Choice, Decision, and Measurement
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THE UTILITY OF MEASURING AND MODELING PERCEIVED RISK

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ABSTRACT. This chapter argues that measures of subjective risk perception are important for the following three reasons: (a) perceived risk is an important dependent variable in its own right, independent from choice, and governmental and corporate risk managers and policy makers need to track public risk perception; (b) decompositions of risky choice alternatives into a risk and a return component that originated in the theory of finance may provide us with a better understanding of the psychology of risky choice, and recent work has suggested measures of risk that depart from the standard equation of risk and variance; and (c) conceptualizing risk perception as a psychological variable that can be affected by decision context or problem framing allows for a definition of risk attitude that has shown greater stability across situations than conventional operationalizations and thus might measure a stable personality trait.

1. INTRODUCTION

The 1980's saw a large volume of work on axiomatic measures of subjective risk, much of it conducted and/or inspired by R. Duncan Luce. Until recently, this work has largely existed in parallel to work on risky choice, and the investigation of risk perception as a psychological variable has been considered suspect by researchers subscribing to the expected utility framework and the tenets of consequentialism. Ward Edwards, for example, only somewhat tongue-in-cheek, has likened the measurement of perceived risk to the collection of judgments about "orthosonority", a nonsense construct invented by S. S. Stevens for which people nevertheless provided systematic ratings.

Outside of the expected utility framework, the concept of risk is not a newcomer. The pioneering work of Markowitz (1959) in the theory of finance as well as the subsequent work of Coombs (1975) on the psychology of risky decision making conceptualized risky choice as a compromise between the riskiness and the value of options. In contrast to the assumption pervasive in the theory of finance that people should and will strive to minimize risk, Coombs assumed that people have

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an ideal point for risk that may or may not be at the zero point, and that – ceteris paribus – they will prefer options that come closest to this ideal point. Coombs hypothesized that a risk order over a set of options and a given individual's ideal point for risk could be obtained from his or her preference order.

Regardless of the success of such unfolding (Lehner, 1980), one may join Coombs in questioning the assumption of the rationality of risk minimization. In most formalizations[1], risk implies upside potential at the cost of downside potential. Whether risk – again ceteris paribus – is considered desirable or something to be avoided will thus depend on the relative emphasis one places on the upside potential relative to the downside potential. Lopes (e.g., 1987) has provided ample evidence that people differ in the extent to which they weigh those two factors when making decisions under risk. This differential weighting of upside vs. downside potential may either be an individual difference characteristic, as argued by Lopes, or a function of the situation or role people find themselves in. Thus Birnbaum and Stegner (1979) found that participants assigned to a seller's role put greater weight on the upper values of a range of price estimates for a used car than those assigned to the buyer's role who put greater weight on the lower estimates.

When upside and downside potential receive differential weight, they can do so in two logically distinct ways. The weights can affect people's perception of the riskiness of different options, such that options with a large downside potential seem proportionately more risky to individuals who put a larger weight on the downside potential. Alternatively, the weights might affect risk preference, rather than (or in addition to) risk perception. That is, keeping perceived risk constant, people who put a larger weight on the downside potential of risky options will find them less acceptable. In other words, the choice between two risky prospects can be different for two individuals either because they differ in their perception of the relative riskiness of the two options but have the same preference for risk (e.g., both are risk averse) or because they perceive the riskiness of the options in the same way but differ in their preference for risk, with one being risk averse and the other risk seeking. To differentiate between these two reasons for the difference in choice, we must be able to assess how both individuals subjectively perceived the riskiness of the two choice options.

In this chapter I will thus address the following two questions: (1) How do people perceive the riskiness of risky options, and is there evidence of individual and/or situational differences in risk perception? (2) Is risk preference also affected by these individual or situational differences or does the traditional economic assumption of universal risk aversion actually hold, after we factor out differences in risk perception?

