Although we are all aware that unfortunate events or accidents are a part of life, there is a tendency for most people to believe that they will not happen to them. Many homeowners in hazard-prone areas do not invest in protective measures to reduce the chances of damage from an earthquake or flood. A surprisingly large number of businesses may not back up their computerized data should their existing system crash or their hardware be destroyed by a fire. Even small investments, such as starter cables, are often purchased only after one experiences a dead battery and is stranded on the road. Decisions about these types of low-probability, high-risk events are particularly problematic. Instead of actually evaluating the probability of the risks, decision makers tend to treat them as all-or-nothing propositions. They vacillate between the idea of “it can’t happen to me” and the sense of inevitability of a reoccurrence when the event actually does happen. The author examines some of the reasons for this phenomenon and then explores strategies for overcoming this tendency, including public-private partnerships.
The following two illustrative examples suggest the challenges that firms and individuals face in deciding on whether to undertake protective measures for their home:

Example 1: Preparing for an Earthquake

The Richter Company is a small industrial firm that has been in business in Northridge California since 1974. When deciding to locate in this part of the country, the owners of the company were aware that the region was earthquake-prone. Still they had not undertaken simple protective measures such as anchoring furniture to keep it from toppling over during an earthquake. They had not backed up their computer data nor arranged for emergency power should an earthquake occur. Furthermore they had not bought earthquake insurance.

The company’s laissez-faire attitude changed after the very severe 1994 Northridge earthquake. Richter was fortunate to suffer only minor damage, but decided to purchase earthquake insurance coverage after the event. Managers anchored their furniture and backed up their computer data. Richter took these actions even though managers were fully aware that seismologists reported that the chances of another earthquake in the area was lower than it was prior to 1994 due to the relief of stress in the fault line running through Northridge.

Example 2: Reducing the Chances of a Theft

Art Safely and Bob Carefree each have two-year leases on apartments in the same building in West Philadelphia. At a recent Crime Watch meeting that both Art and Bob attended, they were given a briefing on the chances of apartment thefts in the area and how the purchase of a dead bolt lock would reduce the likelihood of a break-in. Art is very fearful of crime and decided to purchase the dead bolt; Bob is much less concerned
and decided not to. They both had the same data on the costs of the dead bolt lock and the risks of a theft. The value of the contents of their apartment did not differ appreciably. It appears that Art’s fear of crime was primarily responsible for him investing in the dead bolt lock while Bob’s lack of concern led him not to take this protective action.

Both of these stories suggest that factors not easily quantifiable, such as past experience or fear and anxiety have an important influence on decisions of whether or not to invest in protective measures. Research shows that people often treat these decisions with excessive fear or prudence – and have a hard time carefully evaluating these choices.

This chapter first examines how individuals should decide whether a protective action is worthwhile and in what ways actual choices differ from these predictions. It then focuses on prescriptive measures for improving the decision-making process. Are there ways to encourage consumers and managers to invest in cost-effective protective measures in advance of a low-probability, high consequence event? If it is difficult to provide information or economic incentives so people will voluntarily take these steps, then public-private partnerships may be necessary.

**HOW DECISION MAKERS SHOULD DECIDE ABOUT PROTECTION**

The normative model in the case of protective measures is expected utility theory. Decision makers maximize the expected utility or expected net benefit of the decision. For example, consider the Richter Company’s earthquake policy decision. In deciding whether to purchase earthquake insurance, the Richter Company would consider the
probability of a loss, the cost of protection, the size of the loss without protection and the
duration of the protection. Suppose the annual probability of a severe earthquake is
1/100.1 Suppose the loss to the property and contents of the Richter Company plant from
an earthquake is $900,000 and the firm has the option of purchasing an insurance policy
that would provide them with $600,000 worth of coverage if an earthquake occurred,
reducing its loss to $300,000. Then the Richter Company can compute the expected
benefits of purchasing an insurance policy:

\[
\text{Expected benefits} = \frac{1}{100} (\$900,000) - \frac{1}{100} (\$300,000) = \$6,000
\]

If the insurance premium is less than $6,000, then the cost of the policy is less than the
cost of its expected net benefits to Richter and the firm should purchase coverage.

