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Chapter 1

The risk construct

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CONTENTS

Fischhoff (1985, p. 89) observes that "People disagree more about what risk is than about how large it is." Such statements are common among risk experts. If we were to read 10 different articles or books about risk, we should not be surprised to see risk described in 10 different ways. How, then, can we achieve an understanding of risk-taking behavior when risk, the focal construct, appears to

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be so slippery? Despite ambiguity about what risk is, research on risk taking has been demonstrably productive. Nevertheless, as numerous risk scholars have maintained (e.g. Weber, 1988), it seems that even more progress would occur if there were greater understanding and consensus about the risk construct itself.

It is conceivable that individuals who use the word risk in different ways are referring to entities that have no connection with each other. Consider, say, a trustee who reports that she takes "risk" into account when building clients' stock portfolios and a safety researcher who claims that "risk seeking" explains the behavior of the teenage drivers he studies. Although they are using the same expression, the trustee and the researcher *could* have completely unrelated concepts in mind. We doubt that such is often the case, however. Our thesis is that, instead, disagreements about the risk construct typically are more apparent than real. That is, we submit that a single construct underlies most risk discussions.

If the proposed thesis is correct, why does it *appear* that there is so little consensus about what constitutes risk? There seem to be three explanations. First, as we will argue, although there is indeed a widely accepted implicit risk construct, that construct has several distinct elements. Unfortunately, in practice people often refer to individual risk elements as the entire risk construct, as simply "risk." Second, risk manifests itself in different ways in different situations. The superficial differences in those situations make it hard to recognize that they have an important common denominator—risk. Finally, the illusion of disagreement arises from the fact that, as we will demonstrate, the risk in a given situation is inherently subjective, varying from one individual to the next.

Our aim has been to identify the basic risk concept through an analysis of how the risk expression is used across a variety of circumstances. The presumption is that commonalities and contrasts in such usage should reveal what is essential to the idea of risk. There have been numerous other analyses of the risk concept, each of which offers valuable insights, for instance, those by Fischhoff, Watson, and Hope (1984), Hansson (1989), Hertz and Thomas (1983, Chapter 1), MacCrimmon and Wehrung (1986, Chapter 1), Mehr (1977), and Vlek and Stallen (1980). Our analysis differs from the previous ones in several respects. The major difference, however, is that we have tried to take a broader perspective. Each of the prior analyses emphasized risk in a particular context, for example, public hazards or insurance. We have sought what is common *across* contexts. In this endeavor we are indebted to the earlier analyses, as they have helped illuminate what appears to be universal about risk.

We have found substantial consistency in diverse treatments of risk, and argue that this consistency rests on what can be legitimately called the risk construct. However, like others, we have also observed considerable variety in how risk is characterized. These variations highlight distinctions that, although they do not challenge the risk construct itself, are nevertheless significant in their own right. Each of these distinctions is acknowledged in some areas of risk scholarship though they apparently go unrecognized in others. Thus, the present analysis should be useful to risk specialists not only because it clarifies the focal construct, but also because it brings attention to aspects of risk those specialists might otherwise neglect.

The plan of the chapter is as follows. The first section addresses the role of risk in human activities: What *kind* of thing is risk? Why is it important? We will propose that the risk construct entails three critical elements: loss, the significance of loss, and the uncertainty associated with loss. Thus, the three succeeding sections respectively explore these elements in depth. The last major section of the chapter examines the notion of overall risk.

THE ROLE OF THE RISK CONSTRUCT

The topic of risk often arises, implicitly or explicitly, in the form of a question: "How much risk is acceptable?" For instance, when deliberating pollution control measures, we might ask: "Can we tolerate that much sulphur in our air?" Or when considering our personal finances, we might worry: "Is it really wise for us to reject this bid on our house, hoping that something better will come along?" Several authors have noted that, in isolation, there is no such thing as acceptable risk; because of its very nature, risk should always be rejected (e.g. Kaplan & Garrick, 1981; Slovic, 1987). This observation highlights two related facts. First, risk-taking problems are actually special kinds of decision problems. Second, these dilemmas are "problems" mainly because the relevant options entail other, complicating considerations besides risk.

In a decision problem a person selects an action with the intention of producing outcomes at least as satisfactory as those that would result from any other available option (cf. Yates, 1990, Chapter 1). When this goal is actually achieved, we say that the decision succeeds; otherwise, it fails. Thus, a "decision problem" is the challenge of making a successful decision. In risk-taking situations, risk is one—but only one—significant aspect of the available options. Accordingly, from the decision maker's perspective, the worth of such an alternative can be characterized as

$$\text{Worth} = f(\text{Risk, Other considerations}),$$

where the chance of an option being selected increases with its "worth." If risk is intrinsically repugnant, then the reason an alternative that contains risk is not rejected out of hand is that "Other considerations" must include attractive benefits, as well as perhaps additional negative features. For instance, a pollution control proposal that tolerates high sulphur emissions (significant disease risks) is taken seriously mainly because it also has advantages like low fuel costs and high employment rates for coal miners. So, in summary, the role of

risk is that of one kind of negative feature that might characterize a decision alternative. Some might question the critical assumption that risk is indeed negative, something to be avoided. We will address this issue at the very end of our discussion of overall risk. We now examine what appear to be the essential elements of the risk construct.

THE ELEMENTS OF RISK

Dictionary definitions describe the meanings of words that are accepted by general consensus, or at least consensus among the language experts charged with establishing standard usage. Thus, such a definition seems a reasonable place to begin our analysis of the risk construct. A common dictionary definition of risk is "the possibility of loss."

Risk as loss possibility qualifies for the role prescribed in the previous section; the possibility of loss should certainly make a prospective action less appealing. Moreover, few of us would say that this definition conflicts with or is unrelated to what we mean when we use the word "risk." Indeed, a close examination of the many superficially different risk definitions and measures that appear throughout the literature leads to a similar conclusion. For instance, in their monograph on technological hazards, Fischhoff *et al.* (1981, p. 2) define risk as the "existence of threats" to life or health. In medicine and epidemiology, risk is the chance of some adverse outcome, such as death or the contraction of a particular disease (e.g. Kleinbaum, Kupper, & Morgenstern, 1982). And in the economic and business literature, opportunities whose returns are not guaranteed are commonly described as "risks" (e.g. Camerer & Kunreuther, 1989).

