This is a sample of the instructor resources for *Economics for Healthcare Managers, Second Edition* by Robert Lee. This sample contains the instructor notes and PowerPoint slides for Chapter 4.

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Chapter 4: Describing, Evaluating, and Managing Risk

**Key Concepts**
- Clinical and managerial decisions typically entail uncertainty about what will happen.
- Decision makers often have imprecise estimates of the probabilities of various outcomes.
- Decision making about risk involves describing, evaluating, and managing potential outcomes.
- Insurance and diversification are two ways to manage risk.

**Homework**

4.1 Five of ten people earn $0, four earn $100, and one loses $100. What is the expected payoff? What is the variance of the payoff? *An average is the sum of the earnings divided by the number of observations. In this case, ten people have total earnings of $300, so the average is $30. A variance is the squared difference between each observation and the average, weighted by the share of observations with a value.*

<table>
<thead>
<tr>
<th>Person</th>
<th>Earnings ($)</th>
<th>( p \times (Earnings - Average)^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>$90</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
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</tr>
<tr>
<td>3</td>
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</tr>
<tr>
<td>4</td>
<td>0</td>
<td>$90</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>$90</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>$490</td>
</tr>
<tr>
<td>7</td>
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<td>8</td>
<td>100</td>
<td>$490</td>
</tr>
<tr>
<td>9</td>
<td>100</td>
<td>$490</td>
</tr>
<tr>
<td>10</td>
<td>(100)</td>
<td>$1,690</td>
</tr>
</tbody>
</table>

**Average** = $30

**Variance** = 4,100
4.2 There is a 50 percent chance of making $0, a 40 percent chance of making $100, and a 10 percent chance of losing $100. Calculate the expected value and variance of the payoff. How does your estimate compare to the previous problem? Your answer is the same, as 
\[
0.5 \times 0 + 0.4 \times 100 - 0.1 \times 100 = 30.
\]
The variance is 
\[
4,100 = 0.5 \times (0 - 30)^2 + 0.4 \times (100 - 30)^2 + 0.1 \times (-100 - 30)^2.
\]

4.3 There is a 1 percent chance that you will have healthcare bills of $100,000; a 19 percent chance that you will have healthcare bills of $10,000; a 60 percent chance that you will have healthcare bills of $500; and a 20 percent chance that you will have healthcare bills of $0. What is your expected healthcare spending? Your expected spending is 
\[
3,200 = 0.01 \times 100,000 + 0.19 \times 10,000 + 0.60 \times 500 + 0.20 \times 0.
\]

4.4 There is a 1 percent chance that you will have healthcare bills of $100,000; a 19 percent chance that you will have healthcare bills of $10,000; a 60 percent chance that you will have healthcare bills of $500; and a 20 percent chance that you will have healthcare bills of $0. What will your expected insurance benefits be? Would you be willing to buy complete insurance coverage if it cost $3,712? Explain. Your expected spending is 
\[
3,200 = 0.01 \times 100,000 + 0.19 \times 10,000 + 0.60 \times 500 + 0.20 \times 0.
\]
Because the insurance premium is larger than is your expected spending, you would buy insurance only if you are risk averse.

4.5 Instead of complete insurance, you have a policy with a $5,000 deductible. What will your expected out-of-pocket spending be? What will your expected insurance benefits be? Assuming that the premium equals 116 percent of expected insurance benefits, do you prefer the policy with a $5,000 deductible or complete coverage? Explain. Your expected out-of-pocket spending will be 
\[
1,300 = 0.01 \times 5,000 + 0.19 \times 5,000 + 0.60 \times 500.
\]
Your expected insurance benefits will be 
\[
1,900 = 0.01 \times 95,000 + 0.19 \times 5,000.
\]
Your premium will be 
\[
2,204 = 1.16 \times 1,900.
\]
Which policy you will choose is not clear. The policy with a $5,000 deductible costs significantly less than does the complete coverage policy, but it also exposes you to more risk.
<table>
<thead>
<tr>
<th>Probability</th>
<th>Spending</th>
<th>Benefits</th>
<th>Out-of-Pocket Spending</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>$100,000</td>
<td>$95,000</td>
<td>$5,000</td>
</tr>
<tr>
<td>19%</td>
<td>$10,000</td>
<td>$5,000</td>
<td>$5,000</td>
</tr>
<tr>
<td>60%</td>
<td>$500</td>
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<td>$500</td>
</tr>
<tr>
<td>20%</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>

