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Dimensions of Risk Perception for Financial and Health Risks

David R. Holtgrave[1,3] and Elke U. Weber[2]

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This study of 29 MBA students compares two models of risk perception for both financial and health risk stimuli. The first, inspired by Luce and Weber's Conjoint Expected Risk (CER) model, uses five dimensions: probability of gain, loss and status quo, and expected benefit and harm. The second, inspired by the Sovic *et al.* psychometric model, employs seven dimensions: voluntariness, dread, control, knowledge, catastrophic potential, novelty, and equity. The CER-type model provided a better fit for most subjects and stimuli. Adding the psychological risk dimensions from the Slovic *et al.* model explained only modestly more variance. Relationships between the dimensions of the two models are described and the construction of a hybrid model explored.

KEY WORDS: Risk pereption; dimensional models; financial risk; health risk; safety risk.

1. INTRODUCTION

Social scientists have expended much effort developing models of human risk perception and have found multiple practical uses for these models.[1] As noted by Kraus and Slovic,[2] descriptive models of human risk perception aid in predicting how people will respond in a particular risky situation. How might they react, for example, when told of a new electrical power plant being built in their community? Studies of subjective risk perception and risk acceptability show, for example, that people tend to reject comparisons about the magnitudes of risks (e.g., comparison of lung cancer risk from coke oven emissions and cigarette smoking) when these risks are qualitatively different (e.g., involuntary versus voluntary).[3] Findings such as these help guide the design of risk communication efforts. People also may be able to use insights into their subjective risk perception to help them manage and understand their own responses to risks.

The types of risks considered by research on risk perception have been very heterogeneous.[4] However, most of them fall into two general categories of risk types: health and financial. In this paper, we use the term "health risk" to refer to both health and safety risks. Health risks include such threats as nuclear warfare, pesticides, automobiles, skiing, handguns, and so on.[4] Studies of the other major category of risk — financial — have tended to focus on the risks inherent in monetary gambles,[5] for instance, an even chance of winning or losing ten dollars.

This dichotomous categorization of studies of risk perception into those that consider health vs. financial risk stimuli is similar to that proposed by Yates and Stone.[6] They refer to monetary gambles as "single-dimension" risks, and health risks as "general." The general risk category as defined by Yates and Stone[6] contains two major subcategories: health hazards and consumer purchases.

Many of the health risks studied could be construed as including a financial component (e.g., the economic

[1] University of Oklahoma Health Sciences Center.
[2] Center for Decision Research, Graduate School of Business, University of Chicago, Chicago.
[3] Address all correspondence to Dr. Holtgrave at his new address: Office of the Deputy Director (HIV), National Center for Prevention Services, Centers for Disease Control and Prevention, 1600 Clifton Road, Mailstop D21, Atlanta, Georgia 30333.

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impact of nuclear warfare), but few of the financial risks studied include a health component. The risk perception models developed in these two literatures have focused on either financial or health risk, but not on both categories at once. Indeed, in these two domains, the development of risk perception models has proceeded in a nearly parallel fashion.

The best-known model of risk perceptions for health risks is that developed by Slovic *et al.*[3,4] — hereafter, referred to simply as the Slovic model for brevity. This model posits that risk perceptions are determined primarily by seven characteristics of health risks that have been labeled psychological risk dimensions: voluntariness, dread, control, knowledge, catastrophic potential, novelty, and equity. Table I provides more detailed definitions of these dimensions. The Slovic model has been supported in studies involving a wide range of health risks and in studies involving health risks within a single subcategory (such as railroad hazards).[2] The Slovic model posits that a subject's rating of the riskiness of some stimulus is a linear function of its value on the seven psychological risk dimensions. Therefore, it is well-captured by a linear regression.