Unfortunately, risk as the possibility of loss falls short on essential detail. This definition does not elaborate what is meant by the components of the risk construct, that is, possibility and loss. And, although "the possibility *of* loss" is suggestive on the point, the definition is imprecise about how possibility and loss combine with each other to determine risk. A consistent but more refined characterization of risk seems to be required. We propose the following refinement: The critical elements of the risk construct are (a) potential losses, (b) the significance of those losses, and (c) the uncertainty of those losses. Further, these elements degrade an alternative's worth interactively (see Crouch & Wilson, 1982, Chapter 2). Thus, the effect of increasing the chance of a possible financial disaster on the riskiness—and hence unattractiveness—of a business venture depends on the size of the disaster. For instance, the risk implications of increasing the chance of a liability from 1% to 5% would be much greater if the potential liability were \$2 000 000 rather than \$2000.

In the succeeding sections, we explore the above risk elements and how they jointly determine overall risk. However, two important observations arise immediately from the present conception of risk. The first is that many measures

and operational definitions of risk focus on only one of the risk elements. Such is the case, for example, when epidemiologists say that the risk of cancer in some population is 15 in 100 000, an indication of the uncertainty associated with a particular loss. This does not necessarily conflict with measures that focus on other risk constituents, say, an insurer's indication that providing coverage on a \$250 000 house is riskier than providing coverage on one that costs only \$100 000. These alternative measures are simply indicators of distinct parts of the same entity.

Our second observation is that, strictly speaking, risk is not an objective feature of a decision alternative itself. Instead, it represents an interaction between the alternative and the risk taker. In other words, risk is an inherently subjective construct. This is because, as we shall see, what is considered a loss is peculiar to the person concerned, and so is the significance of that loss and its chance of occurring. For instance, although being admitted to University X would be an honor for one student, having no recourse but to attend the same school would be a disappointment for another student.

LOSSES

A perspective

Most risk-taking situations involve alternatives that, if selected, would eventually produce not just one outcome that matters to the decision maker, but a host of them. It is useful to keep this fact in mind as we further review the risk concept. As an example, imagine an individual who is trying to choose among several job offers. For concreteness, we will call her "Jane Smith." Each of her potential jobs could be described with an "outcome matrix" like the one for Job A displayed in Figure 1.1. There we see that there are numerous categories of outcomes that are pertinent to Jane Smith's satisfaction and which might be realized at a given point during her tenure on Job A, such as her salary, her assigned location, and so on. We also see that various specific outcomes might really occur within those categories, for instance, \$45 000, \$50 000, . . . , for salary, and Chicago, Detroit, . . . , for location. The particular matrix that is shown applies to the circumstances five years into the future. Since our job seeker is actually concerned about an entire career, we recognize that the present characterization is a gross simplification. As implied by the outlines of additional outcome matrices shown in Figure 1.1, for every other time period there is another collection of outcomes that are significant to the person involved. Despite its impoverishment, the current view does serve our purposes.

Jane Smith's eventual satisfaction with Job A would depend on which outcomes in the various categories are actually realized, an "eventual reality." Such an eventual reality can be seen as a collection or vector of outcomes (cf.

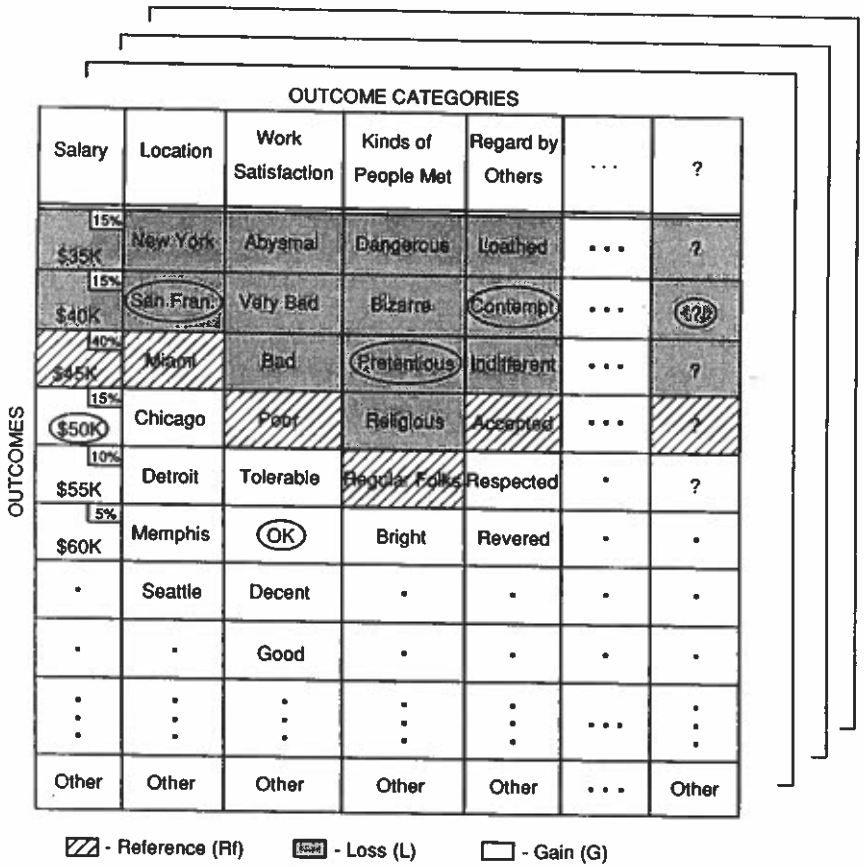

Figure 1.1. An illustrative outcome matrix: Job A for Jane Smith, five years hence. Outcomes that actually would be experienced are circled.

Kaplan & Garrick, 1981). For the sake of argument, imagine that the outcomes that are circled in Figure 1.1 are those that actually happen. Then the eventual reality would be

> ($50 000 salary (G), San Francisco location (L), OK work satisfaction (G), largely pretentious acquaintances (L), held in contempt (L),...)

where the Gs and Ls denote gains and losses, respectively, as defined below. As we shall see, outcome matrices facilitate the discussion of losses as well as other risk issues.