In 1947 the mathematician-economist team of John von Neumann and Oscar
Morgenstern showed that an individual who satisfies a reasonable set of axioms should
choose the alternative that maximizes her expected utility. If the individual or firm is risk
neutral, as in the above example, then this criterion for behavior is the same as
maximizing expected benefits minus expected costs.
Extending the Analysis

There are several different ways that this initial analysis can be extended to provide a more complete model of the decision making process:

Risk Aversion: If the Richter Company is risk averse, then it will want to pay more than $6,000 for $600,000 worth of earthquake insurance. Risk aversion implies that the extra amount of utility from receiving another $1 decreases as one’s total wealth increases. For example, the extra utility of increasing total wealth from $10,000 to $10,001 is greater than an increase from $10,001 to $10,002. If a person is consistently risk averse, this relationship holds for any wealth level and any fixed increase to one’s wealth. For any given premium, the Richter Company will be more interested in purchasing insurance, as it becomes more risk averse. The level of risk aversion depends upon wealth and the risk aversion function.

Multiperiod Protective Decisions: Now consider the case where the Richter Company could reinforce its plant in Northridge, California, so that it is more earthquake resistant. This mitigation measure involves a one-time, upfront investment, but yields benefits only over many years. The difference here is the time value of money, so an appropriate discount rate must be applied to reflect the opportunity costs of the investment in comparison with the savings from earthquake damage. In other words, one should choose the alternative that maximizes one’s discounted expected utility.²
Mult-attribute Model: The above analyses were all based on a single attribute---money---either expended or saved. In reality there may be other factors, some of which are qualitative and thus have an impact on a person’s decisions. For example, if the contents of a house are destroyed or stolen, there may be damaged or lost objects that have sentimental value that cannot be measured in monetary terms. The disruption of production by an earthquake and emotional costs on the employees from the insecurity of working in an unprotected building may be important to Richter in making its decisions. To deal with these factors, one may want to introduce other attributes into the analysis to reflect these non-monetary features of a loss. In general, as one incorporates these other factors into the picture, protection becomes more attractive.

Sensitivity analysis: Many of the estimates of costs and benefits are highly uncertain for determining the relative attractiveness of insurance or loss-reduction measures. Hence, it is often useful to undertake sensitivity analyses to determine how important it is to accurately estimate specific values. For example, a dead bolt lock may be an attractive protective measure over a wide range of theft probabilities and/or loss of contents, in which case one does not need precise estimates of these risk estimates to make a final decision.

CHALLENGES FACING DECISION MAKERS

These adjustments to the model begin to suggest some of the ways that decision-makers normally process information differently from the expected utility model. When behavioral factors are introduced into the picture, they produce unexpected results. These
factors may explain why Richter failed to protect itself against earthquakes when it made more sense from a benefit-cost perspective and bought the protection when it made less sense from this type of formal analysis. Similarly, they also help explain why Safely and Carefree had very different responses to the same threats from neighborhood crime. What is it about human decision makers that make them diverge from the model? The key factors that make protective decisions difficult are discussed below.

**Difficulty Evaluating Low Probabilities**

Several studies show that individuals rarely seek out probability estimates in making their decisions, and that low probabilities are inherently difficult in eliciting reactions. When these data are given to them decision makers often do not use the information. In one study, researchers found that only 22 percent of subjects sought out probability information when evaluating several risky managerial decisions. Even when another group of respondents was given precise probability information, less than 20 percent mentioned the probability in their verbal protocols.

When consumers are asked to justify their decisions about whether or not to purchase warranties for items such as stereos, computers and VCRs, they rarely list probability that the product needs repair as a reason for purchasing this protection. This information should be relevant for deciding how much to pay for the warranty if one were utilizing a normative model of choice.

Why do people have such difficulty dealing with probabilistic information for small likelihood events? They need a context in which to evaluate the likelihood of an event occurring. People may have difficulty gauging how concerned to feel about a 1 in
100,000 probability of death without some comparison points. Most people just do not know whether 1 in 100,000 is a large risk or a small risk.