4.6 Your firm, which operates a nationwide system of cancer clinics, has annual profits of $800 million and cash reserves of $500 million. Your clinics have a replacement value of $200 million, and fire insurance for them would cost $5 million per year. Actuarial data show that your expected losses due to fire are $4 million. Should you buy insurance? *Assuming that your firm is risk neutral, you would not buy fire insurance. Insurance would cost $5 million, and your expected loss is $4 million. Even multiple fires would not significantly reduce your profits or exhaust your firm’s reserves, so not buying insurance makes sense.*

4.7 Your firm rents a supply management system to hospitals. You have received a buyout offer of $5 million. You forecast that there is a 25 percent chance that you will have profits of $10 million, a 35 percent chance that you will have profits of $6 million, and a 40 percent chance that you will have profits of $2 million. Should you accept the offer? Explain. *Your expected profit is $5.4 million = 0.25 × $10,000,000 + 0.35 × $6,000,000 + 0.4 × $2,000,000. As expected profits exceed the offer, you would accept it only if you were risk averse. Risk aversion means preferring a sure $5 million to a risky $5.4 million.*

4.8 You were given a lottery ticket. The drawing will be held in 5 minutes. You have a 0.1 percent chance of winning $10,000. You refuse an offer of $11 for your ticket. Are you risk averse? Explain. *You are not risk averse. The expected value of your ticket is $10 =*
0.001 × $10,000. By refusing a sure offer with a higher expected value, you have revealed that you are a risk seeker.

4.9 Your house is worth $200,000. Your risk of a catastrophic flood is 0.5 percent. Such a flood would destroy your house and would not be covered by homeowner’s insurance. Although you grumble, you buy flood coverage for $1,200. Are you risk averse or risk seeking? Your expected loss is $1,000 = 0.005 × $200,000. Because you prefer a sure loss of $1,200 to a risky loss of $1,000, you are risk averse.

4.10 Your firm faces considerable revenue uncertainty because you have to negotiate contracts with several customers. You forecast that there is a 20 percent chance that your revenues will be $200,000, a 30 percent chance that your revenues will be $300,000, and a 50 percent chance that your revenues will be $500,000. Your costs are also uncertain, as the prices of your supplies fluctuate considerably. You forecast that there is a 40 percent chance that your costs will be $400,000 and a 60 percent chance your costs will be $250,000. Use Excel to set up a decision tree for your profit forecast (it does not matter whether costs or revenues come first). How many possible profit outcomes do you have? What is your expected profit? You have identified six possible outcomes, and your expected profit is $70,000.

<table>
<thead>
<tr>
<th>Cost</th>
<th>Revenue</th>
<th>Profit</th>
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</thead>
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<tr>
<td>$200,000</td>
<td>−$200,000</td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>$400,000</td>
<td>$300,000</td>
<td>−$100,000</td>
</tr>
<tr>
<td>0.4</td>
<td>0.3</td>
<td>0.12</td>
</tr>
<tr>
<td>$500,000</td>
<td>$100,000</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>0.2</td>
<td></td>
</tr>
</tbody>
</table>
Your firm has been sued for $3 million by a supplier for breach of contract. Your lawyers believe that there are three possible outcomes if the suit goes to trial. One, which the lawyers term “highly improbable,” is that your supplier will win the lawsuit and be awarded $3 million. Another, which the lawyers term “unlikely,” is that your supplier will win the lawsuit and be awarded $500,000. The third, which the lawyers term “likely,” is that your supplier will lose the lawsuit and be awarded $0. You have to decide whether to try to settle the case. To do so you need to assign probabilities to “highly improbable,” “unlikely,” and “likely.” What probabilities correspond to these statements?

