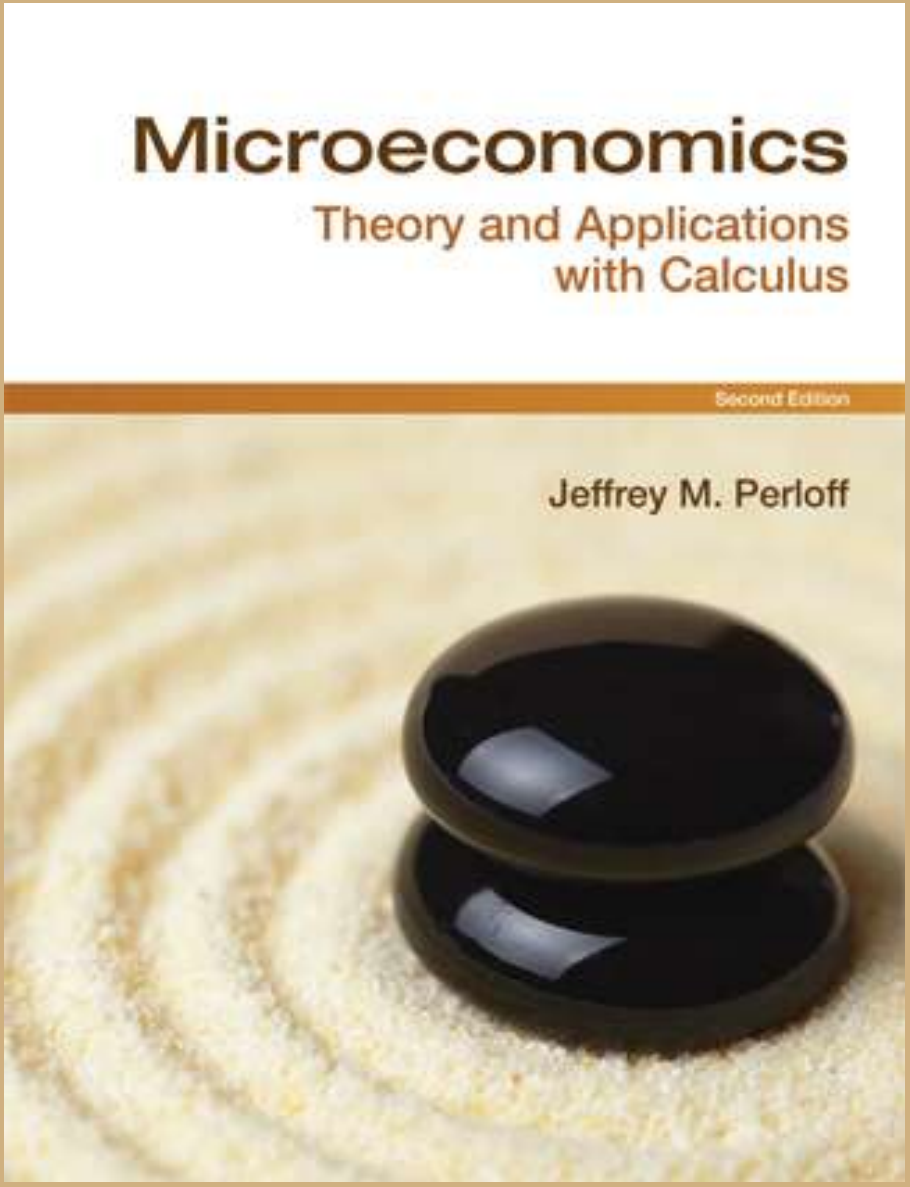
Chapter 16

Uncertainty



We must believe in luck. For how else can we explain the success of those we don't like?

Jean Cocteau

Addison-Wesley
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PEARSON

Chapter 16 Outline

16.1 Degree of Risk

- We incorporate risk and uncertainty into our models of decision making because they can cause consumers and firms to modify decisions about consumption and investment choices.