References

When we experience a loss, we are deprived of an outcome we already possessed or might have acquired; further, we are left with an outcome that is less appealing than the one that was taken away or precluded. Thus, implicit in the loss concept is the notion of a *reference outcome*, or simply a *reference* (cf. Kahneman & Tversky, 1979). This is the focal outcome that is taken away or denied. Any outcome that is preferred to the reference is a gain; one that is less preferred is a loss. As suggested in Figure 1.1, Jane Smith's salary reference (Rf) is $45 000. Any salary lower than $45 000 is a loss (L), and any higher salary, such as the $50 000 she actually earns, is a gain (G). In terms of location, we see that the reference outcome is Miami, Jane Smith's present location, and that her actual location in Job A, San Francisco, is a loss.

Our example implicates two classes of reference outcomes, *status quo references* and *non-status quo references*. A status quo reference is whatever a person presently has, for instance, Jane Smith's current residence in Miami. Being a student, Jane Smith earns nothing. This implies that her $45 000 salary reference is clearly a non-status quo reference. The example also brings attention to the inherent subjectivity of reference outcomes and hence losses. Given her $45 000 reference, Jane Smith's actual salary of $50 000 is a gain. But if that reference had been $55 000, her real earnings would be regarded as a loss.

How is it determined what is a reference outcome and, by implication, what is considered a loss? In various practical situations, practitioners simply declare reference outcomes by fiat, so they can get on with their work. For instance, in finance, the implicit reference is sometimes the investor's current wealth. On other occasions, it is the amount of money the investor might have earned in the most conservative investments, such as bank deposits. We often see "objective" risk measures being constructed from these standard reference outcomes. Such objectively defined references, losses, and risk measures have been retained over the years because the analyses that rely on them have been considered beneficial. For example, financial analyses that use the kinds of objective risk measures described later in the chapter are thought to have facilitated the assembling of more profitable investment portfolios. Most frequently, however, it seems that references are adopted by individuals for various psychological reasons. Hence, most of them form the foundations of subjective rather than objective risk. Examples include the following:

Personal average references: These are outcomes representative of those an individual has experienced most often in the past and therefore reasonably might expect in the future. They are sometimes known as *adaptation level references*. Notice in Figure 1.1 that "Poor" is the work satisfaction reference for Jane Smith. This might be a personal average reference, because "Poor" is, sadly, the level of work satisfaction Jane Smith usually experienced in her previous jobs.

Situational average references: These references are similar to personal average references. The difference is that the average applies to the situation rather than the given individual. For instance, since Jane Smith has never held Job A, she has no basis for establishing a personal average for the kinds of people encountered on that job. However, friends who have occupied the position might tell her that the typical person encountered is "a regular guy," hence her reference of "regular folks." Situational average references are commonly employed in the risk measures used in finance (e.g. expected returns on investment).

Social expectation references: These are outcomes that people who are important to an individual indicate they expect that person to achieve. Perhaps Jane Smith's salary reference of $45 000 is such a social expectation reference, induced by her parents' ideals.

Target references: A target or *aspiration level* (Lopes, 1987) is an outcome a person actively works to attain, say, holding the number of defective parts produced by a manufacturing process to no more than 0.5%. Some targets are established solely by individuals for themselves. In other situations, targets are set by other people. For instance, it is not unusual for corporate managers to impose profitability targets on the division heads who answer to them (cf. Payne, Laughhunn, & Crum, 1980).

Best-possible references: This kind of reference is the most attractive outcome that is possible in the given situation. An example would be a grade of "A-" in a certain course, established as a reference because the professor says he cannot imagine any student deserving anything better than that.

Regret references: A regret reference is the outcome an individual would have attained—or at least the outcome the person *thinks* he or she would have attained—had a competing alternative been selected. For instance, suppose Jane Smith thinks that, had she chosen Job B instead of Job A, other people would regard her with acceptance. This might account for why "Accepted" is Ms Smith's reference for the outcome category of "Regard by Others" in Figure 1.1. A loss implied by a comparison against competing options is sometimes said to induce *regret* (cf. Bell, 1982; Loomes & Sugden, 1982), hence the present terminology. (Also see Dowling, 1986, on the related concept of "choice risk.")

Loss multiplicity

The multiplicity of potential outcome categories—and thus classes of losses—that are possible in risk-taking situations is recognized in several areas of risk research. Consumer behavior is an example where the idea has special prominence. Bauer (1960) was among the first to suggest that risk is a major determinant of whether a consumer buys or rejects a given product; the greater the perceived risk, the less likely the purchase. Many of us experience apprehension—sometimes bordering on terror—when we contemplate large purchases

like cars, especially used cars. Bauer attributes these feelings to the risk inherent to those transactions. Research subsequent to Bauer's paper has shown that the risk that affects consumer purchasing comes in several varieties, which correspond to various distinct kinds of losses a person might suffer as a result of buying a given product. The risk taxonomy developed by Jacoby and Kaplan (1972; Kaplan, Szybillo, & Jacoby, 1974) is the one that is mentioned most often in research on consumer choice. According to that system, the losses a prospective purchase might produce fall into the following categories:

Financial loss	The consumer loses money, either because the product will not work at all (and presumably must be replaced), because it costs a lot to keep it in good condition, or because an equivalent or better product is available at less cost.
Performance loss	There is something wrong with the product or it does not work properly.
Physical loss	The product is unsafe, that is, harmful to one's health.
Psychological loss	The product disagrees with the buyer's self-image or self-concept, the way the buyer thinks about himself or herself.
Social loss	The product adversely affects the way others think about the buyer.
Time loss	The product wastes the buyer's time and causes inconvenience because it must be adjusted, repaired, or replaced (from Roselius, 1971).

Bearden and Mason's (1978) study of consumers' inclinations to buy or reject generic prescription drugs is a concrete illustration of how this conception of distinct loss categories has been used. These investigators found that concerns about performance, financial savings, and safety were among those that determined individuals' drug preferences. Carroll, Siridhara, and Fincham (1986) performed a similar analysis, but from the perspective of pharmacists who might recommend either generic or brand-name medicines. They discovered that concerns about the risks of generics—specifically, how well those drugs might perform—had significant effects on pharmacists' willingness to substitute generic for brand-name products. Such findings are valuable because they allow us to focus attention on those aspects of a risky situation that have major effects on people's behavior and not waste time on those that do not.