2. Modeling Risk Perception

R. Duncan Luce, to whom this volume is dedicated, has contributed substantially to an answer to the first of those questions. Luce (1980, 1981) suggested

[1]In those formalizations that prefer to restrict the term risk to the downside potential of options (see Yates & Stone, 1992a, e.g.), risky choice is subsequentially characterized as a tradeoff between risk as downside potential and other considerations, including attractive benefits.

several possible axiomatic models of risk perception, adding to the literature on risk measurement that had been started by Coombs and his collaborators (e.g., Coombs & Bowen, 1971; Coombs & Huang, 1970; Coombs & Lehner, 1984; Pollatsek & Tversky, 1970). For a review of this history, see Weber (1988). The final modification of this theory, in response to Weber's (1984) and Keller, Sarin, and M. Weber's (1986) empirical work, was the conjoint expected risk (CER) model by Luce and Weber (1986). The CER model captures both similarities in people's risk judgments (by a common functional form by which probability and outcome information of risky options is combined) as well as individual differences (with the help of model parameters that reflect the relative weight given to positive and negative outcome and probability information). Thus the perceived riskiness R of risky option X is described as:

$$\begin{aligned} R(X) = {} & A_0 \Pr[X=0] + A_+ \Pr[X>0] + A_- \Pr[X<0] \\ & + B_+ \mathrm{E}[X^{k_+} | X > 0] \Pr[X>0] + B_- \mathrm{E}[X^{k_-} | X<0] \Pr[X<0], \end{aligned} \tag{1}$$

i.e., it is a linear weighted combination of the probability of breaking even, the probability of a positive outcome, the probability of a negative outcome, the conditional expectation of positive outcomes raised to the power of k_+, and the conditional expectation of negative outcomes raised to the power of k_-, where $k_+, k_- > 0$. Weber and Bottom (1989, 1990) submitted the behavioral axioms on which the CER model is based to empirical tests and found support for the transitivity and monotonicity assumptions. Some violations of the expectation principle for risk judgments in the gain domain (also reported by Keller et al., 1986) were shown to be the result of nonnormative probability accounting, similar to that observed for preferences (e.g. Luce, 1990a). Finally, Weber and Bottom's (1989) results supported the additive combination of gain and loss components hypothesized by the CER model and ruled out, at least as descriptive models, other risk functions (e.g. Fishburn, 1982) that are multiplicatively separable in their loss and gain components. Yates and Stone (1992b) recently described the CER model as the "most viable model to describe single-dimensional risk appraisal" (p. 72), as for example the risk appraisal of financial gambles.

In addition to Fishburn's (1982, 1984) work, several alternative axiomatic models of risk take an exponential form. Sarin (1984) extended Luce's (1980, 1981) work and derived the model

$$R(X) = \mathrm{E}[e^{-cX}]. \tag{2}$$

This model was modified by M. Weber (1990) into a form that made the risk measure location free, by subtracting the mean of the risky option from all outcomes:

$$R(X) = \mathrm{E}[e^{-c(X-\overline{X})}]. \tag{3}$$

3. Individual Differences in Risk Perception

The CER model or other models of risk allow us to identify individual differences in risk perception. In addition to simply finding such differences (e.g. Weber, Anderson, & Birnbaum, 1992), it allows us to pinpoint the locus of such differences. Thus Weber (1988) found that college students and high school teachers differed in their perceptions of financial risks, an effect that was mediated by differences in the parameters k_+ and k_-, with teachers being more sensitive to the magnitude of gains and losses in their risk judgments (i.e., having larger k_+ and k_- parameters). Bontempo, Bottom, and Weber (in press) found cross-cultural differences in the risk judgments of MBAs and security analysts from the United States, the Netherlands, Hong Kong, and Taiwan, in the direction that the risk perception of members of the two Asian countries relative to that of members from the two Western countries was less meliorated by the probability of positive outcomes (A_+) and depended more on the magnitude (k_-) rather than the probability (B_-) of negative outcomes.