- ***Risk*** is the when the likelihood of each possible outcome is known or can be estimated, and no single possible outcome is certain to occur.
  - Estimates of how risky each outcome is allows us to estimate the most likely outcome.

16.1 Degree of Risk

- A ***probability*** is a number between 0 and 1 that indicates the likelihood that a particular outcome will occur.

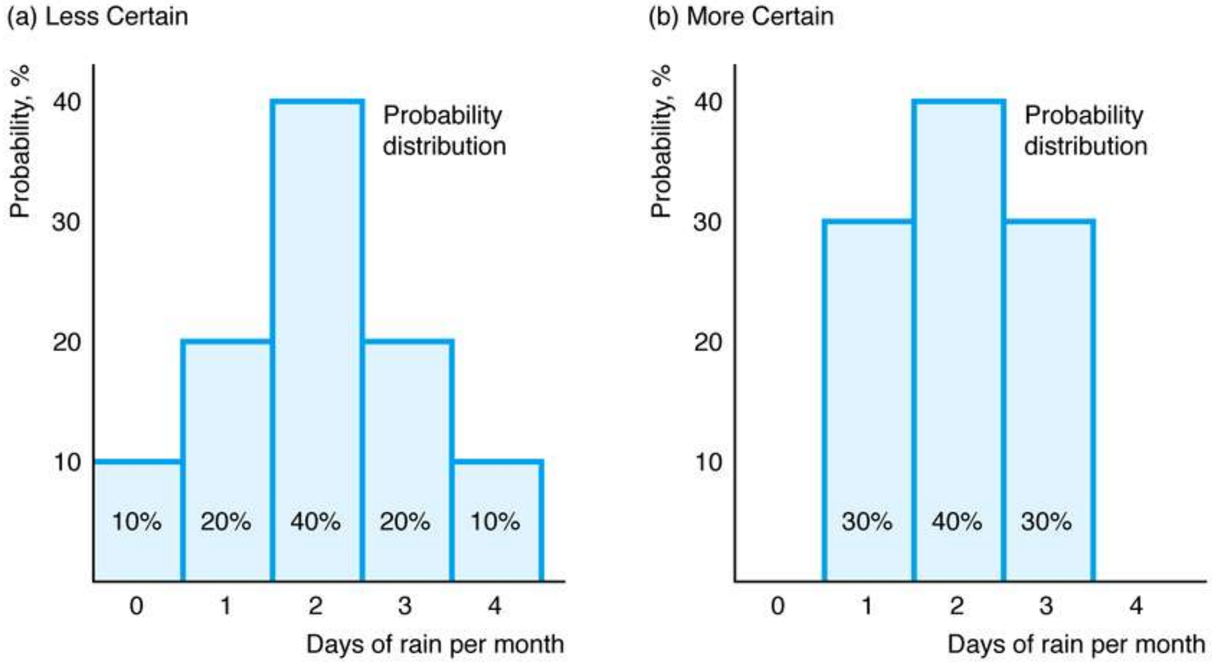
- We can estimate probability with ***frequency***, the number of times that one particular outcome occurred (*n*) out of the total number of times an event occurred (*N*).

$$\theta = \frac{n}{N}$$

- If we don't have a history of the event that allows us to calculate frequency, we can use our best estimate or ***subjective probability***.

16.1 Degree of Risk

- A ***probability distribution*** relates the probability of occurrence to each possible outcome.



16.1 Degree of Risk

- ***Expected value*** is the value of each possible outcome (V_i) times the probability of that outcome (θ_i), summed over all *n* possible outcomes:

$$\mathrm{EV} = \sum_{i=1}^{n} \theta_i V_i$$

- How is expected value used to measure risk?
  - ***Variance*** measures the spread of the probability distribution or how much variation there is between the actual value and the expected value.

$$\text{Variance} = \sum_{i=1}^{n} \theta_i \left(V_i - \mathrm{EV}\right)^2$$

  - ***Standard deviation*** (σ) is the square root of the variance and is a more commonly reported measure of risk.

