7 DEMAND FOR INSURANCE

Many people have been told since their youth that gambling is an unwise activity, only to be dabbled in for entertainment purposes, if at all. But buying health insurance is actually a form of gambling. Take life insurance, for instance—a term life insurance contract is a bet that you will die before some fixed date. To win, you must die early. Despite warnings about the dangers of gambling, life insurance is, in many circumstances, a wise choice. The reason why buying insurance may be wise is that it is a bet that reduces uncertainty. Insurance is a hedge against risk, against the possibility of bad outcomes. But nothing is costless: purchasing insurance means forfeiting income in good times. The homeowner who pays monthly for fire insurance for the fire that never occurs might have been better off spending that income elsewhere. The individual who buys health insurance but never visits the hospital loses out on that income.

What drives the demand for insurance seems to be fear of the unknown. We want to understand what causes people to be afraid of the unknown in the first place. The story economists tell has little to do with the psychology or biology of fear. It has more to do with the mundane topic of declining marginal utility of income.

7.1 Declining marginal utility of income

In this section, we introduce the simplest possible model that illustrates the notion of risk aversion and the demand for insurance. In this model, an individual cares about the income she earns and nothing else. As always, we model preferences by defining a utility function, and in this case the utility function will have a single input— income \( I \). While this is certainly unrealistic, it is all that is necessary to demonstrate risk aversion.

What properties should the individual's utility function \( U(I) \) have? First, utility should increase with income; that is, the first derivative of the utility function is positive:

\[
U'(I) > 0
\]

A second property of this individual's preferences is that her marginal utility of income is declining in income. This means that the first dollar the individual has is very valuable to her, because an income of one dollar \( (I = 1) \) is much better than an income of zero dollars \( (I = 0) \). But if the individual is already a millionaire, gaining an extra dollar means very little to her. Empirically, these preferences seem to be very common. This second property is equivalent to the second derivative of the utility function being negative:

\[
U''(I) < 0
\]

Figure 7.1 graphs a utility function with both of these properties. Utility is increasing with income, but at a declining rate. While this figure may seem simple, it turns out to be the key to understanding why the individual is risk averse; why she might demand insurance, and what sort of insurance contracts she prefers. Indeed, there is a relationship between declining marginal utility of income and risk aversion is a key insight of modern economics.

\[
U(I)
\]

\[
I
\]

7.2 Uncertainty

Our next step is to model uncertainty. Again, our strategy is to build the simplest possible model that accomplishes our task. In this case, suppose that the individual faces a possibility of becoming sick. She does not know whether she will become sick, but she knows the probability of sickness is \( p \in (0, 1) \). Consequently, her probability of staying healthy is \( 1 - p \). She also knows that if she does get sick, medical bills and missed work will reduce her income considerably. Let \( I_s \) be her income if she does get sick, and let \( I_h > I_s \) be her income if she remains healthy.

Whenever there is uncertainty, it is important to have ways of summarizing all the possible outcomes in a concise way. One such summary is the expected value.

<table>
<thead>
<tr>
<th>Definition</th>
<th>7.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>The expected value of a random variable ( X ), ( E[X] ), is the sum of all the possible outcomes of ( X ) weighted by each outcome's probability. If the outcomes are ( X = x_1, x_2, \ldots, x_n ), and the probabilities for each outcome are ( p_1, p_2, \ldots, p_n ) respectively, then ( E[X] = p_1 x_1 + p_2 x_2 + \cdots + p_n x_n ).</td>
<td>( \text{(7.3)} )</td>
</tr>
<tr>
<td>( E[X] ) is also sometimes called the mean of ( X ).</td>
<td></td>
</tr>
</tbody>
</table>

In the individual's case, the formula for expected value of her income, \( E[I] \), is simple. There are only two possible outcomes for \( I \) and we know the probabilities associated with each:

\[ E[I] = p_I I + (1 - p) I_s \]

\( \text{(7.4)} \)
One feature of equation (7.4) is that expected income depends critically on \( p \), the probability of illness. As getting sick becomes more likely, \( p \) rises and the weight given \( I_0 \) in the formula for \( E[I] \) increases. As we would expect, rising \( p \) translates to a reduced expected income.

