is the dread factor, K is the unknown factor, subscript i represents individuals, and subscript j refers to hazards. Hence there were 13 explanatory variables. One would expect the ß coefficients on P, D and K for the hazard in question to be positive and (hopefully) significant, and the ß coefficient for the other hazards to be negative or insignificant. Comparing equations (2) and (1), we can observe that the second right-hand-side term in equation (2) corresponds to the probability term in equation (1), the constant in equation (2) corresponds to the traditional valuations of life expressed by the term $\mathbf{E_i}$, and the final two explanatory variables explain variation in the $\mathbf{U_i}$ term.

The full econometric results are shown in table 1. There is one equation for each of the hazards. Goodness-of-fit is quite poor with adjusted R^2 in the range 0.05 to 0.1. Interpretation of the coefficients in the table can be slightly confusing. The reader's attention is initially directed to the effects of probability and psychometric perceptions on the WTP for that hazard. That is to say in the first equation on aviation one should initially look at the second through fourth coefficients, in the second equation on automobiles the fifth through eighth coefficient, and so on. There are some strong intuitive conclusions. WTP appears to be strongly and positively related to the perceived probability that the person is exposed to the hazard. This is true for all four hazards. There is also strong evidence that in the case of aviation, home fires and automobiles that increasing dread is associated with a higher WTP. While the coefficient on this variable is positive in the case of stomach cancer the t-statistic falls short of statistical significance.

However, the unknown variable takes a counter-intuitive negative sign, and is statistically significant, at the 10% level or better, for all the hazards except for aviation. Thus the less people are informed about the risks of a particular hazard the less they are prepared to spend for research. Psychometric research indicates that the "unknown" effect is composed of whether the victim can observe the hazard when it occurs, how informed the person is about the risk (be it due to personal experience or via the media), and whether the risks are known even to scientists. Given the phrasing of the questions emphasizing charitable contributions to research organizations it is possible that the latter of these may have been uppermost in respondents' minds. Thus respondents who feel that risks are unknown to scientists may also feel that it would be a waste of money to contribute to further research.

The reader's attention is now directed to other coefficients in the table. these are the "cross terms" such as the fifth through thirteenth coefficients in the aviation equation. As described at the beginning of this section, these terms adjust for perceptions of other risks and should intuitively take negative signs or be statistically insignificant. In general this is the case. The only exceptions are an incorrect sign on the unknown factor for automobiles in the home fires equation, and vice-versa. Also, people who believe that the risks of cancer are unknown are willing to spend higher amounts on research in aviation accidents and home fires.

5.2 Analysis across Individuals and Hazards

The second type of analysis introduces variation across hazards. One should preface description of the econometric results with some descriptive statistics of how people evaluated the various hazards. This is shown in table 2. The most striking feature is that stomach cancer has a very large willingness-to-pay, spurred it appears by the fact that people believe that the risk is unknown.

In terms of perceived probability of threat, respondents rank the hazards in the order of actual annual fatalities in the United States, with the exception of stomach cancer which in reality is a greater threat than fires in the home but less than automobile accidents.[11] However, this result may be explained by the fact that the risk of stomach cancer is especially acute for older people, and thus many younger respondents do not feel so personally threatened. All of the other three hazards can be reasonably assumed to represent a real threat to all age groups.

As to the psychometric variables, automobile accidents engender a higher dread than the other three hazards, which are statistically inseparable. We have already discussed that cancer appears to be regarded as the most unknown hazard, followed by aviation, fires in the home, and automobiles. One can compare these rankings of the various hazards with previous psychometric research (Slovic, Fischhoff and Lichtenstein, 1985). There are some notable differences. In terms of dread, respondents to this survey have a greater dread of auto accidents than aviation accidents, while the opposite was true for Slovic's respondents. Aviation is regarded by respondents as relatively more unknown risk than in earlier psychometric studies.

The first regression performed had all the observations placed in a large pool. The regression was of the form:

(3) $$WTP_{ij} = \alpha_0 + ß_1 \ln(P_{ij}) + ß_2 \ln(D_{ij}) + ß_3 \ln(K_{ij})$$

The results are shown in the first column of table 3. The results are somewhat reversed from the analysis in the preceding section. The dread variable is, while positive, not significant, and the unknown variable has changed sign to be positive and significant. The reasons for this change as

[1]Approximate annual fatalities in the United States are 200 in commercial aviation accidents, 4,000 in household fires, 14,000 due to stomach cancer, and 47,000 in automobile accidents. The risks of stomach cancer may be confused with cancer in general which claims about 500,000 victims a year (National Center for Health Statistics, annual).

obvious from table 2. While individuals relate WTP negatively to the unknown factor for each hazard, the stomach cancer hazard engenders a high WTP and unknown factor which is so large as to dominate the results.