16.2 Decision Making Under Uncertainty

- Example: Greg schedules an <u>outdoor</u> event
  - If it doesn't rain, he'll make \$15 in profit (e.g. \$150,000)
  - If it does rain, he'll make -\$5 in profit (loss) (e.g. -\$5,000)
  - There is a 50% chance of rain.
- Greg's expected value (outdoor event):

$$EV = [Pr(\text{no rain}) \times \text{Value}(\text{no rain})] + [Pr(\text{rain}) \times \text{Value}(\text{rain})]$$
$$= \left(\tfrac{1}{2} \times \$15\right) + \left[\tfrac{1}{2} \times (-\$5)\right] = \$5$$

- Variance (outdoor event):

$$\sigma^2 = \left[\theta_1 \times (V_1 - EV)^2\right] + \left[\theta_2 \times (V_2 - EV)^2\right]$$
$$= \left[\tfrac{1}{2} \times (\$15 - \$5)^2\right] + \left[\tfrac{1}{2} \times (-\$5 - \$5)^2\right]$$
$$= \left[\tfrac{1}{2} \times (\$10)^2\right] + \left[\tfrac{1}{2} \times (-\$10)^2\right] = \$100.$$

  - Standard deviation = \$10

16.2 Decision Making Under Uncertainty

- Example, continued: Greg schedules an indoor event
  - If it doesn't rain, he'll make \$10 in profit (e.g. \$100,000)
  - If it does rain, he'll make \$0 in profit
  - There is still a 50% chance of rain.
- Greg's expected value (indoor event)… is the same!

$$EV = \left(\tfrac{1}{2} \times \$10\right) + \left(\tfrac{1}{2} \times \$0\right) = \$5$$

- Variance (indoor event)… is much smaller:

$$\sigma^2 = \left[\tfrac{1}{2} \times (\$10 - \$5)^2\right] + \left[\tfrac{1}{2} \times (\$0 - \$5)^2\right]$$
$$= \left[\tfrac{1}{2} \times (\$5)^2\right] + \left[\tfrac{1}{2} \times (-\$5)^2\right] = \$25$$

  - Standard deviation = \$5
  - Much less risky to schedule event indoors!

16.2 Decision Making Under Uncertainty

- Although indoor and outdoor events have the same expected value, the outdoor event involves more risk.
  - He'll schedule the event outdoors only if he likes to gamble.
- People can be classified according to attitudes toward risk.
- A ***fair bet*** is a wager with an expected value of zero.
  - Example: You receive $1 if a flipped coin comes up heads and you pay $1 if a flipped coin comes up tails.
  - Someone who is unwilling to make a fair bet is ***risk averse***.
  - Someone who is indifferent about a fair bet is ***risk neutral***.
  - Someone who is ***risk preferring*** will make a fair bet.

16.2 Decision Making Under Uncertainty

- We can alter our model of utility maximization to include risk by assuming that people maximize *expected utility*.
- Expected utility, *EU*, is the probability-weighted average of the utility, *U*(•) from each possible outcome:

$$\mathrm{E}U = \sum_{i=1}^{n} \theta_i U\left(V_i\right)$$

  - The weights are the probabilities that each state of nature will occur, just as in expected value.