4. Reasons to Measure Perceived Risk

A wealth of evidence suggests that the perceived riskiness of an option is not an immutable characteristic of that option (as is, for example, its variance) that is perceived in a similar way by different observers and in different contexts. Instead, perceived riskiness appears to be a psychological variable that differs between individuals and possibly across situations. With that in mind, we will now revisit the question of why one should be concerned with the measurement of this variable. In the remainder of the chapter, I will provide a tripartite answer to the question of why researchers as well as practitioners should care about risk perception, and in particular about the identification of individual and situational differences by a descriptive model of risk perception. I will argue that (1) people's perceptions of subjective risk are an important dependent variable in their own right; that (2) the decomposition of risky choice into a tradeoff between a risk and a return component may provide us with a better understanding of the psychology of risky choice; and that (3) the measurement of individual and situational differences in risk perception provides for a new measure of risk preference which holds the promise of restoring the possibility of risk attitudes as stable individual dispositions.

Perceived Risk as a Dependent Variable. The perceptions of the riskiness of new or existing technologies by ordinary citizens or the perceptions of the riskiness of products by consumers are an ever more powerful force that private companies and government regulatory bodies have to reckon with. While business or government experts may have clear quantitative definitions of the risks of products or technologies based on objective data or models, members of the general public often seem to evaluate the same options in very different ways. Much of the early work by Slovic, Lichtenstein, and Fischhoff on psychological risk dimensions (e.g., Fischhoff, Lichtenstein, Derby, & Keeney, 1981) was funded by the Nuclear Regulatory Commission to help them in their bafflement about how public perception of the riskiness of nuclear technology could differ so drastically from the estimates provided by their engineers.

Holtgrave and Weber (1993) were concerned by the lack of connection between the literature on the perception of financial risks, described above, and the literature on the perception of health and safety risks. To remedy this situation, they took a set of risky activities that included both financial risks (e.g., "investing 80% of savings in the stock of a new medical research firm") and health and safety risks (e.g., "riding a bicycle 1 mile daily in an urban area," or "working on a special weapons and tactics police team") and compared the fit of a simplified version of the CER model, originally developed to describe financial risk perception, with the fit of the psychometric risk dimension model by Slovic, Fischhoff, and Lichtenstein (e.g., 1986), originally developed for the perception of health and safety risks. Respondents provided their overall evaluation of the riskiness of these different activities as well as evaluations of the component variables of the two models (probability of a loss or a gain, and expected loss or gain for the CER model; voluntariness, dread, control, knowledge, catastrophic potential, novelty, and equity for the Slovic et al. model). Contrary to expectations, the CER model actually provided a better fit for the health and safety risks than for the financial risks ($R^2 = .64$ vs. .46) and also provided a better fit than the psychological risk dimension model for both financial risks ($R^2 = .46$ vs. .36) and health and safety risks ($R^2 = .64$ vs. .39). Holtgrave and Weber (1993) speculated that the reason for the superior fit of the CER model might be that its dimensions such as probability of negative consequences or harm and expected value of harm come close to the way people naturally think about the overall risk in a given activity or situation. The psychological risk dimension model may need a dimension or dimensions reflecting the probability of harm to provide a better fit, since this dimension is highly correlated with risk ratings. Another reason might be that people consider the pros and cons of activities when judging riskiness; they may use CER dimensions such as the probability of positive outcomes and the expected value of positive outcomes to counter the impact of negative outcomes. The psychometric model focuses exclusively on the downside of activities.