This evaluation can be improved by providing reference points. In one study individuals were presented with either a probability or an actuarially fair insurance premium characterizing the risks associated with the discharge of a hypothetical toxic chemical, Syntox. The chemical had the potential of causing fatalities to individuals living near the fictitious ABC chemical plant located on the outskirts of an urban center in New Jersey.⁷ To give some reference points, respondents also were given the probability of death from a car accident. Finally, the participants were asked a set of questions regarding how risky they perceived the facility to be.

[SEE ATTACHED BOX]
Box 15-1

Scenarios for ABC Chemicals Company with Syntox Discharge and Auto Accident Comparison

The ABC Chemicals Company is a large firm that has a plant in a community on the outskirts of an urban center in New Jersey. A chemical labeled Syntox, used in production at the plant, will be regulated under the Environmental Protection Agency's Clean Air Act Amendments. Syntox is the only toxic chemical used at the plant. As is required in the regulations, ABC Chemicals has determined that the worst conceivable accident at the plant would occur if its entire inventory of Syntox were accidentally released into the atmosphere in a very short time period. If this did occur, a plume of toxic vapors would form that could cover any home in the community, depending on how the wind blows. This vapor would only affect a few homes in the community.

An insurance company has estimated the probability of a discharge of Syntox causing deaths in the community surrounding the plant. The insurance company made the risk assessment to determine what premium it should charge ABC Chemicals to provide $1 million coverage to each resident of the community against death from the discharge of Syntox. Insurance companies charge a higher premium to cover an individual if they believe the risk the individual faces is high; they charge a lower premium if they believe the risk is low.

Half of the respondents then read one of three scenarios as shown by the figures in brackets [ ]:

As background for assessing the risks of Syntox, the probability of an individual dying in a car accident is 1 in 6,000 per year.

The estimated probability of an individual in the community dying from a discharge of Syntox is 1 in 1 million per year. [or 1 in 100,000 or 1 in 10 million]

A regulatory agency has determined that for both car accidents and Syntox discharges, these probability estimates are accurate.

The other respondents read one of three scenarios as shown by the figures in brackets [ ]:

As background for assessing the risks of Syntox, a fair premium for providing $1 million coverage against each death in a car accident is $245 per year.

A premium of 15 cents [or $1.50 or $15.00] per year for each resident of the community is the fair and appropriate one to charge for providing $1 million coverage against each death from a discharge of Syntox.
A regulatory agency has determined that for both car accidents and Syntox discharges, these premiums are fair and appropriate.
People were not able to distinguish between low, medium and high probabilities in judging the riskiness of the facility. Surprisingly, the study also found that subjects did not respond to insurance premiums as a signal of risk. One might think that because most people are familiar with insurance policies, they should know that premiums tend to reflect risk. While they may not be able to think meaningfully about what a 1 in 100,000 chance of death means, they certainly know what $15.00 means. Yet there was no difference between the perceived risk of the ABC chemical plant, whether the annual premiums paid for coverage against fatalities from the release of Syntox were $15.00, $1.50 or 15 cents.

While comparing premiums did not help in the risk assessment process, offering comparisons to other risks did. When respondents were presented with a description of high- and low-probability automobile accident scenarios to compare with a chemical accident, they more accurately classified the safety of the ABC plant as one varied either the probability of a Syntox release or the annual insurance premium. It thus appears that fairly rich context and information needs to be made available to people for them to be able to judge differences between low-probability events.
Simplified Models of Choice

Another challenge in making protective decisions is that instead of seeing a range of probabilities and risks, people tend to simplify the choice into a simple yes or no. Prior to disasters, the low risk is rounded to zero as decision makers believe, “It can’t happen to me.” After disasters, the risk is rounded up to one, “It will happen to me.” In reality, though, the risk is the same – actually lower sometimes, as we saw in the Richter earthquake example.