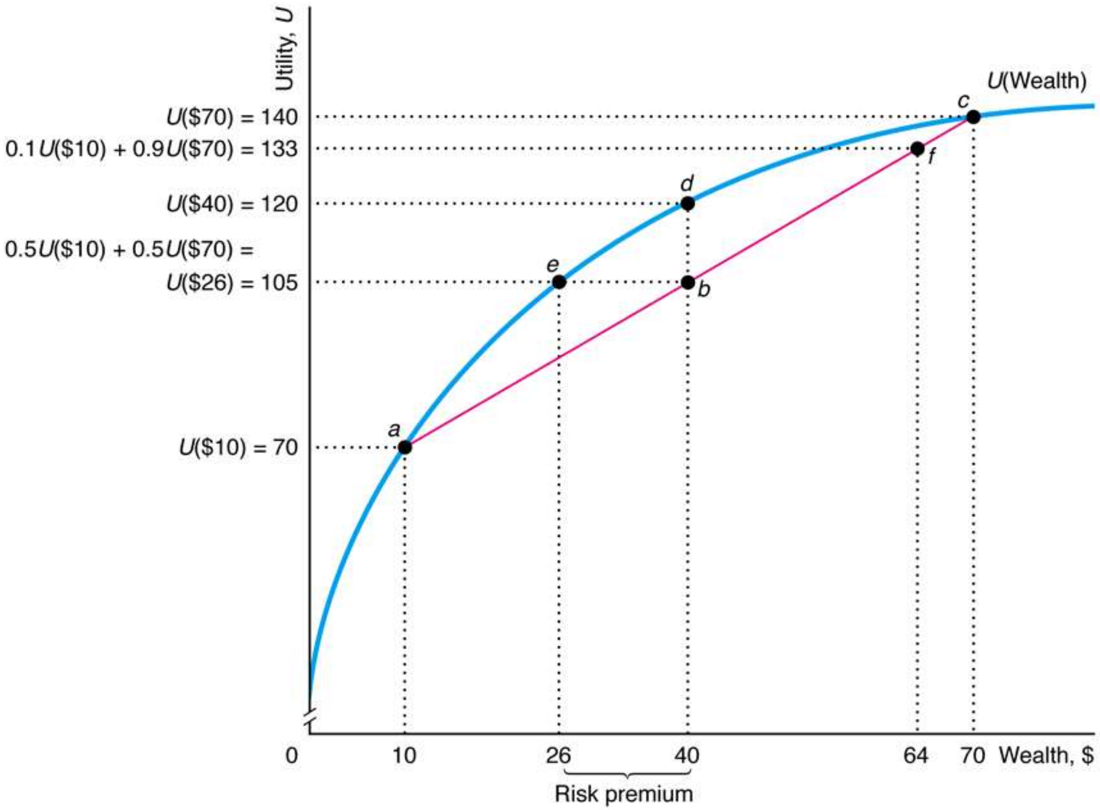
- A person whose utility function is concave picks the less-risky choice if both choices have the same expected value.

16.2 Attitudes Toward Risk

- Example: Risk-averse Irma and wealth
  - Irma has initial wealth of \$40
  - Option 1: keep the \$40 and do nothing → $U(\$40) = 120$
  - Option 2: buy a vase that she thinks is a genuine Ming vase with probability of 50%
    - If she is correct, wealth = \$70 → $U(\$70) = 140$
    - If she is wrong, wealth = \$10 → $U(\$10) = 70$
    - Expected value of wealth remains $\$40 = (½ \cdot \$10) + (½ \cdot \$70)$
    - Expected value of utility is $105 = (½ \cdot 70) + (½ \cdot 140)$
- Although both options have the same expected value of wealth, the option with risk has lower expected utility.