A model of risk perception that has been well-supported for financial lotteries is the Conjoint Expected Risk (CER) model developed by Luce and Weber.[7] This model is a weighted function of five dimensions: probability of gain, loss and status quo, and expected gain and loss. Studies testing the CER model have used well-defined monetary gambles as stimuli.[8–10] The original CER model includes (individual difference) parameterization by which gains and losses are raised to some power before the expected values of benefits and losses are calculated. Power parameters estimated from empirical data are often close in value to unity.[8] Hence, in the present paper, a simplified version of the CER model will be used and referred to as SCER (for "Simplified CER"). The simpler *S*CER model assumes power parameters of unity which makes it linear and more comparable in functional form to the Slovic model. Again, the SCER model is a linear function of the five dimensions listed above.

It is important to observe that the SCER model posits that perceived harm and benefits both influence subjective risk perception. That is, perceived risk is taken to be a function of perceived harm and benefits. This is a markedly different approach than that commonly taken in the literature on health risk. Indeed, several researchers have pursued the study of perceived risks as a line of inquiry separate from the study of perceived benefits and perceived acceptability of risks.[11,12] Furthermore, in risk/benefit analysis, the estimation of risk is taken to be separate from the estimation of benefits — estimated risks and benefits are considered to be quantities to be compared to each other.[13]

The fact that the models that have emerged from these two literatures posit different predictors of risk ratings, raises the following questions: Are perceptions of health and financial risks determined by fundamentally different dimensions, or is there a set of variables that can predict risk ratings for both types of risks? If there is a common set of predictor variables, it suggests that a further integration of the literatures would provide further insights into the important processes of risk perception.

The purpose of the present study is to determine whether one model of risk perception can account for subjects' risk ratings of financial *and* health stimuli. Specifically, we sought to determine whether Slovic's model, the SCER model, or a meaningful hybrid of the two, could explain subjects' ratings of the risk posed by a variety of financial and health stimuli.

Table I. Definitions of Slovic Model Variables

Variable	Definition (each relates to some risky activity)
Voluntariness	Degree to which the activity is voluntary
Dread	Degree to which the negative consequences of the activity are dreaded
Control	Degree to which the person engaging in the activity has control over the consequences
Knowledge	Degree of knowledge the person engaging in the activity has about the associated risks
Catastrophic potential	Worst-case disaster severity of the activity
Novelty	Degree to which the activity is new and novel or old and familiar
Equity	Degree to which the consequences of the activity are fairly distributed.

2. SUBJECTS AND METHODS

Twenty-nine MBA students from the University of Chicago Graduate School of Business were paid to complete a detailed paper-and-pencil survey at their leisure. Although demographic subject characteristics were not formally assessed, it should be noted that this student body consists of approximately 70% male students and 30% female students, in their late twenties, and with several years of work experience.

The first page of the survey asked subjects to familiarize themselves with the list of 22 financial and health risks described in Table II. On this list, financial and health stimuli appeared in random order. On subsequent pages (one page per risky activity), subjects were asked then to rate each activity on the following dimensions: probability of benefit [pr(benefit)], probability of harm [pr(harm)], probability of maintaining the status quo [pr(status quo)], expected benfit [E(benefit)], expected harm [E(harm)], voluntariness, control, knowledge, dread, catastrophic potential, novelty, and equity.

Table II. Risky Activities Used as Stimuli (Specified to Have a One-Year Time Horizon)[a]

•	Riding a bicycle 1 mile daily in an urban area
*	Living near a nuclear power station
*	Driving an auto 10 miles daily in an urban area
*	Living in a home with an average radon level
–	Investing 20% of savings in a blue-chip stock
–	Investing in 1 ounce of gold
*	Playing recreational touch football each weekend
–	Investing 80% of savings in blue-chip stock
*	Using domestic appliances
•	Flying on commercial airplanes once each month
•	Working in a nuclear missile silo
•	Working as a family physician in a rural area
•	Shooting on a target range for recreation each weekend
•	Living in an apartment near Central Park in New York City
–	Investing in 1 ounce of silver
*	Receiving an annual preventive flu vaccination
–	Investing 80% of savings in the stock of a new medical research firm
*	Swimming in an indoor public pool weekly
*	Working as a file clerk
*	Receiving diagnostic x-rays once every 6 months
–	Investing 20% of savings in the stock of a new medical research firm
•	Working on a Special Weapons and Tactics police team

[a] Items marked with an "*" are health risks; items marked with a "–" are financial risks.