### 7.3 Risk aversion

Suppose we conduct an experiment where we offer a starving graduate student a choice between two possible options, a lottery and a certain payout:

- \( A \): a lottery that awards $500 with probability 0.5 and $0 with probability 0.5.
- \( B \): a check for $250 with probability 1.

It is easy to see that the expected value of both the lottery and the certain payout is $250:

\[
E[I]_A = 0.5(500) + 0.5(0) = \$250
\]

\[
E[I]_B = 1(250) = \$250
\]

Despite the fact that both lotteries provide the same expected income, studies reliably find that most people prefer certain outcomes over uncertain lotteries like \( A \). If a starving graduate student says he prefers option \( B \) in the above example, what does that imply about his utility function? To answer this question, we need to define expected utility for a lottery or uncertain outcome. Like expected income, expected utility is an average over all states of the world, weighted by the probability of each state.

**Definition 7.2**

The expected utility from a random payout \( X \), \( E[U(X)] \), is the sum of the utility from each of the possible outcomes, weighted by each outcome’s probability. If the outcomes are \( X = x_1, x_2, \ldots, x_n \) and the probabilities for each outcome are \( p_1, p_2, \ldots, p_n \) respectively, then

\[
E[U(X)] = p_1 \cdot U(x_1) + p_2 \cdot U(x_2) + \ldots + p_n \cdot U(x_n)
\]

(7.6)

The starving student’s preference for option \( B \) over option \( A \) implies that his expected utility from \( B \), \( E[U(B)] \), is greater than his expected utility from \( A \), \( E[U(A)] \):

\[
E[U(B)] \geq E[U(A)]
\]

(7.7)

\[
U(\$250) \geq 0.5 \cdot U(\$500) + 0.5 \cdot U(\$0)
\]

In this case, the starving student prefers the more certain payout over the less certain one, even though the expected value of those two options is equal. We say that the student is acting in a risk-averse manner over the choices available.

The situation that the individual who might get sick faces is similar to the lottery in option \( A \) in that her income \( I \) is a random variable. She gains a high income \( I = I_0 \) if she stays healthy, and a low income \( I = I_1 \) if she is sick. Furthermore, she is uncertain about which outcome will happen, though she knows the probability of becoming sick is \( p \). Her expected utility \( E[U(I)]_p \) in this situation is:

\[
E[U(I)]_p = pU(I_0) + (1 - p)U(I_1)
\]

(7.8)

Figure 7.2 shows how expected utility changes as the probability of sickness changes. Consider the extreme case where the individual is sick with certainty, so the probability of sickness is \( p = 1 \). It should be clear from equation (7.8) that when \( p = 1 \), \( E[U(I)] = U(I_1) \). In Figure 7.2, we label this point \( S \). At that point, the individual’s expected utility equals the utility she gains from a certain income of \( I_1 \). Similarly, if the individual has no chance of becoming sick, \( p = 0 \), her income is \( I_0 \) with certainty, and her utility is \( U(I_0) \). We label this point \( H \) in the figure.

![Figure 7.2: Expected utility from income for different probabilities of sickness.](image)

What if her probability of illness lies somewhere between 0 and 1? In that case, her expected utility falls on a line segment between \( S \) and \( H \) in Figure 7.2. One way to see this is to consider equation (7.8) again. Think of \( U(I_1) \) and \( U(I_0) \) as fixed numbers, since changes in \( p \) have no effect on those quantities. Therefore, equation (7.8) is a linear function in \( p \). As \( p \) increases from 0 to 1, the weight placed on \( U(I_0) \) increases and the weight placed on \( U(I_1) \) decreases.

For instance, when \( p = 0.25 \), the individual’s expected utility is shown at point \( A \), a quarter of the way along the line segment from \( S \) to \( H \). The individual’s expected income at this point is:

\[
E[I]_{0.25} = 0.25 \cdot I_0 + (1 - 0.25) \cdot I_1
\]

and her utility at this point is \( E[U(I)]_{0.25} \). Similarly, point \( B \) represents her expected income and expected utility when \( p = 0.75 \). We can calculate these quantities for any \( p \) by moving along the line segment \( HS \).