Two important ideas are implicit in the recognition of loss multiplicity. The first is that, all other things being equivalent, the greater the number of distinct losses that are incurred, the worse off is the risk taker. For instance, referring back to Figure 1.1, we see that Jane Smith suffered losses in three of the five outcome categories that were explicitly acknowledged—Location, Kinds of People Met, and Regard by Others. Things clearly would have been worse had,

say, work satisfaction been a loss, too. The second idea is related but distinct. Alternatives differ in the numbers of significant outcome categories they entail, for instance, carpets, which are simple, versus computing systems, which are much more complicated. Again, all else being the same, we might expect that the potential for consequential losses—and hence risk—increases as the number of significant categories increases, for example, greater risk for computing systems than for carpets.

SIGNIFICANCE

Risk researchers and laypersons assume that, the more significant the potential losses in a situation, the greater the implied risk. Subjectivity affects this role of loss significance in two ways. We have already seen that reference outcomes can easily differ from one person to the next. Thus, an outcome that is a loss for one individual might well be a gain for another. But even if two individuals both consider the same outcomes to be losses, there is still room for differences in the significance of those outcomes, differences that have bearing on risk. Consider the Location category in Figure 1.1. Imagine a second job seeker besides Jane Smith, "Mary Jones." Like Ms Smith, Mary Jones also feels that locations in San Francisco and New York are losses. But, whereas Jane Smith regards New York as worse than San Francisco, Mary Jones feels the opposite. This could affect the riskiness of accepting Job A. For example, suppose that an assignment to San Francisco is more probable than one to New York. Then, by some conceptions of risk (see the section below on overall risk), accepting Job A would be riskier for Mary Jones than for Jane Smith.

Often potential outcomes are quantified, say, salaries or concentrations of pollutants. Typically, greater magnitudes are preferred to lesser ones or vice versa. For instance, we all prefer making more money to less, but we desire the smallest possible concentrations of pollutants in the air. On the other hand, there also exist quantified outcomes for which some intermediate amount is most preferred, amounts of fluoride in drinking water being an example. For any given quantified outcome, although loss significance is greatest for either maximum, minimum, or intermediate amounts, there can still exist important distinctions in loss significance from person to person.

As an illustration, consider Figure 1.2, which shows value functions for monetary losses for three different individuals, all of whom, of course, prefer having more money to less. Person A's linear value function says that the rate of change in the significance of losing money is constant. For instance, as depicted, losing an additional $10 always reduces Person A's satisfaction by the same amount, denoted D. In contrast, Person B's convex value function indicates diminishing marginal significance as loss magnitude increases. This implies, as suggested in the figure, that losing an additional $10 matters less to Person B

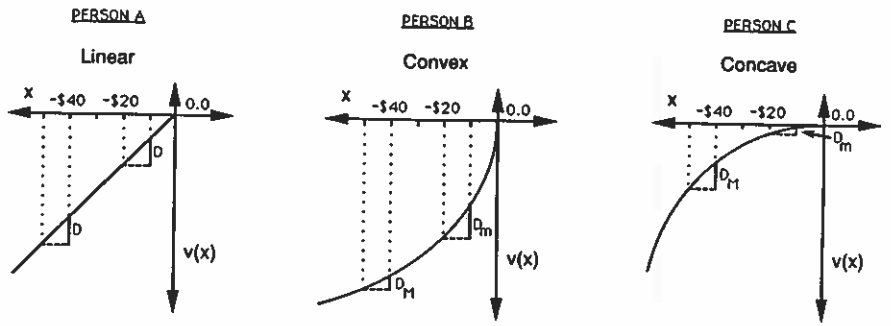

Figure 1.2. Alternative value functions for losses.

when he has already lost a lot rather than a little, D_M vs D_m. Person C's concave value function describes the opposite pattern of loss responses. These different value functions for losses imply corresponding differences in how Persons A, B, and C would appraise the riskiness of alternatives that might result in financial losses. There are also theories of risk taking, such as expected utility theory (see Chapter 2, by Neumann & Politser) and prospect theory (Kahneman & Tversky, 1979), for which these distinctions imply either risk-seeking, risk-aversive, or risk-neutral behavior, in senses that will be defined below.

UNCERTAINTY

Every conception of risk requires that there must be uncertainty about the outcomes of prospective actions; if the outcomes are guaranteed, there is no risk. However, various risk conceptions differ in precisely *how* uncertainty affects risk. At least four roles for uncertainty are commonly discussed, as described presently.

Risk *as* uncertainty

Sometimes risk is said to exist whenever the outcomes of an action are not assured. That is, risk effectively *is* uncertainty. This is implied, for instance, when economists refer to any prospect with unguaranteed returns as a "risk" (e.g. Camerer & Kunreuther, 1989). Note that, in order for this viewpoint to be consistent with the notion of risk as the possibility of loss, the worst potential outcome must be less attractive than the reference. For example, imagine a business deal in which the best that could happen is that one earns $5000 and the worst is a return of $1000. To legitimately say that this deal is risky must mean that the reference is more than $1000.

Risk as uncertainty is the risk conception implicit in many discussions of risk-taking behavior within decision analysis (cf. Keeney & Raiffa, 1976; Winkler, 1972). Consider Gamble G, which captures the essential features of how alternatives are characterized in decision analysis. Gamble G promises a prize of \$10 if a coin toss results in a head, and nothing otherwise. The expected value of a gamble is simply the sum of all the potential payoffs, each multiplied by its probability. It can be shown that the expected value is the mean payoff a gamble would yield over the long run. So, assuming a balanced coin, the expected value of Gamble G is

$$EV(G) = (1/2)(\$10) + (1/2)(\$0) = \$5.$$

If Gamble *G* were played hundreds of times, the average outcome of these plays would be very close to \$5. Suppose an individual is given a choice between a gift of Gamble *G* and a gift of a \$5 bill. The following terminological conventions are typically applied: (a) a preference for Gamble *G* is described as "risk seeking"; (b) indifference between Gamble *G* and the \$5 bill is called "risk neutrality"; and (c) a preference for the \$5 bill is termed "risk aversion."

More generally, risk seeking is evidenced by a preference for an uncertain prospect over a sure thing equivalent to the expected value of that prospect; indifference between those alternatives implies risk neutrality; and preference for the sure thing indicates risk aversion. As far as long-run considerations are concerned, the alternatives in such comparisons are indistinguishable. The above conventions imply that one interpretation of the "risk" that might be avoided or sought in situations like that described is simply the uncertainty about the payoff from any single implementation of the decision maker's choice.