Not surprisingly, a hybrid model that added three of Slovic et al.'s (1986) seven psychological risk dimensions to the CER model ("dread," the degree to which the negative consequences of the risky options were dreaded, which accounted for most of the additional explained variance; but also "catastrophic potential," the worst-case disaster severity of the activity, and perceived "control," the degree to which the person engaging in the activity had control over the consequences) turned out to do the best job in describing the risk perceptions of University of Chicago MBAs for financial risks. Holtgrave and Weber's (1993) results demonstrate that risk perception in different content domains can be captured by the same model. It also suggests that risk perception of financial stimuli can have an "emotional" component for some observers that is not completely described by the "objective" components of the CER model. This result may well have implications in some areas of finance, for example in the identification of noise traders, that is traders who base their investment decisions partly on irrational factors (Lee, Shleifer, & Thaler, 1991). By modeling and comparing, for example, the risk judgments of institutional investors for a set of investment options with those of small private investors, one should be able to determine whether the risk judgments of the latter group (suspected to be noise traders) showed greater evidence of being affected by such emotional risk dimensions as dread or catastrophic potential above and beyond the effects of the objective information about the investment options.

In addition to financial and health and safety risks, the CER model has been shown to describe risk judgments in the domain of lifestyle choices. Palmer (1994) applied it in the context of genetic counseling to successfully model and characterize the judgments made by members of a clinical population of dwarfs about the riskiness of different procreative alternatives available to them. Palmer and Sainfort (1993) argue that the genetic counseling literature has been misguided in equating the perceived riskiness of an adverse event (e.g., the birth of a child with a genetic disorder) with the perceived probability of the event's occurrence. In a review of the literature on the impact of genetic counseling on the reproductive decisions made by couples, the authors submit that the failure of these studies to find a clear relationship between changes in risk perception as the result of genetic counseling and subsequent reproductive decisions is the result of these studies conceiving of "risk" primarily as probability of occurrence. Palmer and Sainfort argue that the risk of different reproductive alternatives perceived by counselees will also reflect the severity of consequences and that, therefore, conceptualizations and measures of risk that combine both probability and outcome information (such as the CER model) ought to be employed.

Given the growing political influence of grassroots organizations and consumer activism, it is becoming increasingly more important to be able to characterize and predict people's intuitive subjective risk judgments. Public perception of the risks of silicone implants (in causing autoimmune diseases), for example, led Dow Corning to stop production of implants in 1992 and file for bankruptcy in 1995, despite two major medical reports of no evidence of silicone-related illnesses and a clean bill of health from the American College of Rheumatology (Cowley, 1995). Controversies about the licensing of technologies such as genetic engineering, or the siting of facilities such as landfills, incinerator plants, or halfway houses for the mentally handicapped, tend to be fueled primarily by disagreements about present or future levels of risk, rather than about disagreements about the acceptability of specific risk levels.

Along the same lines, risk communication and public education campaigns succeed best when they manage to alleviate people's fears, i.e., when they reduce the *perception* of riskiness rather than attempt to influence people's risk-benefit tradeoffs (Long, 1988). Affirmative action or other legal injunctions can, in this context, be seen as an opportunity to expose people, against their will but for the greater social good, to information that will disprove those of their fears that are based on irrational prejudices and stereotypes. Having the halfway house operate in their neighborhood for a year without incidents, for example, will likely result in a lower level of perceived risk than residents had anticipated. To gauge the subjective risk perceptions of members of the general public and to evaluate shifts in perceived risk as a function of educational and other interventions, it is necessary to have a measure of these perceptions. I argued in this section that axiomatic models of risk perception developed for financial stimuli, such as the CER model, augmented perhaps with some of the variables detected by the psychometric work on risk perception, have a broader range of applicability than the domain for which they were originally designed.

New Interest in Risk-Return Models. In contrast to the expected utility framework for modeling risky choice, the risk-return framework commonly found in the theory of finance (e.g., Markowitz, 1959) introduces risk and risk preference as constructs central to risky choice. Some theorists consider risk-return tradeoff models "more intuitively satisfying ... than expected utility"(see Bell, 1995, p. 3). Sarin and M. Weber, (1993, p. 148) describe the "intuitive appeal of risk-value models" as due to the fact that they require that "choice should depend on the riskiness of the gamble and its value." The early risk-return models of finance equated risk with variance, a formalization that is compatible with a quadratic utility function (Levy & Markowitz, 1979). Recent work by Sarin and M. Weber (1993), Jia and Dyer (in press), Bell (1995), and Franke and M. Weber (1996) has shown that a broad range of utility functions have risk-return interpretations. Different utility functions imply different measures of risk, under the assumption of risk aversion and the equating of return with expected value.