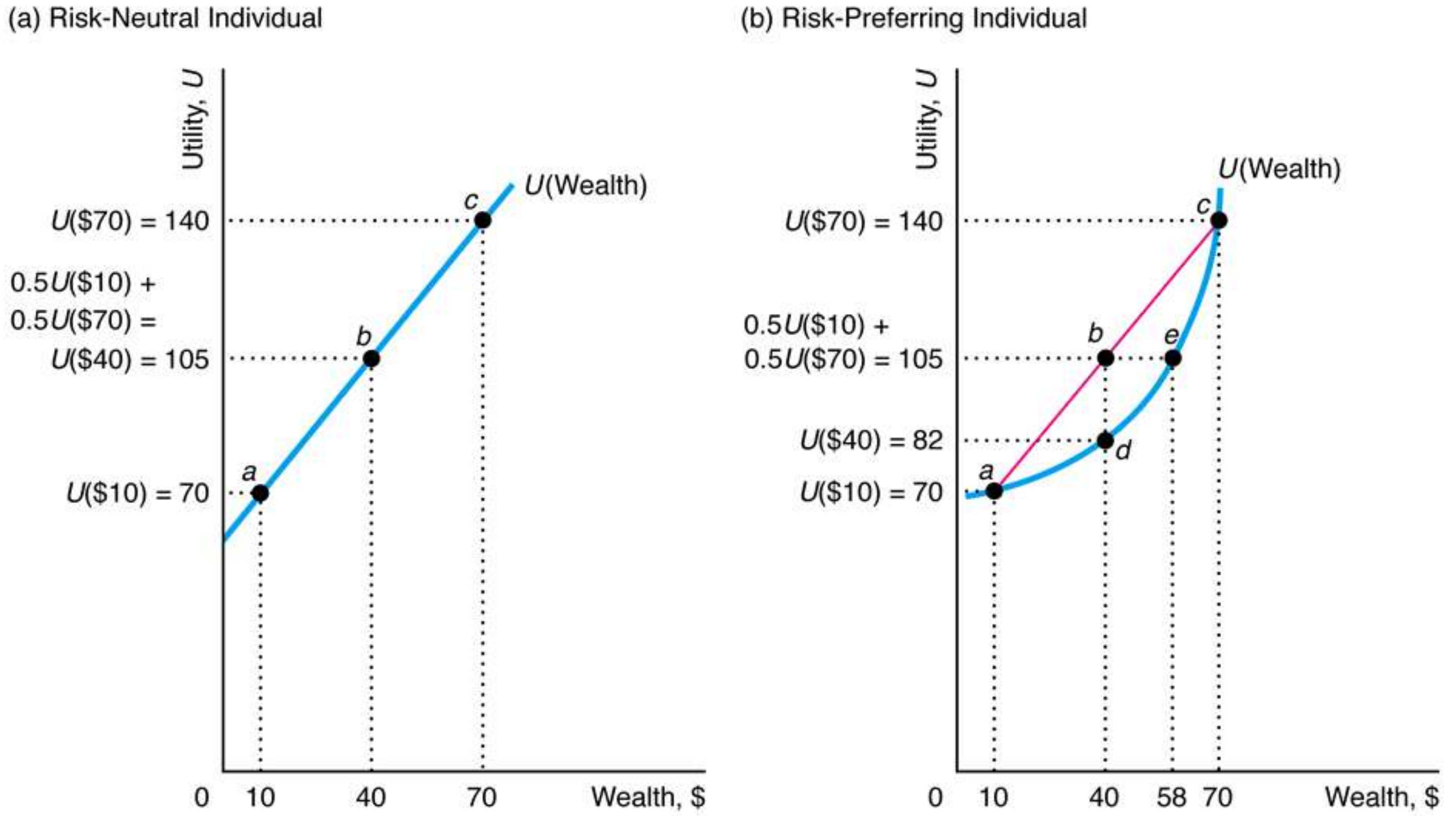
16.2 Attitudes Toward Risk

- Irma is risk-averse and would pay a ***risk premium*** to avoid risk.



16.2 Attitudes Toward Risk

- Risk-neutral and risk-preferring utilities.



16.2 Attitudes Toward Risk

- The degree of risk aversion is judged by the shape of the utility function over wealth, $U(W)$.

- One common measure is the Arrow-Pratt measure of risk aversion:

$$\rho(W) = -\frac{d^2U(W)/dW^2}{dU(W)/dW}$$

  - This measure is positive for risk-averse individuals, zero for risk-neutral individuals, and negative for those who prefer risk.

- The larger the Arrow-Pratt measure, the more small gambles that an individual will take.