Uncertainty about loss categories

Figure 1.1 suggests that there exist other categories besides those explicitly listed but which nevertheless are capable of affecting Jane Smith's satisfaction with Job A. The blank spaces and question marks highlight an important reality. Decision makers typically are unable to anticipate every significant outcome category. For instance, it might well turn out that, if Jane Smith took Job A, the quality of clerical support would be a major source of comfort or grief, although it never crosses her mind when she is trying to decide whether to accept the position. Generalizing, situations differ in the extent to which potential outcome categories—and therefore possible losses—are apparent. The riskiness of those situations increases with the uncertainty about what the categories of losses might be.

Sometimes the locus of uncertainty about loss categories resides in the alternatives themselves. Take the case of public hazards. Laypersons, at least, consider the newness of a technology (e.g. genetic engineering vs coal mining) to be a significant contributor to its riskiness (Slovic, Fischhoff, & Lichtenstein, 1985). In effect, a new technology is risky partly because no one knows what kinds of losses it might produce.

In other circumstances, the uncertainty about loss categories is a reflection of the risk taker's naïveté. Consider the activities of professional risk analysts in business and hazard management (cf. Hertz & Thomas, 1983). A major task of such analysts is unveiling the myriad ways a proposed business venture or public project conceivably could turn out badly. The intent of these exercises is to prevent clients from being "blindsided," that is, experiencing losses whose possibility never even occurred to them. The very surprisingness of these losses makes them all the more devastating. Blindsiding is not confined to business and public affairs; examples from personal situations abound. Take the case of AIDS (Acquired Immune Deficiency Syndrome). Not in their wildest dreams did it cross the minds of AIDS victims in the early 1980s that an incurable, fatal disease was among the hazards of their sexual or drug-taking activities or their receiving blood transfusions in the hospital.

Uncertainty about which losses will occur

Even if it is recognized that losses in a given category *can* occur, there is still uncertainty about *whether* those losses will occur. We assume that, short of loss being guaranteed, the greater the chance of a loss happening, the greater the risk. For instance, suppose that in Job A the chance of Jane Smith being assigned to one of her "loss" cities, San Francisco or New York, is 15%. If the corresponding chance for Job B is only 10%, then Job B is less risky, in that respect, at least.

As noted earlier, loss chances are the standard way of characterizing risk in medicine and epidemiology, for example, with disease mortality rates. Accounting is another arena in which risk is routinely described as loss chances. The end result of an audit performed on a firm's financial statements is a written opinion about whether those statements fairly present what they purport to present, for instance, that stated account balances and inventories do not differ significantly or "materially" from what is claimed. Such opinions are essential for the interests of several parties, including a firm's potential investors. Auditors recognize that their opinions can be erroneous. That is, the auditor might attest that a firm's statements are fair reports when they actually are not, or vice versa. The chance of either error occurring is called *overall audit risk*. Reporting an inappropriate opinion is disastrous for an auditor's reputation, resulting in the loss of future business. More immediately, inappropriate opinions expose the auditor to damaging lawsuits. Accordingly, auditors seek to limit overall audit risk to no more than 5% (Sullivan et al., 1985).

There is an additional important form of uncertainty associated with loss chances. In Figure 1.1, observe that no specific cities are listed underneath Seattle in the Location category. Instead, other potential locations are subsumed under the heading "Other." Some probability might be assigned to the

Other grouping. However, that assignment would not capture the uncertainty embodied in the fact that the constituents in the Other group are not identified explicitly. For instance, suppose that the other possible assignment locations are actually St. Louis, New Orleans, and Salt Lake City. Most of us would say that leaving these cities obscured within an "Other" category constitutes a variety of uncertainty in and of itself. That uncertainty, which contributes to riskiness, is analogous to, but different from, that associated with unspecified loss categories.

Levels of uncertainty

Imagine Surgical Procedure A, which has failed in 200 out of 1000 previous attempts, and Surgical Procedure B, which has failed in one of its total of 5 trials. These procedures are being contemplated for patient "Ronald Davis." Most people would say that the chance of failure for Mr Davis is the same for both procedures: 20%. At the same time, however, they would say that Procedure B is riskier. This example implicates the importance of levels of uncertainty in risk characterizations.

In the present context, the expression "levels of uncertainty" pertains to the firmness of the basis on which loss chances are designated. In the case of Procedure A, the basis is secure, but it is considerably less so for Procedure B. Decision researchers acknowledge a continuum of uncertainty levels, as noted in Figure 1.3. At one extreme, termed "ignorance" by Luce and Raiffa (1957), there is no basis whatsoever for assigning loss chances. At the other extreme of the solid portion of the continuum, the chances of those outcomes are well established by informed consensus. These chances are sometimes described as *canonical* or *objective probabilities*, and in some circumstances are also known as *actuarial* or *aleatory probabilities*. A good example is provided by American legal trials. Thirteen jurors might hear all the evidence in a case. However, only twelve of those individuals actually participate in the jury deliberations and make a decision; one of the original thirteen jurors is randomly selected by lot to be excused. All of us would agree that the chance of any one of the jurors being dismissed is 1/13. Interestingly, Luce and Raiffa referred to the level of uncertainty entailed in this example as merely "risk." To avoid confusion, we will call it "objectivity." Between ignorance and objectivity are various states of what Ellsberg (1961) has described as *ambiguity*.

Uncertainty levels clearly affect people's behavior (e.g. Becker & Brownson,

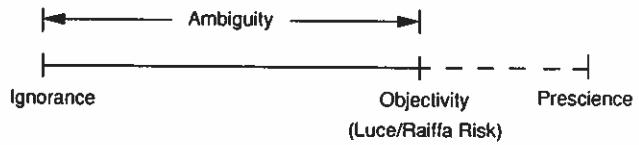

Figure 1.3. Levels of uncertainty.

1964; Yates & Zukowski, 1976). In an illustrative study, Curley, Eraker, and Yates (1984) asked medical patients and hospital visitors about a treatment for stiffness and pain. They found that large numbers of the respondents who would accept the treatment when its chances of success were described as "5 in 10" rejected it when those chances were characterized as "somewhere between 3 in 10 and 7 in 10" (pp. 505–506). Although ambiguity is generally avoided, it is sometimes sought, for instance, when the odds of realizing a gain are remote (Curley & Yates, 1985).