The psychological and axiomatic research on subjective risk perception discussed in the introduction can be characterized as taking a *bottom-up* approach, by starting with absolute or comparative risk judgments and fitting models to them. In contrast, the decomposition of choice into a risk and a return component can be described as providing a *top-down* approach, by starting with choices and utility functions and inferring perceived risk functions from them. Ideally, the two approaches will provide converging evidence for a model or a class of models of subjective risk that describes all observed empirical regularities of both risk perception *and* risky choice. Some such integration is already underway. Thus Jia and Dyer (in press) describe the following measure of perceived risk:

$$R(X) = be^{c\overline{X}}\mathrm{E}[e^{-c(X-\overline{X})} - 1] \tag{4}$$

This measure is (a) consistent with exponential and linear plus exponential utility functions and (b) has properties that are consistent with existing empirical tests of axioms about perceived risk. Their risk function has the implication that the Archimedean assumption (i.e., that when the riskiness of X exceeds that of Y, there exists a positive real number a such that the riskiness of aY exceeds that of aX) need only hold for negative outcome lotteries, consistent with the empirical results of Weber and Bottom (1990). This is the case because Equation 4 can be rewritten as

$$R(X) = b(\mathrm{E}[e^{-cX}]e^{-c\overline{X}}). \tag{5}$$

Only for lotteries with negative expected values will the two components of Equation 5 point in the same direction, guaranteeing that the riskiness of aY exceeds that of aX.

Implicit in the class of generalized risk-return models is the realization that it is possible to define risk in different ways. The framework suggests that differences in choice patterns that can be modelled by different utility functions can also be interpreted as differences in the definition of risk. Sarin and M. Weber (1993) discuss the fact that risk (just as preference) is a learned concept, and that people with different experiences or training may perceive risk in different ways. Weber and Milliman (1997) recently showed that people's perceptions of the risks of a small set of stocks changed over the course of only ten investment periods as a function of whether they consistently made money or lost money. Whether we are considering individual differences in choice or situational differences where the same individual chooses differently as a function of a different context or a different set of previous experiences, risk-return conceptualizations of risky choice suggest that what is changing from choice to choice is the perception of the *riskiness* of the choice alternatives, not the perception of the return (which is assumed to remain equal to the expected value of the options), nor the preference for risk (which is assumed to remain risk averse).

Perceived-Risk Attitude as a Stable Trait. The assumption of risk aversion as the dominant attitude towards risk in the population and its association with a decreasing marginal utility function for money has been around since Bernoulli in the 18th century. Decreasing marginal utility would, of course, result in greater weight being given to the downside rather than to the upside of a risky option. Even though, within the expected utility framework, risk attitudes only serve as descriptive labels for the shape of the utility function that describes the choices (i.e., with risk seeking/avoiding behavior being described by a convex/concave utility function and the corresponding Arrow (1971) – Pratt (1964) index $\frac{-u''(x)}{u'(x)}$), the popular as well as managerial folklore tends to interpret risk preference as a personality trait. While most people are assumed to be risk averse, some – for example, entrepreneurs – are assumed to be risk takers. In addition, risk taking, perhaps because of its rarity, is assumed to be associated with personal and corporate success, an assumption for which there is a small amount of empirical support (MacCrimmon & Wehrung, 1990).