**Expected utility vs. expected income**

The important fact to notice is that we do not read her expected utility off the income-utility curve, but instead off the line segment \( HS \). Figure 7.3 illustrates this distinction in
the case when $p = 0.5$. The individual’s expected income and expected utility from the sickness lottery are:

$$E[I]_{I_{S5}} = 0.5 \cdot I_5 + (1 - 0.5) \cdot I_1$$

$$E[U(I)]_{I_{S5}} = 0.5 \cdot U(I_5) + (1 - 0.5) \cdot U(I_1)$$

In Figure 7.3, the resulting point is labeled $A$ and falls on the line segment $HS$. This point corresponds to the expected utility from income of $E[U(I)]_{I_{S5}}$. This is not to be confused with the utility from expected income $U(E[J]_{I_{S5}})$, which corresponds to point $A'$. This value is the utility that would result if the individual could earn $E[I]_{I_{S5}}$ with certainty. Just like the starving student, the individual gains more utility from the certain outcome than the uncertain outcome. This statement implies that she is risk-averse.

**Definition 7.3**

Risk aversion in the utility–income model:

The following statements are equivalent:

- The individual prefers a certain outcome to an uncertain outcome with the same expected income.
- The individual prefers the utility she would get from her expected income to the expected utility she will get from her actual (uncertain) income.
- $U(E[I]) > E[U(I)]$.
- The individual is risk-averse.

Notice that these statements are all true because the utility–income curve is concave. The geometry of the utility–income curve guarantees that the curve always lies above the line segment $HS$ for any value of $I$. The individual always gains more utility from a certain outcome than an uncertain outcome with the same expected income. This holds true as long as there is some uncertainty, $0 < p < 1$. Recall that we modeled the individual’s utility curve as concave in the first place in order to reflect her declining marginal utility from income (see equation (7.2)). We see now that risk aversion follows directly from this assumption.

While the theory we describe here is intuitively appealing since it relies on standard notions from probability theory, even within economics there is considerable controversy over whether the model accurately describes how people make decisions under uncertainty. Perhaps not surprisingly, people often reason in strange ways when they make decisions in face of the unknown. Psychologists have developed an elaborate story, known as prospect theory, that describes the distortions in reasoning that occur when people think about uncertain outcomes. We will leave that part of the story for later, in Chapter 23, because it builds on the simpler model of expected utility maximization that we describe in this chapter.

### 7.4 Uncertainty and insurance

In our model, a person is either fully well or fully sick but never halfway between. This means that individuals cannot achieve the higher utility at $A'$ from Figure 7.3 on their own, even though risk-averse people would prefer it. A risk-averse individual seeking to achieve $A'$ would need to somehow send money from one potential self in the world where she stays healthy to her other potential self in the world where she becomes sick. She cannot do this herself without some sort of time machine, but she has another option: insurance. As we will see, an insurance contract functions by transferring money from the well state to the sick state.

**A basic insurance contract**

The individual approaches a health insurance company that offers a policy with the following features:

- The individual pays an upfront cost $r$ regardless of whether she stays healthy or becomes ill. The payment $r$ is known as the insurance premium.
- If the individual becomes ill, she receives a payout $q$.
- If the individual remains healthy, she receives nothing from the insurance company (not even a refund of the insurance premium $r$).

Here we return to the notion that buying an insurance contract amounts to a bet. The individual is betting the insurance company that she will be sick. If she falls ill, she "wins" the bet and receives payout $q$. But if she stays healthy, she "loses" the bet and receives nothing in return for the premium paid. For a risk-averse individual, this bet may be wise, because it allows the individual to hedge against illness and reduce uncertainty about her final income. Though she is just as likely to fall ill as before, the financial burden of illness is lower. The insurance does not make her healthier, but it can make her happier.

Let $I_0$ and $I_1$ represent the individual’s income in the healthy and sick states of the world with the insurance contract. These quantities will be functions of $I_0$ and $I_1$, as well as the parameters of the insurance contract: the premium $r$ and payout $q$. Her incomes in the two states are thus
Healthy: \( I_h = I_h - r \)  

Sick: \( I_s = I_s - r + q \)  

Recall that the individual's goal in buying insurance was to achieve an income of \( E[I] \) with certainty, whether she is healthy or sick. What the individual would like most is 

\( E[I] = E[I_h] = I_h \)  

(7.10)

An insurance contract that fulfills equation (7.10) is said to be actuarially fair, full insurance. We discuss these terms in more detail shortly.