Regardless of what people actually do, there is not general agreement among risk specialists about what role, if any, levels of uncertainty should have in a proper characterization of risk, or even in decision making. Some (e.g. Raiffa, 1961) maintain that ambiguity avoidance or ambiguity seeking should be prohibited because such behavior violates expected utility theory, which is often taken as a norm of rationality. However, Hazen (1990) has shown that ambiguity preferences can be reconciled with utility theory for decisions that will be implemented repeatedly.

Relatedly, surveys indicate that business executives make a sharp distinction between "risk taking" and "gambling" (March & Shapira, 1987). These executives contend that, although risk taking is an essential part of their responsibilities, gambling is something they avoid. The executives' conceptions of gambling situations appear to involve at least two things. First, in gambles the probabilities of losses are unacceptably high and the chances of gains are too slight. Second, and more importantly from our perspective, beyond a certain point it is impossible to learn anything to reduce the uncertainty in a gamble.

As an example, consider the card game of blackjack. In principle (though no casino would allow this), a player could use a computer to follow the course of play and calculate the actuarial probabilities of particular cards appearing on every drawing, say, determining that $P(8 \text{ or better}) = 43\%$ for a given situation. This would almost certainly improve the player's winnings, because the player's unaided judgments are virtually guaranteed to differ from the actuarial probabilities. And it can be shown that these unaided judgments should lead to choices that, in the long run, produce worse payoffs. However, by the very nature of random drawings, our computer-assisted player cannot approximate the foresight of a clairvoyant, who would *know* what card would appear on every selection from the deck. Such constraints on knowability are intolerable to executives. Thus, a large part of executive risk handling involves discovering more about what would happen if a given action were taken, for instance, by acquiring intelligence about competitors' abilities to respond to one's initiatives, thereby lessening the risk. If a situation does not permit this kind of discovery, executives avoid that situation if they can. (See also Wehrung *et al.*, 1989.)

Executives' remarks about the reducibility of uncertainty suggest that levels of uncertainty beyond objectivity should be acknowledged. As implied by the dotted line extension to the continuum in Figure 1.3, in some cases it is indeed

possible to do better than merely reaching objectivity. Or perhaps it is more appropriate to say that we can sometimes achieve versions of objectivity that more closely approach "prescience," wherein one literally knows whether a loss is going to occur.

To continue the previous blackjack example, imagine that the situation that resulted in the computed probability $P(8 \text{ or better}) = 43\%$ were repeated 1000 times. We should expect a card with value 8 or better to be drawn on approximately 430 of those occasions. Unfortunately, our blackjack player cannot anticipate *which* of the 1000 occasions would be the ones with the high-value cards. Now, if a clairvoyant were to report probability judgments for each of the 1000 card drawings, the clairvoyant would indicate $P'(8 \text{ or better}) = 100\%$ on precisely those 430 occasions when a card of 8 points or better is drawn and $P'(8 \text{ or better}) = 0\%$ in the remaining 570 instances. Thus, for both the mortal blackjack player and the clairvoyant, the probability assignments are "objective" in that their average values match the actual relative frequency of the focal event. However, the clairvoyant's assignments are clearly superior. Executives cannot hope to always attain the prescience of a clairvoyant, but they see it as eminently reasonable to strive for such perfection.

OVERALL RISK

As noted previously, in various practical and research situations, risk specialists often index risk according to only one of the elements distinguished above, for example, loss probabilities. This does not mean that these individuals believe that such measures fully capture the risk construct. It is just that, for the limited purposes at hand, those measures are sufficient. For instance, mortality rates are adequate risk measures in many public health discussions because it is taken for granted that deaths from the pertinent diseases represent significant losses to society. Moreover, death from one cause is considered the same as death from any other. In our terminology, since there is no variability in the significance of the relevant losses, significance can be ignored and the focus can be placed on uncertainty. (But suppose a disease affects mainly one segment of the population, such as children or drug addicts. This could well change how the situation is regarded.) So, beyond the demands of particular situations, how should various risk elements combine with one another to determine overall risk? Here we describe the major positions that have been taken on the issue, first presenting the underlying concepts and then how they have been expressed in the literature. (Also see Libby & Fishburn, 1977; and Yates, 1990, Chapter 11.)

The core ideas: interaction and independence

At the heart of the combination principles we will consider are two basic ideas. The first applies to how the significance and uncertainty associated with a given

loss jointly affect overall risk. Suppose we let the uncertainty associated with specific Loss_i be represented by its probability, $P(\text{Loss}_i)$. And let us characterize the significance of that loss by the importance index $I(\text{Loss}_i)$. The first risk combination notion is then captured by the following conceptual equation (cf. Crouch & Wilson, 1982, Chapter 2):

$$\text{Risk}_i = P(\text{Loss}_i) \otimes I(\text{Loss}_i) \tag{1.1}$$

We see here that the loss likelihood and loss significance constructs are combined by an operator $\otimes$ that behaves essentially, though not completely, like multiplication.

As indicated earlier in the chapter, the prevailing view is that uncertainty and significance should combine interactively. Thus, constant differences in significance should have little influence on overall risk if the chances of the pertinent losses are small, but should matter a great deal if those chances are substantial. This notion is well captured by a multiplication-like operator. Risk specialists sometimes hedge on fully accepting multiplication operators because there are instances where such operators contradict intuitions about how risk should behave. For instance, Kaplan and Garrick (1981) contend that it is difficult to equate (as implied by Equation 1.1) the riskiness of a low probability-high damage scenario (e.g. breaking a leg) and a high probability-low damage scenario (e.g. getting a cold). In fact, there is some evidence that multiplication operators do not faithfully represent conceptions of how loss chances and significance combine, among laypersons, at least (e.g. Bettman, 1975).