Unfortunately, there are two problems with the interpretation of risk preference as a personality trait. First, different methods of assessing risk preference can result in different classifications (Slovic, 1964; MacCrimmon & Wehrung, 1990). Second, individuals do not appear to be consistently risk seeking or risk averse across different domains or situations, either in laboratory studies or in managerial contexts. Thus people have been shown to be risk averse for gains but risk seeking for losses (e.g. Payne, Laughhunn, & Crum, 1980), a phenomenon sufficiently stable that Kahneman and Tversky's (1979) prospect theory describes it as an empirical regularity which they model by a value function that is concave for gains, but convex for losses. In addition, choice- and utility-function inferred risk attitudes have not been stable across domains, with people appearing, for example, risk averse in their financial decisions but risk seeking in their recreational choices or vice-versa (e.g. MacCrimmon & Wehrung, 1986).

Weber and Milliman (1997) recently showed that a measure of risk attitude that takes into consideration situational and contextual differences in the perception of the riskiness of options has much greater potential to be consistent for a given individual across situations, and thus to qualify as a measure of a stable personality trait. They called their measure *perceived-risk attitude*, since it measures whether – ceteris paribus – a person tends to seek out options that he or she perceives to be more risky (perceived-risk seeking) or less risky (perceived-risk averse). It is easy to see why such a measure could (but need not, necessarily) lead to greater cross-situational consistency. Our approach is similar to the logic behind Dyer and Sarin's (1982) measure of relative risk attitude, which was to remove differences in marginal value functions from utility functions, to see whether any remaining curvature (the relative risk attitude which reflected solely one's attitude towards uncertainty) was more consistent for a given individual across domains (unfortunately, it was not; see Keller, 1985b). Instead of factoring differences in marginal value out of choice, the perceived-risk attitude measure factors differences in perceived risk out of choice. If an individual's choices appear to be the risk seeking when she is deciding between investment options but appear to be the risk averse when she is deciding between recreational sports possibilities, it may well be that she has a positive attitude towards risk for money, but a negative attitude towards safety risks. On the other hand, it is also possible that her perception and definition of a risky investment option does not coincide with that implied by the expected-utility interpretation of her choices (e.g., risk equal to variance). Assume, for example, that she needs to pay off a balloon mortgage next year and otherwise risks losing her house. In this case, a risky investment option is one that does not provide her with any chance of earning that balloon payment by next year, which may be true for low-variance options. Thus it is at least possible that the woman in our example is consistently perceived-risk averse in both the financial and the recreational decision, that is, she is choosing the option that she perceives to be less risky in both domains. What is different in the two domains and hence affects the option that she chooses is her definition of what constitutes risk in the two domains.

What success does such a measure of perceived-risk attitude (that unconfounds situational differences in risk perception from situational differences in risk preference) have in bringing about greater cross-situational consistency in risk preference? The answer is overwhelmingly positive. In the first investigation of this issue, Weber and Bottom (1989) asked their respondents to choose between pairs of lotteries that either had only positive outcomes or had only negative outcomes and, at a later point in time, asked them to rate which lottery in each pair was riskier. They classified those individuals as perceived-risk averse who consistently chose the option that they had designated as less risky, and those individuals as perceived-risk seeking who consistently chose the option that they had designated as more risky. Consistency was defined statistically by a sign-test, and those individuals who showed no significant relationship between perceived risk and preference were classified as perceived-risk neutral. Each individual's perceived-risk attitude for the set of positive outcome lotteries was compared to his or her perceived-risk attitude for the set of negative outcome lotteries. Even though choices had reflected for most people in the direction predicted by prospect theory (Kahneman & Tversky, 1979), perceived-risk attitudes were quite stable across the two domains. 76% of all participants were either perceived-risk averse or perceived risk neutral for both sets of lotteries. Only one person with a negative perceived-risk attitude in the gain domain displayed perceived-risk seeking in the loss domain.