Let us consider an insurance contract \( X \) with the following parameters. In this contract, assume the individual receives the difference between her healthy income and sick income if she is sick: \( q = I_h - I_s \). In addition, assume that the premium is set such that the contract represents a fair bet: \( r = pq \). On average, the individual neither gains nor loses income from this contract.

The following algebra shows that with contract \( X \), the individual's income is \( E[I] \), regardless of whether she turns out to be healthy or sick. In each column we start with equation (7.9) and substitute in the parameters of this insurance contract; in the second line, we substitute \( r = pq \); in the third line, we substitute \( q = I_h - I_s \).

\[
\begin{align*}
\text{Healthy state} & \\
I_h &= I_h - r \\
&= I_h - pq \\
&= I_h - p(I_h - I_s) \\
&= pl_h + (1-p)I_h \\
&= E[I_h] \\
\text{Sick state} & \\
I_s &= I_s - r + q \\
&= I_s - pq + q \\
&= I_s - p(I_h - I_s) + (I_h - I_s) \\
&= pi_s + (1-p)I_h \\
&= E[I_s] \\
\end{align*}
\]

With this contract, the individual can receive \( E[I] \) with certainty. This enables her to achieve points on the utility function, like \( A' \), in Figure 7.3, whereas before she was only able to achieve points on line segment HS below the utility–income curve. With the insurance contract, the individual's utility increases even though her income does not. The insurance contract creates utility seemingly out of nowhere; simply by reducing uncertainty, the insurance contract can make the risk-averse individual better off.

The nature of the insurance contract is that the individual loses income in the healthy state \( I_h > I_s \) and gains income in the sick state \( I_s = I_s \) relative to the state of no insurance. This is the sense in which the insurance contract acts as an instrument that transfers income from the healthy state of the world to the sick state. The risk-averse individual willingly sacrifices some good times in the healthy state to ease the bad times in the sick state.

**Fair and unfair insurance**

Consider now the same insurance contract we have been discussing from the point of view of the insurance company. Let \( E[I] \) be the expected profits that the insurer makes from offering a contract with premium \( r \) and payout \( q \) to any consumer with probability of sickness \( p \). If the customer actually stays healthy, the firm earns \( r \) dollars. On the other hand, if the customer falls ill, the firm still receives the premium \( r \) but loses the payout \( q \). By applying the formula for expected value (see equation (7.3)), we find:

\[
E[I(p,q,r)] = (1-p)r + p(r-q) = r - pq
\]

(7.11)

In a perfectly competitive insurance market, profits will equal zero. Just like in any competitive market, if profits were positive, new entrants would compete away those profits until all the firms left in the market would be making zero profits. If the profits were negative, then the insurer is giving money away to customers in the long run and will go out of business. Firms leave the market until profits reach zero. Setting expected profits to zero in equation (7.11) implies \( r = pq \). This condition is known as actuarial fairness.

**Definition 7.4**  

**Actuarially fair insurance contract:** an insurance contract which yields zero profit in expectation; also called fair insurance:

\[
E[I(p,q,r)] = 0 \implies r = pq
\]

(7.12)

An insurance contract which yields positive profits is called unfair insurance:

\[
E[I(p,q,r)] > 0 \implies r > pq
\]

(7.13)

When insurance is fair, in a sense, it is also free. The customer's expected income does not change from buying the contract, so she effectively pays nothing for it. Despite the fact that the premium \( r \) is positive in an actuarially fair contract, the price is actually zero. Thus, we reach the counter-intuitive conclusion that the premium associated with an insurance contract is not its price.

In the real world, of course, nothing is free, and insurance markets are not perfectly competitive. Insurance companies make some positive profits on the contracts they sell, so there must exist insurance contracts with positive prices that consumers actually purchase. An insurance contract with a positive expected profit for the insurer is called an actuarially unfair contract. Applying the firm's profit equation (equation (7.11)), we find that the profit-making insurer must set premiums \( r \) above the expected payout \( pq \):

\[
E[I(p,q,r)] > 0 \implies r > pq
\]

(7.14)

The difference between the premium \( r \) and expected payout \( pq \) is analogous to the price of the contract and determines the change in expected income. The higher \( r \) rises above \( pq \), the pricier the contract is and the more unfair it becomes. Risk-averse consumers may still be willing to pay positive prices for unfair insurance contracts if doing so sufficiently reduces their uncertainty. But there is a limit to the price even risk-averse customers will pay for additional certainty, as we discuss in Section 7.5.

