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Perceived Risk, Dread, and Benefits

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This paper uses regression techniques to take a second look at a classic risk-perception data set originally collected by Paul Slovic, Sarah Lichtenstein, and Baruch Fischhoff. As discussed in earlier studies, the attributes *expected mortality, effects on future generations, immediacy,* and *catastrophic potential* all significantly affect risk ratings. However, we find that perceived risk and dread show different regression patterns; most importantly, only perceived risk ratings correlate with expected mortality. In addition, average risk ratings are found to be significantly affected by perceived individual benefits, which suggests that perceptions of risk are net rather than gross indicators of harm.

KEY WORDS: Risk; perceptions; tradeoffs; benefits.

1. INTRODUCTION

Economists, engineers, and decision scientists have developed sophisticated technical models to assist in managing environmental risks. However, the public frequently rejects the recommendations of these models. Risk-perception research attempts to explain this discrepancy by arguing that technical assessments of risk fail to take account of all the dimensions or characteristics that concern the public.[1] Whereas risk assessments tend to focus on expected lives lost or expected dollar damages, psychometric studies conducted by psychologists, sociologists, and other risk-perception researchers argue for the inclusion of measures such as dread, catastrophe, voluntariness, equity, newness, perceived risk, and familiarity[2,3,4] as part of risk-management decision processes.

Nonetheless, these additional dimensions of risk have not been integrated readily into the practice or techniques of risk management. There are many reasons for this. Some maintain that risk perceptions largely reflect ignorance of key technical information. Some point to biased media coverage or argue that psychological concerns should not be traded for expected lives.[5] Others note that the psychometric risk dimensions are measured in such a way (e.g., ratings of dread) that it is not clear how to relate them to specific management actions or how to incorporate them in decision frameworks based on maximizing net dollar benefits or an overall measure of utility.[6]

In this paper, we used regression techniques on data collected by Paul Slovic, Sarah Lichtenstein, and Baruch Fischhoff to examine links between the characteristics of risk sources (i.e., technologies, products, and activities) and their psychometric risk ratings. First, we tested the extent to which risk perceptions relate to observable features of products, technologies, or activities; that is, to those attributes of a facility or product that can be affected by the actions of a risk manager. After quantifying the relative contribution of specific attributes, managers then could take concrete steps designed to change the perceived risk associated with a technology or product and focus mitigation on the most relevant feature of each technology that is causing public concern.[7,8] Second, we tested for differences in the definitions of perceived risk and dread and examined how psychometric risk ratings are changed when economic

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benefits or mortality concerns are included. Third, we quantified the relative importance of different risk dimensions, identifying a small number of specific attributes on which managers could focus to obtain information about the level of public concern.

2. DATA

This study relies on questionnaire data that served as the basis for a classic series of papers by Slovic *et al.*[3,9] that did much to bring risk perception concerns to the attention of public decision-makers.[4] The questionnaires asked 175 participants (90 women and 85 men) to rate 90 different potentially hazardous products, technologies, and activities (ranging from hair dyes and bicycles to nuclear power plants) on each of 18 risk characteristics. Ratings also were made in terms of annual expected fatalities, several overall measures of risk acceptability, and six perceived benefit measures.[5]

The current study does not pursue the risk-perception behavior of individuals, a topic which deserves separate treatment. The analysis relies on the mean psychometric scores across the sample for each question and explores whether average assessments (across respondents) of a technology's attributes are related to average indices of dread and perceived risk.

We omitted six items included in the Slovic *et al.* study because they were neither products, technologies, nor consumer activities, and their inclusion might bias the outcome. Specifically, we excluded items such as terrorism and warfare, because they are inherently dangerous and outside the sphere of concerns normally considered by risk managers. The complete set of risk and benefit characteristics examined in this study is listed in Table I, along with the associated definitions and units.

We also did not include all the risk characteristics explored in the original study. The purpose of our analysis is to identify actions that could be taken by a risk manager to reduce dread or perceived risk. Several of the risk characteristics employed by Slovic *et al.*, therefore, were omitted because we considered them to be outside the bounds of actions open to risk managers. For example, the scale "control over risk," which assesses the degree to which "proper action [can] reduce the likelihood or number of fatalities," is likely to matter to people in terms of their assessments of perceived risk. However, it was not included as an attribute in this study because beliefs regarding control largely relate to the risk source (e.g., automobiles vs. nuclear power plants) rather than to the actions of risk managers. Several other risk characteristics were omitted because they require specialized knowledge or because we felt respondents could not rate them reliably. For example, we omitted the scale "known to science" because we felt most respondents would not be able to assess the level of knowledge existing among scientists. We also omitted the exposure scale because it was considered ambiguous: the scale could be interpreted differently depending on what respondents believed to constitute exposure (any amount? a dangerous amount?).