Research shows that decision makers use “threshold models” in making decisions. In a laboratory experiment on purchasing insurance, many individuals bid zero for coverage, apparently viewing the probability of a loss as sufficiently small that they were not interested in protecting themselves against it. Similarly, many homeowners residing in communities that are potential sites for nuclear waste facilities have a tendency to dismiss the risk as negligible.

It is easy to see why the "it will not happen to me" strategy violates the tenets of expected utility theory. Instead of weighing the outcome from an event by its perceived probability of occurrence, individuals who utilize a threshold model do not even consider the consequences from such events. They essentially treat them as impossible, and hence have no reason to invest in protective measures. After the event, however, the potential for loss is much more concrete, so people tend to treat them not just as possible but probable.
High Discount Rates or Myopia

Because people have short time horizons in planning for the future, they may not fully weigh the long-term benefits from investing in loss reduction measures.\(^{11}\) This is part of the reason that people are reluctant to incur the high immediate cost of energy-efficient appliances in return for reduced electricity charges over time.\(^{12}\) There is even less interest in investing in protective measures where there is only a small chance that the person will benefit from having taken such action.

In one study, subjects indicated the maximum they were willing to pay for such protective measures as investing in a dead bolt lock for their apartment, purchasing a steering wheel club and strengthening their homes against earthquakes.\(^{13}\) By varying the number of years that each of the measures provided protection, we could determine how much more the person was willing to invest in the item as a function of time. If a person was willing to pay $50 for a dead bolt lock if he planned to live in his apartment for 1 year then he should be willing to pay up to $91.65 if he had a two-year lease and an annual discount rate of 20%. If one learned how much the person was willing to pay for the protective measure as a function of time, then one could work backwards and compute the implied annual discount rate, which was consistent with these dollar figures.

Table 15-1 indicates that individuals tend to follow three different decision strategies in determining their maximum willingness to pay for risk protection. Strategy 1, labeled “Relatively Low Discounting,” includes all people whose annual discount rate is less than 20%. These individuals are consistent with a discounted expected utility model.

Relatively few individuals behave in this manner. The “Myopic Behavior” group consists
of those whose implied annual discount rate is greater than 20%. Their willingness to pay does not increase very much as time is increased, thus implying the use of short time horizons on their part. The third group does not change its willingness to pay as one changes the number of years that the protective measure will be useful. This implies an infinite discount rate. This behavior appears to indicate that the individual believes there is a fair price for the item that should not be affected by time of use. Most people fall into this third category.

Table 15-1
Percentage of Subjects Willing to Pay for Protective Measures

<table>
<thead>
<tr>
<th>Change in Number of Years</th>
<th>Relatively Low Discounting $\ r \leq 20$</th>
<th>Myopic Behavior $\ r &gt; 20$</th>
<th>No Change in Willingness To Pay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lock</td>
<td>18 %</td>
<td>34 %</td>
<td>47%</td>
</tr>
<tr>
<td></td>
<td>(r= .14)</td>
<td>(r= .72)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9 %</td>
<td>33 %</td>
<td>58 %</td>
</tr>
<tr>
<td></td>
<td>(r= .11)</td>
<td>(r= .77)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 %</td>
<td>35 %</td>
<td>35 %</td>
</tr>
<tr>
<td></td>
<td>(r= .12)</td>
<td>(r= .67)</td>
<td></td>
</tr>
<tr>
<td>Club</td>
<td>25 %</td>
<td>35 %</td>
<td>40 %</td>
</tr>
<tr>
<td></td>
<td>(r= .1)</td>
<td>(r= .72)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 %</td>
<td>31 %</td>
<td>49 %</td>
</tr>
<tr>
<td></td>
<td>(r= .12)</td>
<td>(r= .79)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21 %</td>
<td>38 %</td>
<td>41 %</td>
</tr>
<tr>
<td></td>
<td>(r= .1)</td>
<td>(r= .69)</td>
<td></td>
</tr>
<tr>
<td>Quake</td>
<td>14 %</td>
<td>41 %</td>
<td>45 %</td>
</tr>
<tr>
<td></td>
<td>(r= .1)</td>
<td>(r= .72)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>27 %</td>
<td>34 %</td>
<td>71%</td>
</tr>
<tr>
<td></td>
<td>(r= .13)</td>
<td>(r= .67)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30 %</td>
<td>38 %</td>
<td>32%</td>
</tr>
<tr>
<td></td>
<td>(r= .12)</td>
<td>(r= .74)</td>
<td></td>
</tr>
</tbody>
</table>