Of each risky activity, subjects also rated the overall riskiness and attractiveness (attractiveness ratings are not considered further here). Probability dimensions were rated on a 0 through 1 scale, and all other dimensions were rated on a 1 through 100 scale. Instructions as to the use of all scales were provided. Subjects wrote their numerical responses on blank lines. We intentionally left undefined terms such as, "benefits," "harm," and "risk."

3. RESULTS

Linear regression analysis was used to determine the degree of fit of the Slovic and SCER models to the risk ratings. Analyses were done separately for each subject (across stimuli) and then done separately for each stimulus (across subjects). Principal components factor analysis with varimax rotation was used to study the relationships among the dimensions of the two models.

Analyzing each subject's data separately, the SCER model (with 5 variables) accounted for 31–100% of the variance in the overall risk ratings (the mean across subjects was 70.76 with a standard deviation of 18.57). The Slovic model (with 7 variables) accounted for 17–92% of the variance (the mean across subjects was 59.38 with a standard deviation of 22.11). The SCER model accounted for more variance than the Slovic model for 19 of 29 subjects ($p < .07$ by sign test), even though (a) the SCER model has a smaller number of variables than the Slovic model and (b) the percentages of variance-accounted-for are not adjusted for number of variables. Using unadjusted percentages of variance accounted for actually constitutes a bias *against* the SCER model because it contains fewer variables. Adjusting the percentage of variance accounted for by the numbers of variables does not alter the qualitative conclusions of this paper.

Table III shows the results of the within-stimuli linear regression analyses. The SCER model accounted for more variance than the Slovic model for 20 of the 22 stimuli ($p < .001$ by sign test).

Tables IVa and IVb give the results of the linear regression analyses as performed across all subjects and all stimuli. Again, the SCER model accounts for more variance than the Slovic model (even though it has fewer predictor variables). However, linear regression analyses indicate that in all stimulus domains each model accounts for a significant amount of variance on the margin of the other model (at the .05 level). This was assessed using an F-test for comparing a hybrid model with all 12 predictor variables (from both models) to either the

Table III. Regression Results by Stimulus: Percentage of Variance-Accounted-For in Risk Ratings

Stimulus	SCER model	Slovic model
Bicycle	57	46
Nuclear plant	80	61
Auto	56	36
Radon	79	42
20% savings—blue chip	69	35
Gold	39	29
Football	55	38
80% savings—blue chip	65	58
Appliances	93	93
Airplane	75	45
Missile silo	88	55
Family physician	17	70
Target range	48	43
Central Park apartment	62	52
Silver	51	17
Flu shot	65	47
80% savings—med. research	34	23
Swimming pool	49	60
File clerk	36	28
X-ray	77	45
20% savings—med. research	39	30
SWAT police team	47	20

Table IVa. Overall Regression Results: Percentage of Variance-Accounted-For in Risk Ratings

	Stimulus domain		
Model	Financial	Health	Overall
SCER	46	64	60
Slovic	36	39	30
SCER on margin of Slovic	22[a]	28[a]	32[a]
Slovic on margin of SCER	12[b]	2[c]	2[d]

[a] The SCER dimensions of probability of harm, expected harm, and probability of status quo entered the stepwise regression equation.
[b] The Slovic dimensions of dread, catastrophic potential, voluntariness, and equity entered the stepwise regression equation.
[c] The Slovic dimensions of catastrophic potential, dread, and voluntariness entered the stepwise regression equation.
[d] The Slovic dimensions of dread, control, catastrophic potential, and novelty entered the stepwise regression equation.