This process of elimination left six risk attributes, as well as expected annual mortality and two benefit measures, as potential explanatory variables for dread and perceived risk.[6] The six risk attributes include many of the variables discussed in the literature as potentially significant contributors to risk perceptions: voluntariness of exposure, equity, newness, effects on future generations, immediacy of impacts, and the potential for catastrophic accidents. The benefit measures include personal pleasure and economic gains to society.

3. RESULTS

We regressed these nine variables upon the dependent variables dread and perceived risk using a linear regression model. There are 84 observations in each regression, one for each of the products, technologies, or activities. The results are displayed in the A columns of Table II.

These models explain 75% and 82% of the variation in the risk measures. However, several variables are not statistically significant and, in an attempt to arrive at a more parsimonious listing of risk dimensions,[11] these variables were dropped from the full model. As displayed in the B columns of Table II, the result is a six variable model with the two benefit measures, expected mortality, and only three risk characteristics: impact on future generations, immediacy, and catastrophe. The *R*-

[4] The data set analyzed here was collected by Slovic *et al.* in 1978–1979 and replicated in 1987 with similar results.[10] As a test of robustness, we repeated key regression runs using the more recent data set; the results were not substantially different from those obtained using the earlier data discussed in the text.

[5] Slovic *et al.* used factor analytic techniques to condense the more than 50,000 individual ratings to a small set of higher-order characteristics or factors. Further descriptions of the data set and earlier analyses are found in Slovic.[1,3]

[6] Attributes that were not included in the original data set, including factors such as outrage, trust, or blame, could not be included in this analysis.

Table I. Definition of Characteristics and Rating Scales

Voluntariness	Do people become exposed to this risk voluntarily?	Risks assumed voluntarily/involuntarily
Immediacy of effect	To what extent is the risk of death immediate—or is death likely to occur at some later time?	Effect immediate/delayed
Newness	Is this risk new and novel or old and familiar?	New/old
Catastrophe	Is this a risk that kills people one at a time (individual risk) or a risk that kills large numbers of people at once (catastrophic risk)?	Individual/catastrophic
Equity	To what extent are those who are exposed to the risks the same people as those who receive the benefits?	Risks and benefits match/mismatched
Future generations	To what extent does present pursuit of this activity or technology pose risks to future generations?	Very little threat/great threat
Economic benefits	Economic benefits include the contribution of the activity, product, or technology toward providing jobs, income, and increased personal or national productivity of goods and services	No benefits/very great benefits
Pleasure benefits	Pleasure benefits include intellectual stimulation, entertainment (fun), aesthetic enjoyment, relaxation, novelty, and camaraderie	No benefits/very great benefits
Dread	Is this a risk that people have learned to live with and can think about reasonably calmly, or is it one that people have great dread for—on the level of a gut reaction?	No dread/dread
Perceived risk	What is the risk of dying (across all U.S. society as a whole) as a consequence of this activity, technology, or product?	Low risk/high risk
Expected mortality	Number of deaths if next year is average	Number

squares remain very high with this parsimonious model at .74 and .81. Further, dropping the least significant variables did not strongly affect the remaining coefficients, with the possible exception of the coefficient on future generations which gained in importance.

To test the extent to which the results are an artifact of the rating scale, we also recalibrated all the 1–7 variables: ratings from 1–3.5 were transformed as −1, ratings from 3.5–4.5 were given a 0, and ratings greater than 4.5 were shown as 1.[7] All regressions were re-estimated with these alternative scales, and the results are shown in Table III.

4. DISCUSSION

The original factor analyses conducted by Slovic *et al.* yielded important insights into the nature of perceived risks. The significance of these findings has been well documented through the past decade of work by risk-perception researchers.[(10)] In fact, it is the classic status given to the results of the Slovic *et al.* factor analyses that encouraged us to conduct this reanalysis of their data using linear regression techniques. The regression results presented in this paper provide several new insights into the linkage between dread or perceived risk and the attributes of a risk source.

Three risk characteristics are shown to explain much of the variation in both dread and perceived risk: future generations, immediacy, and catastrophic potential. However, the regression patterns are not identical. Higher dread ratings are associated with greater impacts on future generations, more immediate impacts, and more catastrophic impacts. The results for perceived risk are similar but catastrophe has the opposite impact: the more catastrophic an item, the less its perceived risk. This result may occur because several of the items rated highest on the perceived risk scale primarily affect those individuals engaged in the activity, such as smoking and drinking alcoholic beverages, and have little catastrophic potential.