**Full and partial insurance**

So far we have examined insurance contracts where the insured individual ends up with the same income in the sick state and the healthy state, \( I_s = I_h \). This property is known as state independence, because the individual's income no longer depends on her health status. An insurance contract that achieves state independence completely eliminates income uncertainty and is called a full insurance contract.
Not all insurance contracts are full, however. An insurance contract can be designed that reduces income uncertainty without completely eliminating it. Under partial insurance, income in the sick state even with insurance is still lower than income in the healthy state ($I_q < I_h$), but some income is still transferred from the healthy to the sick.

<table>
<thead>
<tr>
<th>Definition 7.5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full insurance contract</strong>: an insurance contract that achieves state independence; income in all states is equal: $I_q = I_h$</td>
</tr>
<tr>
<td><strong>Partial insurance contract</strong>: an insurance contract that is state-dependent; income in the sick state is still less than income in the healthy state: $I_q &lt; I_h$</td>
</tr>
</tbody>
</table>

Just as we derived the premium $r$ in the cases of actuarially fair and unfair insurance, we can derive the payout $q$ in the cases of full and partial insurance. We rely on the state-independence property of full insurance and the state-dependence property of partial insurance:

- **Full insurance**
  - $I_q = I_h$
  - $I_q - r + q = I_h - r$
  - $I_q + q = I_h$
  - $q = I_h - I_q$

- **Partial insurance**
  - $I_q < I_h$
  - $I_q - r + q < I_h - r$
  - $I_q + q < I_h$
  - $q < I_h - I_q$

The size of the payout $q$ determines the fullness of the insurance contract. A contract with a payout that fully covers the spread between $I_h$ and $I_q$ is full, while contracts with payouts that do not fully cover this difference are partial. The closer an insurance contract's payout $q$ comes to equaling $I_h - I_q$, the fuller we say that contract is.

Just as we think of the fairness of a contract as its effective price, we can think of the fullness of a contract as its effective quantity. Fuller contracts offer higher quantities of insurance, in the sense that they provide greater income certainty and produce greater expected utility.

Figure 7.4 compares an individual's income and utility under three different insurance contracts that are all actuarially fair but vary in their degree of fullness:
- **No insurance**: the individual receives either $I_h$ or $I_q$, and has expected utility at $A$.
- **Partial insurance**: the individual receives either $I_q'$ or $I_h'$, and has expected utility at $A'$.
- **Full insurance**: the individual receives both $I_q'$ and utility at $A'$ with certainty.

From Figure 7.4 we see that the expected utility from full insurance at $A'$ is highest, followed by utility from partial insurance $A'$ and then no insurance $A$. The income uncertainty the individual faces is largest in the case of no insurance: she receives either $I_h$

or $I_q$, which may be significantly different. Partial insurance lowers her uncertainty but does not eliminate it altogether since $I_q'$ is still less than $I_h'$. Only with the highest quantity of insurance — full insurance — does the individual reach state independence and fully eliminate income uncertainty.

### 7.5 Comparing insurance contracts

So far we have defined actuarially fair insurance contracts and full insurance contracts separately. In fact, insurance contracts are defined by the extent to which they are both fair and full. Table 7.1 shows how various combinations of premium $r$ and payout $pq$ result in different types of insurance contracts. Of course, there is an infinite number of partial contracts, unfair contracts, and every possible interaction between the two. The four-way classification in Table 7.1 is a convenient way to study and compare the different contracts.

<table>
<thead>
<tr>
<th>Table 7.1. Premium and generosity of different insurance contracts.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fair</strong></td>
</tr>
<tr>
<td><strong>Full</strong></td>
</tr>
<tr>
<td>$q = I_h - I_q$</td>
</tr>
<tr>
<td><strong>Partial</strong></td>
</tr>
<tr>
<td>$q &lt; I_h - I_q$</td>
</tr>
</tbody>
</table>

The contract's parameters $r$ and $q$ determine its level of fairness and fullness for any particular individual with given values of $p$, $I_h$, and $I_q$. At a fixed level of fairness (which we can think of as a fixed price), full insurance is preferable to partial insurance because it provides certainty about income. At a fixed level of fullness (or a fixed quantity), however, fair insurance is preferable because it costs less than unfair insurance and delivers the same benefit.