It would appear that stomach cancer is in a league apart from other risks. Thus it is similar to feelings about nuclear power found in previous studies, which had very high dread and unknown factors and a very large WTP (Savage, 1991). It was therefore decided to rerun equation 3 excluding the observations for stomach cancer. The results are shown in the second column of table 3. Now the results are similar to those found in the previous section of the paper. WTP rises with dread and falls with the unknown factor. One should ask why it is that stomach cancer has a high unknown factor and a higher WTP, yet we find that for more everyday hazards the unknown factor and WTP are inversely related. My interpretation is that people view cancer as being an area where scientific knowledge is in its infancy and that there is the possibility of a substantial improvement in medical knowledge from further research. This attitude is fostered by the continual solicitation for money by research organizations specializing in cancer research. In contrast I suspect that as I hypothesized earlier, people regard the more scientifically unknown of everyday hazards as promising poor return for their research dollar.

Numerical valuation of life cannot be obtained from the data collected for this analysis. We have constrained people to allocating a budget of $100, and only obtained an ordinal scale of perceived probability of occurrence. However, it is possible to get some idea of the implicit relative valuation of life. This can be done by removing the effect of perceived probability of occurrence from WTP. That is to say, if we consider the more everyday hazards shown in the second column of table 3:

(3) $$\text{Relative VOL}_i = 12.81 + 1.514 \ln(D_i) - 0.841 \ln(K_i)$$

If the mean values of the dread and unknown variables from table 2 are substituted in, we calculate a relative measure of implicit valuation of life of $13.67 for aviation, $13.93 for fires, and $14.32 for automobiles. While the nature of the questions in this study does not permit the conclusion that the valuation of life for automobile accidents is 5% higher than that for aviation accidents, we have established the principle that they are different from each other in a statistically significant way. Thus the higher dread and lower unknown aspects of automobile accidents compared with aviation accidents and fires suggest that highway projects should be evaluated with a higher valuation of life than that used for aviation or fire prevention projects

A second pair of regressions were conducted to correct for individual response scaling, a common problem in psychometric empirical analysis. That is to say that while two individuals may rank the four hazards identically on the issue of, say, dread, one might anchor his or her response around the number 5 on the 1 - 7 scale, and the other around the number 3. The respondents do this not because the first person feels a heightened dread for all the risks, but because they are unsure where to anchor their answer on the 1 - 7 scale. Variables were used to represent an individual's deviation from their mean answer to the psychometric questions. The regression was therefore:

(5) $$WTP_{ij} = \beta_1 \ln(P^{\#}{}_j) + \beta_2 \ln(D^{\#}{}_j) + \beta_3 \ln(K^{\#}{}_j)$$

Where the # superscript indicates that panel data techniques have been employed by subtracting each individual's mean value for that variable from each observation. There is therefore three explanatory variables.

Clearly this method is not necessary superior to that in equation 3 in that while the scaling problem has been removed, so has some potentially important information e.g., a person who gives a scores of 6 and 7 for the various hazards probably is more fearful than someone who gives 1 and 2 although this latter regression treats both as being equivalent. Therefore the results shown in table 4 should not necessary be regarded as an improvement over table 3. However one notes that the results are quite similar. When the stomach cancer hazard is included the unknown factor is positive and significantly related to WTP and the dread factor is not. When the analysis is limited to aviation, autos and fires then the dread factor is positive and significant and the unknown factor negative and significant.

Despite the existence of high statistically significant explanatory variables, all four regressions in table 3 and 4 have very poor goodness-of-fit.

5.3 Demographic Analysis

The final piece of analysis is an attempt to look behind the psychometric variables to try to understand whether there are certain definable subgroups of the population who attach high WTP to various hazards. Based on the demographic data collected in the survey the following regression was run for each hazard:

(6) $WTP_i = \alpha_0 + ß_1 \ln(AGE) + ß_2 \ln(SCHOOL) + ß_3 \ln(INCOME) + ß_4 MALE + ß_5 BLACK$

where: AGE is the persons age in years

SCHOOL is the number of years spent in school (all of grade, high, undergraduate and graduate education together)

INCOME is the mid-point of the annual pre-tax income bands the person could select from. These were \$5,000, \$15,000, \$30,000, \$50,000, \$80,000 and \$125,000.

MALE A dummy variable taking the value 1 for male.

BLACK A dummy variable taking the value 1 if the respondent was black.