Neither voluntariness nor newness are important explanatory variables in the regressions.[8] As shown in Ta-

[7] For the fatalities scale, responses of 10 or fewer deaths per average year (32% of the total) were coded as −1, responses of 11–99 (45%) were coded as 0, and responses of 100 or more (23%) were coded as 1.

[8] Voluntariness and newness do impact risk perceptions when included alone. Numbers shown are standardized regression coefficients with only that variable included; numbers in parentheses are *t*-statistics.

Independent variable	Dependent variable	
Voluntariness	.39	.20
	(3.88)	(1.82)
Newness	−.42	−.23
	(4.16)	(2.13)

Table II. The Relationship of Measurable Risk Attributes to Dread and Perceived Risk[a]

	Dependent variable				
	Dread		Perceived risk		
Independent variable	(A)	(B)	(A)	(B)	(C)
Economic gain	−.25	−.28	−.12	−.14	−.13
	(2.84)	(3.44)	(1.62)	(1.97)	(1.34)
Personal gain	−.37	−.38	−.19	−.19	−.16
	(3.81)	(4.98)	(2.26)	(2.92)	(2.19)
Voluntariness	−.03	—	−.01	—	—
	(0.24)		(0.09)		
Immediacy	+.36	+.37	+.27	+.28	+.29
	(3.36)	(3.62)	(2.97)	(3.20)	(3.36)
Newness	−.09	—	−0.1	—	—
	(0.99)		(0.14)		
Catastrophe	.16	.21	−.16	−.10	−.16
	(1.51)	(2.39)	(1.73)	(1.32)	(1.08)
Equity	.14	—	.14	—	—
	(1.16)		(1.29)		
Future generation	.45	.57	.69	.77	.91
	(3.07)	(5.02)	(5.50)	(7.91)	(8.02)
Expected mortality	.08	.05	.38	.37	.33
	(0.85)	(0.59)	(4.50)	(4.85)	(5.56)
Pleasure-technology	—	—	—	—	−.50
					(3.97)
Catastrophe-technology	—	—	—	—	.24
					(2.13)
r^2	.75	.74	.82	.81	.83

[a] The multiple regression model is linear. The numbers shown are the standardized regression coefficients. The numbers in parentheses are t-statistics. A constant term not shown is in each regression.

Table III. The Effects of Alternative Scaling[a]

	Dependent variable	
Independent variable	Dread	Perceived risk
Economic gain	−.30	−.24
	(3.83)	(3.46)
Personal gain	−.26	−.17
	(2.97)	(2.19)
Voluntariness	.02	.01
	(0.16)	(0.14)
Immediacy	.10	−.11
	(1.03)	(1.28)
Newness	−.16	−.06
	(1.75)	(0.74)
Catastrophe	.26	.06
	(3.00)	(0.75)
Equity	.25	.18
	(2.52)	(2.01)
Future generation	.24	.30
	(2.32)	(3.25)
Expected mortality	.23	.62
	(2.58)	(7.78)
r^2	.67	.74

[a] The multiple regression model is linear. The numbers shown are the standardized regression coefficients. The numbers in parentheses are t-statistics. A constant term not shown is in each regression. All risk variables with 1–7 scales have been recalibrated to −1, 0, or 1.

ble II, voluntariness has little effect on either dread or perceived risk when considered in the context of the other risk variables. One interpretation of this result is that voluntariness is not important in and of itself but acts as a proxy for other variables, such as equity or personal benefits. Newness is also insignificant, despite the attention placed on the contrast between new and unfamiliar vs. old and familiar technologies or products in earlier risk research and risk communication.

Expected mortality has little effect on dread ratings but strongly affects ratings of perceived risk. People do not dread hazards that have higher expected mortality associated with them. However, perceived risk ratings do correlate with expected mortality. In relative importance (i.e., the magnitude of the standardized regression coefficient), expected mortality is second only to effects on future generations in explaining perceived risk.