SCER or Slovic model alone. We also fit the SCER model on the margin of the Slovic model using *stepwise* linear regression. That is, the Slovic model was fixed into the regression equation and the SCER dimensions allowed to enter one-at-a-time until no additional one met a default .15 significance level for entry. On the margin of the Slovic model, the SCER model accounts

Table IVb. Overall Regression Results: Standardized Regression Coefficients Used in Predicting Risk Ratings[a]

		Stimulus domain		
Model	Variable	Financial	Health	Overall
SCER	pr(benefit)	−.15	−.11	−.16*
	pr(harm)	.43*	.48*	.49*
	pr(status quo)	−.14*	−.10*	−.12*
	E(harm)	.24*	.31*	.26*
	E(benefit)	.12	.04	.09*
Slovic	Voluntariness	.06	−.13*	−.02
	Control	−.14*	.02	−.21*
	Knowledge	.04	.01	.07
	Dread	.24*	.36*	.32*
	Novelty	−.01	−.08*	−.06
	Catas. potential	.44*	.17*	.13*
	Equity	−.07	−.25*	−.17*

[a] An "*" indicates that the parameter is significantly different from zero at $p < .05$. A "pr()" denotes the probability of the parenthetical expression. An "*E*()" denotes the expectation of the parenthetical expression.

for 32% *additional* variance across all subjects and stimuli. The Slovic model fit on the margin of the SCER model accounts for only 2% additonal variance across all subjects and stimuli. However, when the Slovic model is fit on the margin of the SCER model for only the financial stimuli, it accounts for an additional 12% of the variance.

The standardized regression coefficients in Table IVb suggest that pr(benefit) and *E*(benefit) are significant predictors of perceived risk when all stimuli are considered. When financial and health risk are considered separately, these two predictor variables related to benefits still have sizable coefficients but fail to reach conventional levels of statistical significance. The Slovic dimensions of dread, catastrophic potential, and control are significant predictors of perceived financial risk.

The results suggest that it may be possible to construct a meaningful hybrid of the two models that would provide better explanatory power than either model alone. Factor analyses provided information about the relationships between the dimensions of the two models. The factor analytic results are displayed in Tables Va, Vb, and Vc. In terms of explaining risk ratings of financial stimuli, the Slovic dimension of "dread" adds considerable explantory power to the SCER model. The factors with relatively large loadings on pr(benefit) and *E*(benefit) explain additional variance regardless of the stimulus domain.

The bivariate correlations between the hybrid model dimensions and the risk ratings were also examined. For

Table Va. Factor Analysis Results over All Subjects and Financial Stimuli[a]

	Rotated factor pattern			
Variable	Factor 1	Factor 2	Factor 3	Factor 4
pr(benefit)	−22	86	7	−22
pr(harm)	85	−17	8	19
pr(status quo)	−19	−54	12	−32
E(harm)	82	1	−14	−11
E(benefit)	0	86	8	−7
Voluntariness	49	20	36	−47
Control	−32	2	67	11
Knowledge	12	16	52	−13
Dread	11	−8	−13	85
Novelty	11	−13	57	−32
Catastrophic potential	59	6	22	44
Equity	6	−2	69	0
(Eigenvalue/12)*100	18	16	15	12
R^2 in risk ratings	44	1	<1	11

[a] R^2 denotes "percentage of variance-accounted-for."

Table Vb. Factor Analysis Results over All Subjects and Health Stimuli[a]

	Rotated factor pattern		
Variable	Factor 1	Factor 2	Factor 3
pr(benefit)	−58	23	67
pr(harm)	84	−24	−5
pr(status quo)	−24	0	−85
E(harm)	84	−24	−6
E(benefit)	−55	15	65
Voluntariness	−26	55	−7
Control	−13	69	18
Knowledge	3	80	20
Dread	64	−27	−20
Novelty	−30	30	38
Catastrophic potential	42	26	3
Equity	−49	50	4
(Eigenvalue/12)*100	26	18	15
R^2 in risk ratings	58	<1	5

[a] R^2 denotes "percentage of variance-accounted-for."

financial stimuli, the four predictors with the best explanatory power are as follows: pr(harm), *E*(harm), catastrophic potential, and dread. For health stimuli, and across all stimuli, the four best predictors are as follows: pr(harm), *E*(harm), dread, and pr(benefit).