16.3 Avoiding Risk

- There are four primary ways for individuals to avoid risk:

1. **Just say no**
   - Abstaining from risky activities is the simplest way to avoid risk.
2. **Obtain information**
   - Armed with information, people may avoid making a risky choice or take actions to reduce probability of a disaster.
3. **Diversify**
   - “Don’t put all your eggs in one basket.”
4. **Insure**
   - Insurance is like paying a risk premium to avoid risk.

16.3 Avoiding Risk Via Diversification

- Diversification can eliminate risk if two events are ***perfectly negatively correlated***.
  - If one event occurs, then the other won't occur.

- Diversification does not reduce risk if two events are ***perfectly positively correlated***.
  - If one even occurs, then the other will occur, too.

- Example: investors reduce risk by buying shares in a mutual fund, which is comprised of shares of many companies.

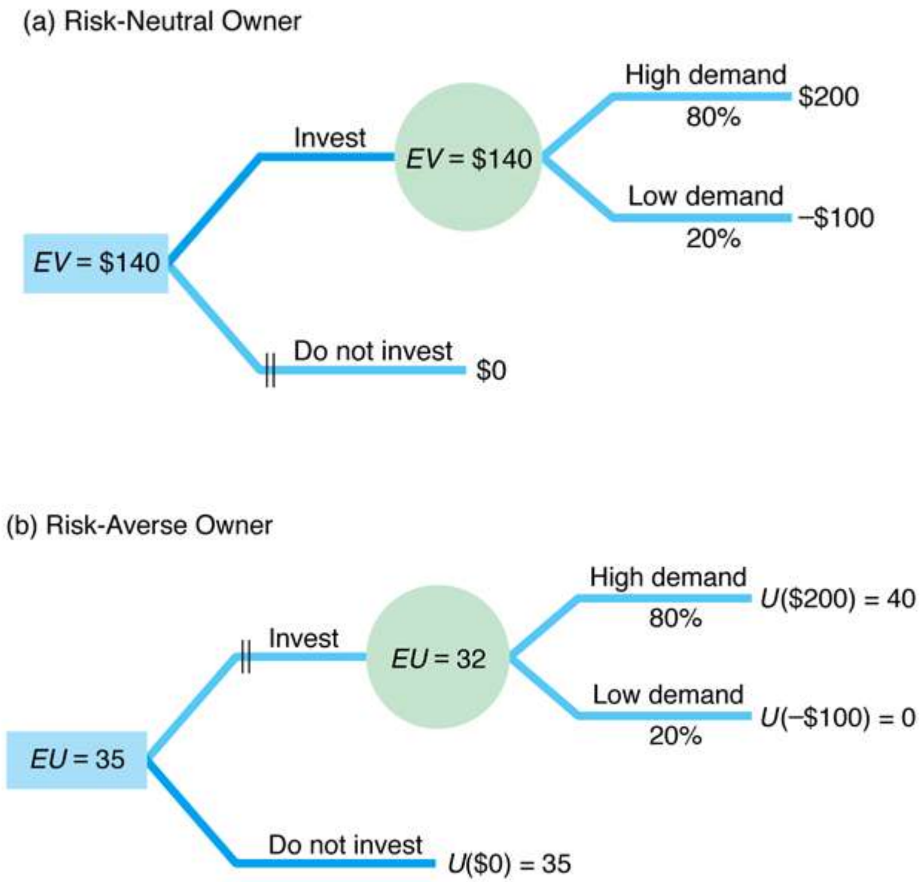
16.3 Avoiding Risk Via Insurance

- A risk-averse individual will ***fully insure*** by buying enough insurance to eliminate risk if the insurance company offers a fair bet, or ***fair insurance***.
  - In this scenario, the expected value of the insurance is zero; the policyholder's expected value with and without the insurance is the same.

- Insurance companies never offer fair insurance, because they would not stay in business, so most people do not fully insure.