These two rules imply that insurance that is both fair and full (the upper-left quadrant in Table 7.1) is always preferable to anything else. Accordingly, we term this the ideal contract because it is the best attainable contract from the consumer's point of view. Whenever the individual is offered a choice between the ideal contract and a non-ideal
One, she chooses the former. But when she is offered a choice between two non-ideal contracts, she can only decide between them by a closer comparison of her expected utilities under each.

**Two non-ideal contracts**

Consider a market with only two health insurance contracts being offered: contract $P$ which is fair but partial, and contract $F$ which is full but unfair. Because neither is ideal, we cannot say which contract is the better choice for any potential customer until we evaluate her expected utility under each option.

Figure 7.5 depicts the situation of an individual considering these two contracts. In this example, we define a full-but-unfair contract $A'$ that offers a higher expected utility than the partial-but-fair $A$. Although contract $F$ is unfair and thus more expensive in terms of expected income, its fullness makes it worth the added cost. For a risk-averse individual with this utility function, the reduction in uncertainty warrants paying an actuarially unfair price.

![Figure 7.5. Two non-ideal contracts, $A'$ and $A$.](image)

But there is still a limit to how much the individual is willing to pay, even for full insurance. As the unfair-but-full contract $F$ becomes progressively more unfair, it moves left on the income–utility diagram, representing a gradual decline in expected income. If the unfair-but-full contract becomes too unfair, the individual’s expected utility will drop to below her expected utility from the fair-but-partial contract. Graphically, this occurs when $E[U]_{F}$ falls lower than $E[U]_{A}$. At that point, the individual prefers contract $P$ to contract $F$.

We can determine the highest degree of unfairness that the customer is willing to tolerate before switching to the fair-but-partial contract. Figure 7.6 illustrates two contracts such that expected utility from both is equal. The first contract $P$ is the same fair-but-partial contract that we considered before. The second contract $F$ is an unfair-but-full contract that leaves the customer indifferent between $P$ and $F$. That is, $E[U]_{P} = E[U]_{F}$.

$F'$ is more unfair than contract $F$ in Figure 7.6; it provides a lower expected utility and income. The individual prefers $P$ to any contract more unfair than $F'$, because $P$ then gives higher expected utility. So $E[U]_{P} - E[U]_{F'}$ is the most that the individual is willing to pay to eliminate uncertainty when the partial insurance contract $P$ is available.

![Figure 7.6. A partial-fair contract $A'$ and a full-unfair contract $A''$ offering the same utility.](image)

7.6 Conclusion

It is surprising how diminishing marginal utility of income goes in explaining the demand for insurance and risk aversion. The theory applies beyond income to many other decisions that people make under uncertainty. Any good or item that has a higher marginal value when you have a little of it than when you have a lot can be the subject of a similar analysis:

- **Mid-twentieth-century singer and actress Marlene Dietrich was famous for her trademark long legs. The insurance exchange Lloyd’s of London organized an insurance policy that would pay out $1,000,000 in case her legs came to harm.**

- **In medieval Europe, peasants who faced climatological uncertainty sought to reduce risk.** Crop yields were "susceptible to a lack of rainfall, too much rainfall, a flooding creek, frost, bugs, molds, and all other manner of shocks" (Bekar 2000). Peasants hedged against uncertainty by scattering their holdings in hills and valleys with different microclimates. They were willing to travel long roads between different parcels to reduce risk of total crop failure.

- **One hypothesized reason for large family sizes in developing countries is high infant mortality risk. According to this hypothesis, children serve as insurance against the vicissitudes of old age. The elderly do not want to be left childless after they are no longer able to work productively. Raising many children may be expensive, but serves as a hedge against this risk.**

Whether the subject is health insurance, Marlene Dietrich’s legs, horticultural strategies in medieval Europe, or family planning in poverty-stricken Mozambique, the basic logic of hedging bets is the same. People are consistently willing to sacrifice utility in the good state in exchange for utility in the bad state. Because we are naturally risk-averse about so many things, insurance is an essential economic tool that arises wherever uncertainty exists.