Personal-benefit measures negatively affect risk ratings: if a recipient derives personal pleasure from using a good, that good receives lower dread and perceived risk ratings. Economic benefits also correlate negatively with risk ratings, although their effect is smaller. Apparently, people have a difficult time isolating the specific impacts of a risk source and respond to risk ratings as a net measure (i.e., risk minus perceived benefits). Risk ratings consequently cannot be taken strictly at face value. Especially in an analysis that conceptually separates risks and benefits, risk ratings must be treated cautiously because they may incorporate some benefits already.[12,13]

There are several possible problems with this analysis. First, because some of the risk characteristics are moderately correlated, one must interpret the variables cautiously. As a check on the intercorrelations problem, we conducted an exploratory factor analysis on the complete data set. This yielded a four-factor solution reflecting the following concerns: the potential for catastrophic accidents, immediacy, social benefits, and fatalities. Personal benefits and effects on future generations both loaded as part of the strong first factor. We then used the factor scores to predict dread and perceived risk; for both models, predictive power was high (R-squares were

.76 and .72, respectively). These results therefore generally support those shown in Table II.

Second, the 1–7 scales used to rate the risk variables may introduce a false scaling effect; that is, a score of 6 should not be assumed to be three times the magnitude of a score of 2. A general conclusion from Table III, in which all the 1–7 variables are recalibrated, is that the psychometric results are robust with respect to scaling. However, for both dread and perceived risk, the explanatory effect of immediacy is considerably weaker, whereas the effect of equity is stronger. Expected mortality also is more significant under the alternative scaling in explaining both dread and perceived risk.

A third potential problem is that the coefficients might vary across the three different item types: technologies, products, and activities. To determine whether these models of risk are the same, we estimated the six-variable model independently for each of the three groups. An F-test on whether the coefficients for all three models are the same has a p-value of .048 for perceived risk and 0.24 for dread, indicating that the models for dread are not statistically different across all three item types, but for perceived risk there is a statistically significant difference.

The perceived risk model was then examined in more detail to determine which coefficients varied across the three types of sources. The coefficients for pleasure and catastrophe were found to be significantly different for technologies relative to products and activities. Both of these technology-specific coefficients are included in the revised model presented in Table II, column C. Personal pleasure has a much stronger role in reducing the perceived risk of technologies vs. products and activities. In addition, the catastrophic potential of technologies has a strong impact on perceived risk but the catastrophic potential of products and activities does not affect perceived risk. This result could reflect some underlying difference between technologies and other sources, such as the degree of control a normal citizen exercises over the source. However, the result may simply be due to the lack of variation across the sample of catastrophic potential for activities and products.

5. CONCLUSION

This study suggests that a small number of attributes of risk perceptions related to technologies, activities, and products can explain a great deal of the variation in risk psychometric measures obtained for a diverse set of goods. Four characteristics—impacts on future generations, the potential for a catastrophic accident, the immediacy of health effects, and equity—strongly influence ratings of the dread and perceived risk associated with technologies, products, and activities.

The regression results show that each of the two dependent variables, dread and perceived risk, reflect widely held public concerns about risks that are not captured by expected mortality or morbidity. However, the regression patterns for dread and perceived risk are not identical; based on these results, the frequent assumption of equivalence between perceived risk and dread is not correct. The study also adds to the evidence that expected mortality does not explain dread at all: attempts by risk managers to increase statistical safety may have little impact on dread ratings or public support for a technology. In contrast, perceived risk is affected by expected mortality: goods that pose greater risk to life receive higher perceived risk ratings.

The research confirms that risk psychometric ratings are influenced by the perceived benefit, either personal or economic, that individuals expect from the source. In this sense, psychometric risk ratings appear to be "net" ratings by individuals of whether a good leaves them better off or worse off. They cannot be interpreted strictly as ratings of just the hazard. This result is especially powerful with respect to technologies, and it has implications for the identification and evaluation of risks, because it suggests that people may not hold separate risk and benefit categories as part of their mental models of a proposed option. Consequently, it is troublesome to include psychometric ratings directly in analyses which logically isolate risks from benefits.

The result also has interesting implications for risk communication,[14] suggesting that proponents of a hazardous technology, facility, or product might attempt to increase the salience of the associated benefits rather than rely solely on attempts to convince stakeholders that risks are small. In light of the multidimensional characterization of risk sources, we have no doubt that this strategy would work better for some products, activities, and technologies than for others. Nevertheless, the linkage between benefits and risk perceptions serves to focus attention on the acceptability of direct tradeoffs, which we believe to be a useful perspective, rather than on the less interpretable absolute levels of costs, risks, or benefits.

The risk characteristics examined in this study play a similar role across technologies, activities, and products with two notable exceptions: the effect of personal benefits is more important for technologies, and the negative effect of catastrophe is specific to technology. Two plausible explanations for these differences are that people may undervalue the benefits of items they do not directly use and that people may be wary of items whose use is controlled by third parties (e.g., corporations). These concerns may suggest new attributes that should be included in future studies of risk perceptions.

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