Having run this regression for each hazard separately, and then as a pool of all the data, it was clear that the former approach was more enlightening. The results are shown in table 5. The most notable feature is that older people attach a higher WTP to stomach cancer than do younger people, and this has the effect that the older people place a much lower valuation on the other three hazards. This result is not surprising. Blacks appear to have a much lower WTP for stomach cancer but this is compensated by a much higher WTP for research to lower the risks of fires in the home. Again, this is not surprising. A casual perusal of the Chicago newspapers would suggest that a disproportionate number of fatal household fires occur in minority neighborhoods. In general the higher a person's income the lower the WTP in the case of aviation and the higher in the case of stomach cancer. It should be noted, however, that the goodness-of-fit is again quite poor. In evaluating the results some multicollinearity problems were expected. However, with the exception of a correlation coefficient of -0.44 between SCHOOL and BLACK, other correlations were quite small.

6. CONCLUSIONS

A major conclusion from this work is that there are certain kinds of hazards which are in a class apart from all others. These risks engender considerable fear and a high willingness-to-pay to reduce them. Previous work by the current author (Savage, 1991) and also by the psychologists has found that nuclear power is one such example. The current work has found that stomach cancer also fits into this category, especially for older people. This hazard shares with nuclear power the fact that people feel that the threat is unknown.

Amongst the other three hazards considered - commercial aviation, fires in the home, and automobiles - a more consistent pattern emerged. Hazards which make people become nervous when thinking about them (i.e., dread) are generally associated with a higher willingness-to-pay to reduce that hazard. However for hazards about which the risk is considered unknown engender a lower willingness-to-pay. This latter result need not be regarded as being counter-intuitive. When people think that a hazard is unpredictable in occurrence, and that scientists do not have a good understanding of the risks, then people would prefer to spend their income on research into other hazards where there is a greater chance that preventive measures may be discovered.

While the data collected for this analysis does not permit calculation of a numerical value of life, it is possible to obtain some measure of the relative valuation across hazards. This can be done by adjusting the calculated willingness-to-pay for each hazard by the perceived probability of occurrence. Having done this we find that the underlying valuations of life vary across the hazards studied, and is explained by the statistically significant effects of the dread and unknown variables. The data collected as part of this analysis suggests that people value their lives higher when considering automobile accidents as compared with aviation accidents or fires in the home.

The practical implications of the findings are firstly that researchers should not be disappointed at the wide variation in the valuation of life found in empirical studies. Different hazards will produce different values of life. Secondly, practitioners should not strive for, and use, a common valuation of life when making policy decisions regarding priorities for spending to reduce hazards.

REFERENCES

Fischhoff, Baruch, Paul Slovic, Sarah Lichtenstein, Stephen Read, and Barbara Combs. (1978). "How Safe is Safe Enough? A Psychometric Study of Attitudes Towards Technological Risks and Benefits". *Policy Sciences* 9, 127-152.

Graham, John D. (1982). "Some Explanations for Disparities in Lifesaving Investments". *Policy Studies Review* 1, 692-704.

Johnson, Eric J., and Amos Tversky. (1984). "Representation of Perceptions of Risks" *Journal of Experimental Psychology: General* 113, 55-70.

Jones-Lee, Michael. (1989). *The Economics of Safety and Physical Risk*. New York: Basil Blackwell.

Jones-Lee, Michael, Max Hammerton, and Peter Philips. (1985). "The Value of Safety: Results of a National Sample Survey". *Economic Journal* 95, 49-72.

McDaniels, Timothy. (1988). "Comparing Expressed and Revealed Preferences for Risk Reduction: Different Hazards and Question Frames". *Risk Analysis* 8, 593-604.

Mooney, Gavin. (1977). *The Valuation of Human Life*. London: MacMillan.

National Center for Health Statistics. (annual). *Vital Statistics of the United States*. Washington, D.C.: U.S. Government Printing Office.

Savage, Ian. (1991). "Psychological Features Affecting Valuation of Life". *Economics Letters* 35, 379-383.

Slovic, Paul, Baruch Fischhoff, and Sarah Lichtenstein. (1980). "Facts and Fears: Understanding Perceived Risk." In Richard Schwing and Walter A. Albers (eds.), *Societal Risk Assessment: How Safe is Safe Enough?*. New York: Plenum.

Slovic, Paul, Baruch Fischhoff, and Sarah Lichtenstein. (1985). "Characterizing perceived risk." In Robert W. Kates, Christoph Hohenemser and Jeanne X. Kasperson (eds.) *Perilous Progress: Managing the Hazards of Technology*. Boulder, CO: Westview.

Viscusi, W. Kip. (1992). *Fatal Tradeoffs: Public and Private Responsibilities for Risk*. New York: Oxford University Press.