The second idea that recurs in risk combination principles applies to situations in which more than one loss might occur. It says that the effects of those losses are independently cumulative. That is, in contrast to the interactive combination of significance and uncertainty, the contribution to overall risk made by one potential loss is always the same, regardless of the other potential losses that might accompany it. Suppose, as suggested above, that the risk involving potential Loss_1 is denoted by $\text{Risk}(\text{Loss}_1)$, that with potential Loss_2 by $\text{Risk}(\text{Loss}_2)$, and so on. Then the second risk combination concept is embodied in this conceptual equation:

$$\text{Overall Risk} = \text{Risk}(\text{Loss}_1) \oplus \text{Risk}(\text{Loss}_2) \oplus \cdots \tag{1.2}$$

In this equation, the operator $\oplus$ is equivalent to addition. Thus, the overall risk implied by a collection of potential losses is an accumulation of the contributions made by each of them.

Note that the above cumulation principle precludes context effects. That is, the risk contribution of any given potential loss is always the same, no matter what other losses might be combined with it. For instance, the effect of financial risk on the overall riskiness of a prospective action is the same, whether the other potential losses entail physical injury or social embarrassment. Curiously, there seems to have been no controversey over the legitimacy of this notion.

Exactly how the ideas of interaction and independence have been operationalized in risk research and risk management is illustrated in the overall risk representations described below (see also Yates, 1990, Chapter 11, for further discussion, including numerical examples).

Expected loss

Expected loss is the overall risk characterization that captures the previous principles most directly. The expected loss concept is most easily described as it applies to quantified outcomes. Let us denote by L the loss implied by a given outcome X and reference Rf. More explicitly.

$$L = Rf - X, \tag{1.3}$$

Further, let $P(L)$ describe the probability of that loss. Then the expected loss (EL) is simply the sum of all potential losses, each weighted by its probability:

$$EL = \sum P(L)L, \tag{1.4}$$

where the summation is taken over all outcomes considered worse than the reference. As a specific example, consider Jane Smith's six potential salaries in Job A, as described in Figure 1.1. The percentages associated with the respective salaries are their probabilities. It is easy to show that, given Jane Smith's reference salary of \$45 000, the expected loss is \$2250.

A variant of expected loss applies to nonquantified outcomes. It takes the following form:

$$EL = \sum P(L)IR(L), \tag{1.5}$$

where $IR(L)$ is an importance rating assigned to the loss L represented by outcome X, and the summation is taken over all the outcomes considered worse than the reference. Imagine that location is Jane Smith's sole consideration in choosing jobs. Suppose that in Figure 1.1 there are probabilities 0.10 and 0.05 that Ms Smith would be assigned to San Francisco and New York, respectively, her only "loss" locations. Further, suppose that Ms Smith considers it worse to be sent to New York, with loss importance ratings of 6 and 8 attached to San Francisco and New York correspondingly. Then the expected loss would be 1.0 rating points (since $0.10 \times 6 + 0.05 \times 8 = 1.0$). If a similar calculation indicated that the expected loss for another position, Job B, is 1.6 points, then we would say that Job B is the riskier prospect.

Semivariance

One could argue that the risk associated with quantified losses should not increase directly with the magnitude of a loss, but instead should grow more

dramatically. The *below-reference semivariance* (*Semvar*) is a risk measure that captures this requirement:

$$\text{Semvar} = \sum P(L)L^2, \tag{1.6}$$

where the notation is the same as before. In the case of Jane Smith's salary on Job A, the semivariance would be Semvar = 18.75×10^6, in squared dollar units.

Is it reasonable to think that for most people loss significance grows with the square of the loss? Some theories of decision behavior (e.g. Kahneman & Tversky's, 1979, prospect theory) suggest not, that in fact losses generally exhibit diminishing marginal significance. The semivariance can be generalized to allow for this possibility by replacing L^2 in Equation 1.6 by L^a, where a is a constant less than 1.0 (Fishburn, 1977).

Variance

As suggested in our previous discussion of gambles, the expected value (EV), or mean, of any distribution is the sum of all the possible values of the pertinent quantity, each weighted by its probability. Thus, the expected salary for Job A in Figure 1.1 is \$45 250. The expected value is the reference that is used in the most common overall risk measure in finance (Elton & Gruber, 1987), the *variance* (Var):

$$\text{Var} = \sum P(X)(X - EV)^2, \tag{1.7}$$

where the summation is taken over all outcomes X, not just the ones that are losses. Literally, the variance is a measure of how much the outcomes vary or differ from one another. It is straightforward to show that, for Job A salaries, Var = 43.69×10^6, in squared dollars.

The variance is sometimes regarded as a flawed risk measure because it is affected not only by losses, that is, outcomes below the reference, but by gains, too. Thus, two alternatives whose outcome distributions are identical with respect to losses could nevertheless be considered to entail different amounts of risk. So what is the attraction of the variance? Mainly computational convenience and the fact that financial analyses relying on it have proved useful (cf. Levy & Sarnat, 1990, Chapter 9).

Overall risk when there are multiple outcome categories

Implicit in the overall risk characterizations described above is the assumption that there is a single outcome category, for instance, either salary or location. Suppose, as is typically the case, there are several categories. What then? Curiously, the issue is seldom explicitly discussed. But one domain where the

question *has* been addressed is consumer behavior. There the suggested approach is a direct extension of the independent cumulation principle (e.g. Bearden & Mason, 1978). Thus, the generalization of expected loss as in Equation 1.5 would be

$$EL = \sum\sum P(L)IR(L), \tag{1.8}$$

where the second summation extends over all the pertinent outcome categories. For instance, in the case of Jane Smith's Job A, the expression for expected loss would look something like the following

$$EL = (0.15)IR(\$50\,000 - \$35\,000) + (0.15)IR(\$50\,000 - \$35\,000)$$
$$+ P(\text{San Francisco})IR(\text{San Francisco}) + P(\text{New York})IR(\text{New York})$$
$$+ P(\text{Abysmal})IR(\text{Abysmal}) + P(\text{Very Bad})IR(\text{Very Bad}) + P(\text{Bad})IR(\text{Bad})$$
$$+ \cdots$$

An assessment

How well do the present overall risk characterizations capture the essence of what people mean by risk? First of all, the various measures such as expected loss and variance do not necessarily even rank order different situations the same way as to their putative riskiness. That is, although according to expected loss, Alternatives A, B, and C might be ranked $A > B > C$ in riskiness, the ranking might be something like $B > C > A$ according to the variance. Thus, not every one of the overall risk descriptions can be a *perfect* risk representation. Beyond this observation, however, two complaints can be voiced about the very approach embodied in these accounts.