In a follow-up study, Weber and Milliman (1997) looked at the stability of three different definitions of risk attitude across decisions in the gain vs. the loss domain. Using commuter trains with risky arrival times as choice alternatives, Weber and Milliman asked respondents to choose between pairs of trains that had either only positive arrival times (faster than or equal to the status quo) or only negative arrival times (slower than or equal to the status quo). The same pairs of trains were also shown again at a later point in time with the request to judge which of those two trains was the riskier one. In addition, respondents answered questions that allowed for the construction of their utility functions for faster and slower commuting time as well as their marginal value functions for gains vs. losses in commuting time. Choices again reflected from pairs with faster arrival times (gains) to pairs with slower arrival times (losses), though in the direction opposite from the pattern commonly observed for monetary gambles. Consistent with this difference in choice pattern, there was little consistency in people's risk attitude across the gain and the loss domain when risk attitude was defined by the shape of an individual's utility functions for gains and losses in commuting time. Only 22% of commuters had consistent utility-function risk attitudes in both domains, about evenly divided between risk seeking (convex utility functions) and risk aversion (concave utility functions). Consistency improved some, but not dramatically, to 37% when differences in marginal value for gains vs. losses were factored out, and people's relative risk attitudes for gains vs. losses in commuting time were compared. However, consistency jumped to 87% when differences in the perceptions of the riskiness of gains vs. losses in commuting time were factored out, in other words, when perceived-risk attitudes for gains vs. losses were compared. About two-thirds of the individuals who showed a consistent perceived-risk attitude in the gain and the loss domain were consistently risk averse, i.e., choosing trains that they perceived to be less risky; the other third was consistently perceived-risk seeking, i.e., preferring trains that they perceived to be riskier (expected values were approximately the same in each pair).

In a second study, Weber and Milliman (1997) tested MBA students with stock market experience in two sessions of an investment game where they had to pick one of six stocks (described by standard financial indicators) in each of ten investment periods. In one session of the game, participants lost money in most of the ten periods, whereas in the other session (with order of sessions, of course, counterbalanced) they made money in most of the ten periods. Choice patterns were quite different for the two sessions (with more switching in the failure session), as were the ratings of the riskiness of the six stocks, as mentioned earlier. When controlling for those changes in the perceived riskiness of the stocks from the successful to the unsuccessful investment session, perceived-risk attitudes again showed remarkable consistency across sessions. Overall, 83% of the investors had the same perceived-risk attitude in both sessions, with three-quarters of them consistently investing in stocks that they perceived to be less risky and one-quarter consistently investing in stocks that they perceived to be more risky.

Finally, Weber and Hsee (in press) obtained risk judgments as well as minimum buying prices for risky options in both the money domain (investments) and the time domain (time management plans that may save or cost working hours per week). Respondents lived in one of four countries: the United States, Germany, the People's Republic of China, or Poland. While both risk judgments and buying prices showed significant between-country differences (with Americans perceiving the most risk and the Chinese the least risk in both domains, and the Chinese paying the highest prices for the financial options and the Germans the highest prices for the time options), after differences in risk perception were factored out of the choices of every respondent, the proportion of individuals who were perceived-risk averse or perceived-risk seeking were not significantly different in either the four countries or the two domains (money vs. time). Around 70% of respondents tended to pay more for options perceived to be less risky (i.e., were perceived-risk averse), whereas the other 30% tended to pay more for those options perceived to be riskier (i.e., were perceived-risk seeking). When perceived-risk attitudes of the same individual in the two domains were compared, 76% of respondents showed the same perceived-risk attitude in this within-subject comparison.

5. SUMMARY AND IMPLICATIONS

Risk perception appears to be a useful construct in all three applications examined in this chapter. Deviations of subjective risk perception from objective definitions of risk (e.g., risk equals variance) are firmly established, as are interpretable individual and situational differences in risk perception. Many measures of subjective risk exist in the literature and researchers continue their efforts to find the measure that best describes absolute and relative risk judgments as well as satisfying other theoretical restrictions.

Individual, situational, and domain differences in risk perceptions do not mean, however, that a single model of subjective risk will be insufficient. As I showed, the CER model has been able to describe the perception of the riskiness of financial, health and safety, and lifestyle choices, and captured domain and respondent similarities (in the functional form of the integration of probability and outcome information) as well as domain and individual differences (in the weighting of different types of information) by differences in its parameter values. This makes risk judgments qualitatively different from judgments of "orthosonority," where each respondent provided judgments in an orderly fashion without any consistency in information weighting or integration across respondents.