(r= average implied annual discount rate within that category)

Source: Kunreuther, Onculer and Slovic (1998)
In the case of investing in an earthquake protective measure, the constant willingness to pay even when time horizons changed could be explained if these individuals believed that the value of their property would increase to reflect the cost of the protective measure. However, none of the subjects used this argument to justify their decisions. In the case of the investment in a dead bolt lock to protect their apartment from theft, this rationale would not hold since the renters could not take the lock with them when leaving the apartment.

In fact, when subjects were asked to specify what arguments they utilized in determining how much they would be willing to pay for the dead bolt lock, few used reasons suggesting that they were utilizing a discounted expected utility model. Most subjects referred to the selling price – focusing on the cost of the product rather than the value of the protection – when asked how they determined their maximum willingness to pay.\textsuperscript{14}

\textbf{Role of Affect and Emotions}

There is now a growing body of evidence that affect and emotions play an important role in people’s decision processes for choices when there are uncertain outcomes.\textsuperscript{15} In the context of investing in protective measures, people are more willing to purchase insurance if they have more affection for an object.\textsuperscript{16} The expected utility model does not predict this behavior. Rather, these findings appear to be explained by a "consolation
hypothesis," according to which, people perceive insurance compensation as a token of consolation.

A simple example illustrates the importance of affection on the decision on how much to pay for shipping insurance on an antique clock:

Suppose that you are about to move to a new city. Your company will pay for all the moving expenses. Among the things you ask the moving company to ship is an antique clock. There is some chance that the clock may get lost in shipment. The moving company does not provide insurance, but you can purchase insurance from an independent company yourself. Buying insurance will not affect the chance of loss, but if you buy insurance and the clock is lost, you will receive $100 in compensation. The clock no longer works and cannot be repaired. It has literally no market value.

Half of the respondents then read a high-affection description:

However, it has a lot of sentimental value to you. It was a gift from your grandparents on your 5th birthday. You grew up with it. You learned how to read time from it. You have always loved it very much.

The remaining half of the respondents read a low-affection description of the clock:

It does not have much sentimental value to you. It was a gift from a remote relative on your 5th birthday. You didn’t like it very much then, and you still don’t have any special feeling for it now.

Both groups of participants were then asked to indicate the maximum amount they were willing to pay for the shipping insurance. They were given 11 choices, ranging from $0 to $50 or more. On average, those in the high-affection condition were willing to pay about twice as much ($22.24) for the shipping insurance as those in the low-affection condition ($10.51). This result supports the consolation hypothesis. Presumably, those who loved the clock would feel greater pain if the clock was lost and therefore would be in greater need of consolation. This is true even when the clock has no monetary value and cannot easily be replaced.
In protective decisions, fear is often a powerful emotional factor. Art Safely’s fear of crime is what makes him more willing to spend on a dead bolt. The Richter Company’s fear of another earthquake, now that it has experienced the first one, also may contribute to its decision. The impact of emotions on decisions is discussed in more detail in Chapter 2 and strategies for a more detached and reflective approach are explored in Chapter 6.