Table Vc. Factor Analysis Results over All Subjects and All Stimuli[a]

	Rotated factor pattern		
Variable	Factor 1	Factor 2	Factor 3
pr(benefit)	−49	32	70
pr(harm)	81	−26	−6
pr(status quo)	−26	3	−82
E(harm)	80	−25	−4
E(benefit)	−43	24	71
Voluntariness	−15	47	3
Control	−9	65	7
Knowledge	8	75	12
Dread	58	−32	−18
Novelty	−18	49	20
Catastrophic potential	51	31	2
Equity	−33	58	0
(Eigenvalue/12)*100	21	19	15
R^2 in risk ratings	53	<1	3

[a] R^2 denotes "percentage of variance-accounted-for."

4. DISCUSSION AND CONCLUSIONS

The CER-type model accounted for more variance in the perceived risk ratings than the Slovic model for a majority of subjects and for nearly all stimuli. Across subjects and stimuli, the SCER model accounted for 60% of the variance in the perceived risk ratings, while the Slovic model accounted for 30%. On the margin of the Slovic model, and across stimulus domains, the SCER model accounted for a sizable amount of variance. On the margin of the SCER model, the Slovic model accounted for sizable additional variance only in the financial domain. In this domain, the Slovic dimension of "dread" is an important variable not entirely captured by the SCER model.

It is notable that the SCER model generally fit better for health risks than the Slovic model, since the Slovic model was developed in the domain of health risks while the original CER model was not. It is also of interest to note that the Slovic model dimension of "dread" is important in the domain of financial risks.

On the basis of this evidence, it seems fair to say that the CER model, even in its simplified form, is a well-fitting general model of both financial and health risk perceptions. In the financial domain, augmenting the SCER model with the Slovic dimension of "dread" provides for an even better-fitting model.

There are several possible explanations for the suc-

cess of the SCER model. One reason may be that the SCER dimensions of pr(harm) and E(harm) come close to the way subjects naturally think about the overall risk in a given activity. The Slovic model may need a dimension (like pr(harm)) reflecting the likelihood of harm, since this dimension is highly correlated with risk ratings. Another reason may be that subjects consider the "pros" and "cons" of activities when judging riskiness; the SCER dimensions of pr(benefit) and E(benefit) capture subjects' perceptions of the contributions of the positive aspects of risky activities. Previous research on health risks has tended to focus only on the negative aspects.

Augmenting the SCER model with the Slovic dimension of "dread" provides a new hybrid model with explanatory power worthy of further attention. Future research in this area should include attempts to validate the hybrid model for other subject populations and stimulus domains. Indeed, the subjects studied may not be representative of the general population, and generalizations of the present findings should be made with caution.

There are multiple practical recommendations to be gained from the present findings (given the above caveats). This research suggests that risk perception includes a balancing of harms and benefits. Risk communicators may wish to help audience members balance the pros and cons of a given threat. Message recipients may find a "balance sheet" communication format to be congruous with their own thought processes. Therefore, they might be more amenable to listening to a message formated in this way than a purely persuasive message which addresses only the pros *or* cons. For instance, a governmental agency might encourage radon mitigation by helping homeowners to balance the financial costs of foundation vent pipes with the potentially increased property value and lessening of lung cancer chances. It also seems fair to conclude that research on risk perception should include perceived benefits as a potential predictor of perceived risk (rather than studying perceived benefits as a separate area of inquiry).

The present findings suggest that the dimension of probability of harm is an important predictor of risk ratings. This dimension is lacking in the Slovic model. It too, should be considered in practical risk communication efforts, and seems especially relevant in the making of risk comparisons. Indeed, it may be that people think of the probability of harm as a risk *defining* characteristic (much like dimensions of voluntariness and control).

Another implication of the current paper is that emotional dimensions such as dread are important in the perceived risk of financial gambles. This is interesting because Yates and Stone[6] describe financial gambles as "single-dimension" risks. This work suggests that even financial gambles may be better described by models that include emotional factors as well as purely financial characteristics.

Therefore, it appears that further integration of the literatures on financial and health risk perception is to be recommended as one way to deepen an understanding of the important process of human risk perception.

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