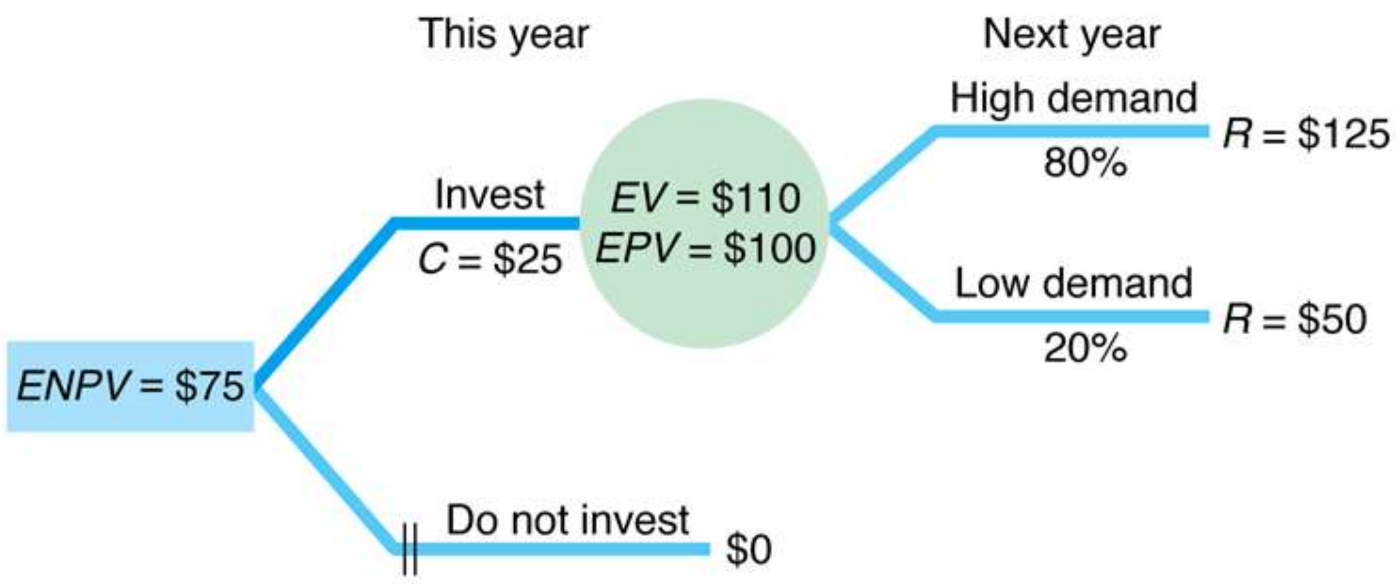
16.4 Investing Under Uncertainty

- **Risk-neutral**
  - Owner invests if the expected value of the return from investment is positive
- **Risk-averse**
  - Owner invests if the expected value of the investment exceeds the expected value of not investing