Going to trial will cost you $100,000 in legal fees. One of your lawyers believes that your supplier will settle for $100,000 (and you will have legal fees of $25,000). Should you settle? It is not clear what probabilities correspond to these statements, and different people will have different ideas about what they are. Settling will cost you $125,000. Going to court will cost you $100,000. Assume for the moment that a highly improbable outcome is half as likely as an unlikely outcome. If an unlikely outcome has more than a 0.005 chance of happening, settling will be less expensive.
Additional Discussion Questions

- What traits characterize someone who is risk averse? A risk-averse individual is willing to pay to reduce risk. Because insurance premiums cost more than do the expected losses they cover, only risk-averse individuals buy insurance.

- Finance analysts argue that publicly traded firms should be risk neutral or risk seeking because their owners can diversify away most risks by holding diversified portfolios. Does the same logic hold for the managers of these organizations? No. Managers’ portfolios of jobs are not diversified. They are apt to face real costs if the firm experiences significant losses as a result of risk taking.

- Most large employers self-insure for health insurance claims. Most small employers do not. Why is self-insurance more attractive to large employers? Large firms submit enough claims to significantly reduce their spending variability.

- Why is a variance a better way to describe risk than is a range? Why is it a worse way? Variance better describes risk because it looks at the entire distribution of outcomes, not just the extremes. It describes risk poorly because it tends not to convey much meaning to observers who are not accustomed to working with variances.

- What sort of concrete strategies could the CEO of a healthcare system adopt to reduce the risks facing her organization? The CEO could sponsor a diversified array of innovations, operating on the premise that some are likely to succeed and some are likely to fail. The CEO could further reduce risk by working with partners, sharing both the risk and profits.
How to Describe Risky Outcomes

• Describe probabilities.
  – Subjective probabilities
  – Objective probabilities

• Value possible outcomes.
  – Monetary value
  – Utility
Probabilities:
Subjective Versus Objective

• Examples of objective probabilities:
  – In 2004, 380 people per 100,000 filed for bankruptcy, so $p = 0.0038$.
  – SEER data show one new case of prostate cancer per 1,439 people, so $p = 0.0007$.

• Examples of subjective probabilities:
  – In Nevada, bankruptcy rates have typically been above average, so $p > 0.0038$.
  – Several people in your family have had prostate cancer, so $p > 0.07\%$. 
Which would be more useful in decision making?

• A firm estimate of $p = .0038$.
  – Based on good evidence
  – Objective
  – Not applicable to this population

• A fuzzy estimate of $p = \text{about .01}$. 
  – Not based on good evidence
  – Consistent with what we know
  – Based on the judgment of the decision maker
How to Describe Risky Outcomes

• Calculate descriptive statistics.
  – Expected value
  – Variability
Expected value $= E(X)$

- $E(X) = P_1 \times X_1 + \ldots + P_n \times X_n$
  - $P_k = \text{probability of state } k$
  - $X_k = \text{value in state } k$

- The expected value need not be
  - the most likely outcome, or
  - even a possible outcome.
Outcome variability measures are helpful only in making comparisons.

• Measured by:
  – Range of outcomes
  – Variance
  – Standard deviation
  – Coefficient of variation

• If you are not comparing outcomes, measures of variability are not helpful.
<table>
<thead>
<tr>
<th>Option A</th>
<th>Option B</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>7</td>
<td>.5</td>
</tr>
<tr>
<td>2</td>
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<td>.3</td>
</tr>
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<td>1</td>
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</table>
Variance = \( V(X) \)

- \( V(X) = P_1 \times (X_1 - E(X))^2 + \ldots + P_n \times (X_n - E(X))^2 \)

- A larger \( V(X) \) means higher risk only when expected values are the same.
One scenario is more risky than another with the same expected value if any of the following is true:

• The variance is larger.
• The standard deviation is larger.
• The coefficient of variation is larger.
• The range is larger.
Which option is riskier, A or B?

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Which option is riskier, A or B?

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<td>.3</td>
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<tr>
<td>1</td>
<td>2</td>
<td>.2</td>
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</tbody>
</table>

3.8 10.8 = Expected value

4.96 31.36 = Variance

2.23 5.6 = Standard deviation

.59 .52 = Coefficient of variation
Risk preferences are about attitudes toward variability.

- A risk-seeking person prefers more.
- A risk-neutral person does not care.
- A risk-averse person prefers less.
Which option would a risk seeker choose? Which option would a risk averter choose?

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