The first complaint lies in the reliance on probabilities for specific outcomes as a representation of uncertainty. The most obvious reason this is problematic is that it neglects other aspects of uncertainty, such as that which arises from not knowing which loss categories are possible in a given situation. It also ignores issues associated with levels of uncertainty and uncertainty reducibility.

The second objection rests on the observation that risk is multidimensional, that it entails numerous distinct elements. Some observers claim that the very idea of overall risk as a quantity is unreasonable. As Kaplan and Garrick (1981) put it: "a single number is not a big enough concept to communicate risk" (p. 25). Such a statement could mean several things. But one of those potential meanings is that overall risk cannot be "measured" in the sense that it might be impossible to consistently map risk appraisals from multiple dimensions onto a single continuum (cf. Roberts, 1979). Whether this is in fact the case is an important issue for future risk scholarship.

Aside from the question of whether risk appraisals *can* be reduced to a single overall risk indicator consistently, why would one want to do so? Has that

aspiration been misguided, as might be inferred from Kaplan and Garrick's (1981) remarks? Probably not. One approach that is sometimes taken in making risky decisions is to trade off risk against benefits (cf. Crouch & Wilson, 1982). This strategy has several appealing features. However, it can be implemented only when risk is characterized by a single index (see also Fischhoff, Watson, & Hope, 1984).

Risk repugnance

We noted at the outset that most treatments of risk assume that risk is inherently repugnant. This assumption is not universal, however. Some analyses seem to allow for indifference or even attraction to risk. Others assert that individuals might have intermediate "target" levels of risk that they find most appealing. Thus, our review of the risk construct would be incomplete without addressing the risk repugnance issue.

Are there circumstances in which the consensus conception of risk does not require that risk be shunned? We propose that the answer to this question is "No." We submit that claims to the contrary only *seem* to be such. Consider arbitrary risky Alternatives A and B, with A riskier than B. In the scheme introduced previously, these options could be represented as

A = (High risk, Other considerations)

B = (Low risk, Other considerations)

To justify the claim that risk is not repugnant, in choosing between some such A and B, a risk taker must choose Alternative A, with the assumption that "*Other considerations*" *are equivalent in both options*. Our thesis is that most—if not all—analyses of risk-taking behavior that appear to reject risk repugnance describe situations where the alternatives in fact differ with respect to "Other considerations." More specifically, there is a confound, whereby the greater risk in high-risk options is offset by positive features missing from their competitors. These analyses also sometimes use special definitions of risk that disagree with the consensus notion of risk

There is too little space available to present detailed arguments for our thesis for all the apparent risk repugnance counterclaims that appear in the literature. However, a few remarks about some of those proposals indicate the nature of the arguments.

Expected utility theory and decision analysis: As noted previously, expected utility theory, which is operationalized in decision analysis (see Chapter 2, by Neumann & Politser, and Chapter 10, by Pitz), allows for risk indifference and risk seeking. But also recall that the latter terms are defined in a restrictive manner in that context. Thus, to reprise our earlier example, an individual is said to be risk seeking if she rejects a $5 bill in favor of Gamble G, which

promises $10 if a balanced coin toss yields heads and nothing otherwise. Notice that the risk characterization implicit in this example demands the kind of confound described above. When the decision maker selects the gamble, implying the possibility of "losing" money relative to the potential gain of $5, she simultaneously acquires the possibility of gaining $10, an outcome that is precluded by accepting the $5 bill.

Thrill seeking: As described by Bromiley and Curley in Chapter 4, and consistent with common experience, there are lots of instances where people seek out and relish high-risk games. The most obvious examples are sports like racing and mountain climbing, in which life itself is imperiled, as well as casino gambling, where financial ruin is not uncommon. Actually, risk seems endemic to almost all games, especially competitive ones. People say the games would be "boring" without the risk of losing. We note that, in all these cases, there is again a confound between the riskiness and benefits of the activities. Individuals are plausibly not attracted by the risk of those activities, in the sense of their loss potential, but instead by the prospect of the exhilaration which accompanies *escaping* from the potential loss. Moreover, such escapes typically are accompanied by significant auxiliary rewards, for example, prestige.

Target risk levels: Wilde's (1982) risk homeostasis theory seems to imply that people do not seek to minimize risk in activities like driving. Instead, the theory appears to say that we seek intermediate target risk levels. However, as argued by Wagenaar in Chapter 9, a more careful analysis of models such as risk homeostasis theory paints a different picture. The risk taker is actually portrayed as trading off risk against benefits (even if only implicitly), where the benefits of alternative actions increase with their riskiness. For instance, along with the greater risk implied by driving fast is the advantage of arriving earlier at one's destination. The results of these subjective risk-benefit analyses only appear to indicate intermediate risk targeting if one ignores the benefits.

Coombs's (1975) portfolio theory explicitly posits intermediate risk targets for monetary gambles, conditional upon constant expected values. Once again, varying risk while holding expected value constant requires the kind of confound between increased risk and potential gains that casts doubt on the legitimacy of the special meaning of "risk seeking" as the term is used in decision analysis. Moreover (see, for example, Lehner, 1980), portfolio theory provides a good description of the risk-taking behavior of very few individuals.

SUMMARY

At first glance, it appears that there is substantial disagreement among risk researchers and others about what should be understood as risk. This disagreement suggests that there might not be a core conception of risk that drives most research that purportedly examines risk-taking behavior. However, a careful analysis of how risk has been discussed and studied implies that there is indeed implicit general agreement about a fundamental conception of risk.

In this consensus view, risk is one among several considerations that can affect the subjective worth of the decision alternatives that people face. At its core, risk is the possibility of loss. There are three essential risk elements: (a) losses, (b) the significance of those losses, and (c) uncertainty associated with those losses. These elements are inherently imprecise and subjective. For instance, losses are defined relative to reference outcomes, which vary according to principles that are not only poorly understood but virtually unstudied. And loss uncertainty can reside not only in the chances of particular losses happening, but also in the very *kinds* of losses that are capable of occurring. The prevailing assumption is that the significance and uncertainty of losses contribute to overall riskiness in an interactive manner, while the risk contributions of several potential losses are implicitly assumed to be independent of one another. However, it is not entirely clear that the various acknowledged elements of risk can be consistently aggregated to form overall risk.

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