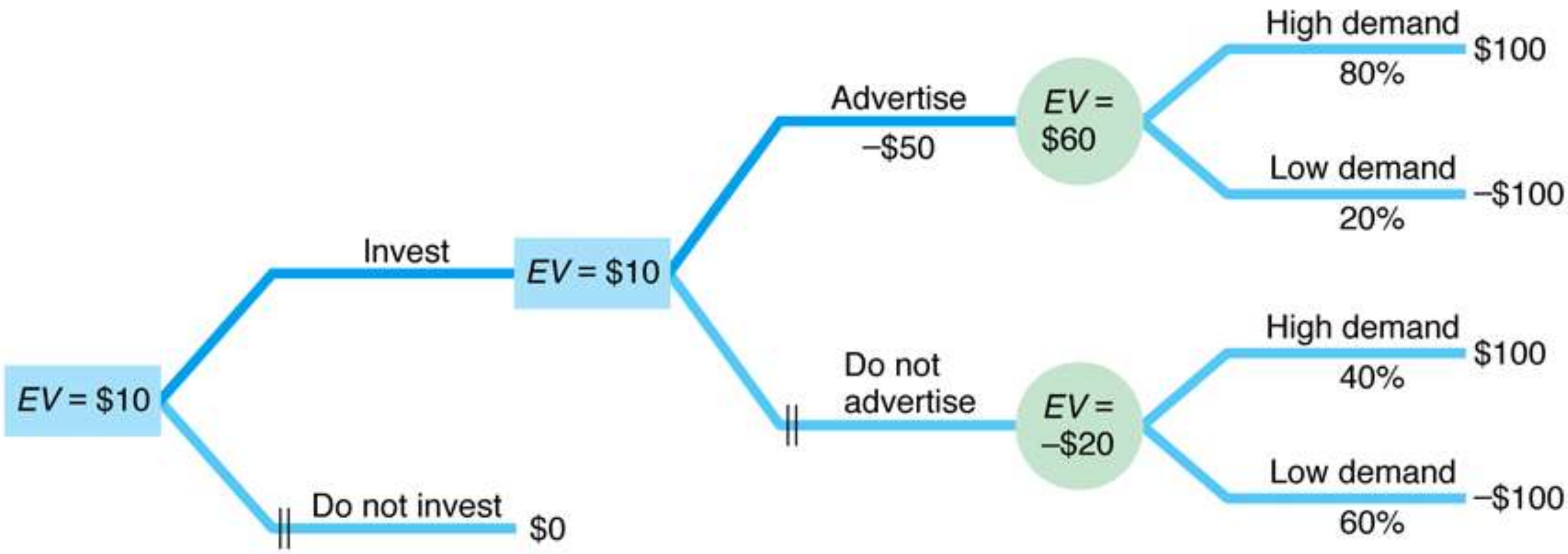
16.4 Investing with Uncertainty and Discounting

- A risk-neutral owner invests if the expected net present value of the return from investment is positive



16.4 Investing with Altered Probabilities

- A risk-neutral owner can incur an additional cost through advertising to alter the probability of high demand.



16.5 Behavioral Economics of Risk

- Why do many individuals make choices under uncertainty that are inconsistent with the predictions of expected utility theory?
  1. Difficulty assessing probabilities
     - Gambler's fallacy
     - Overconfidence
  2. Behavior varies with circumstances
     - Low-probability gambles
     - Certainty effect
  3. Prospect theory

- We briefly discuss each of these explanations.

16.5 Behavioral Economics of Risk

- People often have mistaken beliefs about the probability that an event will occur.

- The ***gambler's fallacy*** arises from the false belief that past events affect current, independent outcomes.
  - Example: flipping 'heads' 10 times in a row does not change the probability of getting 'heads' on the next flip from 50%.

- Some people engage in risky gambles because they are overconfident.
  - Surveys of gamblers reveal big gap between estimated chance of winning a bet and objective probability of winning.

16.5 Behavioral Economics of Risk

- Some people's choices vary with circumstances.
- Otherwise risk-averse people (who buy insurance!) will buy a lottery ticket, despite the fact that it is an unfair bet.
  - Utility function is risk averse in some regions, risk preferring in others.
- Many people put excessive weight on outcomes they consider to be certain relative to risky outcomes (*certainty effect*).
- Many people reverse their preferences when a problem is *framed* in a different but equivalent way.
  - Attitudes toward risk are reversed for gains versus losses.

16.5 Behavioral Economics of Risk

- ***Prospect theory*** is an alternative theory (to expected utility theory) of decision making under uncertainty.
  - People are concerned about gains and losses in wealth (rather than the level of wealth as in expected utility theory)
- The prospect theory value function is S-shaped and has three properties:
  1. **Passes through origin**: gains/losses determined relative to initial situation
  2. **Concave to horizontal axis**: less sensitivity to changes in large gains than small ones
  3. **Curve is asymmetric**: people treat gains and losses differently.

16.5 Behavioral Economics of Risk

- Prospect Theory Value Function