The risk perceptions of ordinary citizens and consumers are becoming an ever more powerful factor in the economic and political decisions made in the United States. Whether they "make sense" or approximate nonsensical "orthosonority," they need to be measured to track trends, make comparisons between segments of the population of the United States or cross-national comparisons, and to assess the impact of communications, actions, and interventions.

In addition, perceived risk also appears to be a useful intervening construct. Similar to other subjective self-report measures such as, for example, consumer confidence, it may help to predict subsequent behavior. Current work on generalized risk-return models implies that, as choice patterns change, so does the definition of risk. If so, then an individual's or a group's attitude towards risk may be a constant, even though behavior changes. If choice can differ either because of differences in perceived risk or because of differences in risk attitude, both cannot be simultaneously inferred from choice. In a series of studies that assessed people's perception of the subjective risk of risky options independently from choice, the overwhelming result was that risk perception tended to change alongside with choices and that perceived-risk attitude (either seeking or avoiding options perceived to be riskier) was remarkably constant for a given individual across situations or domains. In line with traditional economic wisdom, the majority risk attitude (between 70% to 80% of the respondents in different studies) was that of perceived-risk aversion.

A final topic worthy of some consideration is the relationship between the conceptualization of risky choice presented in this chapter and its conceptualization in a currently very popular class of models that model risky choice as the maximization of rank- and sign-dependent utility. In this chapter, risky choice was conceptualized as a perceived risk-return tradeoff, with perceived risk as a variable open to individual and situational differences and perceived-risk attitude as determining the desirability of perceived risk in the tradeoff. People can make different choices between a given pair of risky options either because they differ in their perception of the options' riskiness or because they differ in their perceived-risk attitudes (see Mellers, Schwartz, & Weber, this volume). In rank- and sign-dependent utility conceptualizations of risky choice (e.g., Luce & Fishburn, 1991; Tversky & Kahneman, 1992; for a review see Weber & Kirsner, 1996), people can make different choices either because they have different utilities for the outcomes of the choice alternatives or because they differ in the rank- and sign-dependent redistribution of decision weights assigned to those outcomes. The correspondence between individual or situational differences in the components of these two frameworks is essentially an empirical question, and unfortunately no empirical comparison has yet been conducted. One may, however, speculate about the outcome of such a comparison. In a series of studies of rank-dependent utility theory (a special case of a class of models Birnbaum refers to as configural weight models, where the weight given to a particular outcome depends on the configuration of other possible outcomes), Birnbaum (e.g., Birnbaum et al., 1992) has reported excellent model fits with the use of an identity function for the mapping of objective dollar outcomes into the utility function component of his rank-dependent models. This suggests that the utility transformation of outcomes in rank-dependent models is secondary to their success in accounting for people's deviations from an expected value evaluation of risky prospects. Nonlinearity in the utility function of rank- and sign-dependent models may map into nonlinearity in the (riskless) marginal value functions of (positive and negative) outcomes in a particular outcome domain, but probably has little to do with either risk perceptions or risk attitudes. I would suspect that, similar to expected utility models, rank-dependent utility models contain both effects of risk perception and effects of perceived-risk attitudes in their outcome weighting function. The "pessimism" of a particular rank-dependent weighting scheme that assigned disproportionate weights to low outcomes, for example, may be the result (a) of choices based on an equally pessimistic evaluation of the riskiness of choice alternatives paired with a relatively neutral attitude towards perceived risk or (b) of choices based on a relatively rank-neutral evaluation of the riskiness of choice alternatives paired with a negative or aversive attitude towards downside risk. Risk perception and perceived-risk attitudes will be confounded in any utility model estimated exclusively on the basis of choice data. To obtain a psychological interpretation of either utility functions or weighting functions, it is therefore advisable to obtain and model perceived risk judgments in addition to choices.