TABLE 1

ANALYSIS OF VALUATION OF LIFE FOR EACH HAZARD

(Independent variables in natural logarithms, standard errors in parentheses)

Willingness to Pay for:	AVIATION	HOME FIRES	AUTOS	CANCER
Constant	9.939*** (1.668)	13.132*** (1.913)	14.597*** (2.175)	62.431*** (3.803)
Aviation - Dread	1.588* (0.887)	- 1.210 (0.925)	- 0.298 (1.052)	- 0.082 (1.839)
Aviation - Unknown	- 0.160 (0.790)	0.410 (0.906)	0.515 (1.030)	- 0.797 (1.801)
Aviation - Probability	3.321*** (0.768)	- 0.557 (0.880)	- 0.314 (1.001)	- 2.434 (1.750)
Fires - Dread	1.143 (0.955)	4.877*** (1.095)	- 0.963 (1.245)	- 5.092** (2.177)
Fires - Unknown	0.918 (0.914)	- 3.190*** (1.048)	2.673** (1.191)	- 0.423 (2.083)
Fires - Probability	- 0.005 (0.954)	4.434*** (1.094)	1.804 (1.244)	- 6.233*** (2.175)
Autos - Dread	- 0.938 (1.091)	- 2.445** (1.251)	2.661* (1.423)	0.690 (2.488)
Autos - Unknown	- 0.434 (0.933)	1.705* (1.069)	- 2.050* (1.216)	0.778 (2.126)
Autos - Probability	- 0.224 (1.063)	1.224 (1.218)	5.078*** (1.386)	- 6.033** (2.423)
Cancer - Dread	- 0.288 (0.814)	- 0.878 (0.934)	- 0.903 (1.062)	2.107 (1.856)
Cancer - Unknown	1.592** (0.727)	1.893** (0.833)	- 0.520 (0.948)	- 2.994* (1.657)

Cancer - Probability	- 1.221	- 2.234	- 5.050***	8.473***
	(0.835)	(0.958)	(1.089)	(1.904)
N	914	914	914	914
Adjusted R^2	0.047	0.098	0.064	0.079

* = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level.

TABLE 2

MEAN VALUES FOR VARIABLES FOR EACH HAZARD

(Standard errors in parentheses based on sample sizes, after taking account for missing values, in the range 956 - 1019)

	AVIATION	HOME FIRES	AUTOS	CANCER
Dread	3.63 (0.07)	3.77 (0.07)	4.54 (0.06)	3.64 (0.08)
Unknown	3.67 (0.06)	2.89 (0.05)	2.53 (0.05)	4.36 (0.07)
Probability	2.58 (0.06)	3.21 (0.06)	4.33 (0.06)	2.87 (0.07)
Willingness to Pay	$14.61 (0.46)	$17.96 (0.53)	$20.78 (0.60)	$46.66 (1.05)

TABLE 3

ANALYSIS ACROSS INDIVIDUALS AND HAZARDS

(Independent variables in natural logarithms, standard errors in parentheses)

Willingness to Pay for:	All Hazards	Aviation, Autos, Fires
Constant	18.807***	12.810***
	(1.090)	(0.817)
Dread	0.403	1.514***
	(0.657)	(0.506)
Unknown	2.461***	- 0.841*
	(0.609)	(0.477)
Probability	3.387***	4.043***
	(0.683)	(0.515)
N	3760	2832
Adjusted R^2	0.011	0.050

* = significant at 10% level, *** = significant at 1% level.

TABLE 4

PANELLED ANALYSIS ACROSS INDIVIDUALS AND HAZARDS

(Independent variables are paneled and in natural logarithms,
standard errors in parentheses)

Willingness to Pay for:	All Hazards	Aviation, Autos, Fires
Dread	2.634*	2.998**
	(1.437)	(1.266)
Unknown	5.586***	- 3.256***
	(1.229)	(1.165)
Probability	6.317***	4.516***
	(1.318)	(1.112)
N	3761	2833
Adjusted R^2	0.012	0.023

* = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level.

TABLE 5

ANALYSIS OF VALUATION OF LIFE BY DEMOGRAPHICS

(standard errors in parentheses)

Willingness to Pay for:	AVIATION	HOME FIRES	AUTOS	CANCER
Constant	53.954*** (9.207)	39.372*** (11.093)	51.467*** (11.982)	-44.937*** (21.380)
ln(AGE)	- 5.868*** (1.324)	- 4.276*** (1.596)	- 4.820*** (1.723)	14.988*** (3.074)
ln(SCHOOL)	1.588 (2.468)	1.069 (2.973)	- 5.293* (3.211)	2.591 (5.730)
ln(INCOME)	- 2.100*** (0.632)	- 0.893 (0.762)	- 0.038 (0.823)	3.050** (1.469)
MALE	- 1.289 (0.974)	0.115 (1.174)	2.904** (1.268)	- 1.783 (2.262)
BLACK	2.314* (1.227)	5.595*** (1.479)	0.577 (1.597)	- 8.459*** (2.849)
N	799	799	799	799
Adjusted R^2	0.044	0.026	0.013	0.044

* = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level.