MAKING BETTER PROTECTIVE DECISIONS

We have seen how difficulties in evaluating low probabilities, a focus on short time horizons and how emotions like fear and love interfere with the ability to make well reasoned decisions about protection against risks. Given this description of how people make protective decisions and their deviations from normative models, how can we improve the choice process? Some combination of the following options may be helpful in this regard:

Present probabilities using concrete comparisons: Remember, people have great difficulty evaluating low-probability risks, but they do a better job when these risks are presented in concrete form. They might not know what a one-in-a-million risk means, but they can better interpret the figure when it is compared to the risk of an automobile accident. People need to see these decisions in the contexts of risks that they understand. Research indicates that comparisons of risks are much more effective in helping decision makers focus than translating the risks into dollar values of insurance premiums. Presenting the information in this form can help decision makers better assess the risk.
Avoid microscopic numbers: People also are willing to pay considerably more to reduce the risk of some adverse events if the likelihood is depicted as ratios rather than very tiny probabilities. For example, saying that the risk of an event occurring when one is protected is half of what it is when one is not protected elicits a far stronger reaction than saying the risk is reduced from .000006 without protection to .000003 with protection. Similarly, people are more willing to wear seatbelts if they are told they have a .33 chance of an accident over a 50-year lifetime of driving rather than a .00001 chance each trip. Adjusting the time frame also can affect risk perceptions. For example, if the Richter Corporation is considering earthquake protection over the 25-year life of its plant, managers are far more likely to take the risk seriously if they are told the chance of an earthquake is 1 in 5 during the entire period rather than 1 in 100 in any given year. Studies have shown that even just multiplying the single-year risk—presenting it as 10 in 1,000 or 100 in 10,000 instead of 1 in 100—makes it more likely that people will pay attention to the event. Most people feel small numbers can be easily dismissed, while large numbers get their attention. One challenge for future research is to determine ways to present information to individuals so that they understand the meaning of low and high probabilities.

Use private-public partnerships: Private insurers, financial institutions and other private sector groups alone are unlikely be able to address these challenges in risk management. Rather, a combination of public and private involvement may be much more desirable. First, private sector firms such as insurers and banks can offer incentives to purchase
protection in the form of loans and other vehicles. For example, if the Richter Corporation has to spend $15,000 to make its plant more earthquake proof and save $200,000 in property damage from a severe quake, it might have trouble justifying the decision in the short run. If the risk of a severe quake each year is 1/100, the expected reduction in annual loss is just $2,000, which would be reflected in an equivalent reduction in its annual insurance premium. But the $15,000 investment wouldn’t pay for itself in the 2-5 year payback period required by Richter management.

How could one encourage the managers of the Richter plant to make the investment? If Richter could finance the protection as a 20-year loan with an interest rate of 10 percent, it would now face an annual payment of $1,700 (with an annual $2,000 reduction in its insurance premium). This means Richter comes ahead $300 per year, the bank earns a reasonable interest rate and the insurers have enough policies that they don’t have an abnormally high risk of insolvency.

Even with financial incentives, there may be a need for public policy measures. When a building collapses it may break a pipeline and cause a major fire that would damage other property not affected by the earthquake in the first place. Losses from these and other “externalities” would not be covered by Richter’s insurance policy. A well-enforced building code that requires cost-effective mitigation measures would help reduce these risks and provide a better context in which private insurers can then insure against the specific individual risks.
As we have seen, protective decisions offer particular challenges for decision makers and policymakers. These may be some of the greatest hidden “risks” of these types of decisions, which often lead companies to overprotect or underprotect against risks. With care, when we recognize these limitations, we can move to decisions that are closer to meeting a set of optimality criteria. We also can create decision contexts through establishing corporate decision processes and public regulations to protect against such errors in these low-probability, high-risk events.
NOTES

1 The likelihood of an earthquake is just as high whether insurance is purchased or not. This is equivalent to saying that there are no moral hazard problems. Moral hazard exists if the probability is higher after a person buys insurance. A classic example of moral hazard is when an individual drives more carelessly after she has purchased automobile insurance. Hence the chance of a car accident increases because insurance was purchased.


8 These finding are consistent with the subjective probability weighting function of prospect theory in which probabilities below a threshold may be treated as zero. See, for example, Kahneman, D. and Tversky, A. (1979) “Prospect Theory: An Analysis of Decision Under Risk” Econometrica 47:263-291.


11 Loewenstein and Prelec (1992), see Note 2.


These justifications are consistent with recent experiments by Schkade and Payne (1994) and Baron and Maxwell (1996) which revealed that the willingness to pay for public goods was affected by cost information.


