Managerial Economics in a Global Economy, 5th Edition
by Dominick Salvatore

Chapter 13
Risk Analysis
Risk and Uncertainty

• Risk
  – Situation where there is more than one possible outcome to a decision and the probability of each outcome is known

• Uncertainty
  – Situation where there is more than one possible outcome to a decision and the probability of each outcome is unknown
Measuring Risk
Probability Distributions

• Probability
  – Chance that an event will occur

• Probability Distribution
  – List of all possible events and the probability that each will occur

• Expected Value or Expected Profit

\[ E(\pi) = \bar{\pi} = \sum_{i=1}^{n} \pi_i \cdot P_i \]
# Measuring Risk

## Probability Distributions

### Calculation of Expected Profit

<table>
<thead>
<tr>
<th>Project</th>
<th>State of Economy</th>
<th>Probability (P)</th>
<th>Outcome (π)</th>
<th>Expected Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Boom</td>
<td>0.25</td>
<td>$600</td>
<td>$150</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>0.50</td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>Recession</td>
<td>0.25</td>
<td>400</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Expected profit from Project A</td>
<td></td>
<td></td>
<td>$500</td>
</tr>
<tr>
<td>B</td>
<td>Boom</td>
<td>0.25</td>
<td>$800</td>
<td>$200</td>
</tr>
<tr>
<td></td>
<td>Normal</td>
<td>0.50</td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>Recession</td>
<td>0.25</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Expected profit from Project B</td>
<td></td>
<td></td>
<td>$500</td>
</tr>
</tbody>
</table>
Measuring Risk
Probability Distributions

• Discrete Probability Distribution
  – List of individual events and their probabilities
  – Represented by a bar chart or histogram

• Continuous Probability Distribution
  – Continuous range of events and their probabilities
  – Represented by a smooth curve
Measuring Risk
Probability Distributions

Discrete Probability Distributions

Project A; $E(\pi) = 500$, Low Risk

Project B: $E(\pi) = 500$, High Risk
Measuring Risk
Probability Distributions

Continuous Probability Distributions

Project A: $E(\pi) = 500$, Low Risk
Project B: $E(\pi) = 500$, High Risk
Measuring Risk
Probability Distributions

An Absolute Measure of Risk: The Standard Deviation

\[ \sigma = \sqrt{\sum_{i=1}^{n} (X_i - \bar{X})^2 \cdot P_i} \]
Measuring Risk
Probability Distributions

Calculation of the Standard Deviation
Project A

\[ \sigma = \sqrt{(600 - 500)^2 (0.25) + (500 - 500)^2 (0.50) + (400 - 500)^2 (0.25)} \]

\[ \sigma = \sqrt{5,000} = $70.71 \]
Measuring Risk
Probability Distributions

Calculation of the Standard Deviation
Project B

\[ \sigma = \sqrt{(800 - 500)^2 (0.25) + (500 - 500)^2 (0.50) + (200 - 500)^2 (0.25)} \]

\[ \sigma = \sqrt{45,000} = $212.13 \]
Measuring Risk
Probability Distributions

The Normal Distribution

$$Z = \frac{\pi_i - \bar{\pi}}{\sigma}$$
Measuring Risk
Probability Distributions

A Relative Measure of Risk: The Coefficient of Variation

\[ \nu = \frac{\sigma}{\pi} \]

Project A

\[ \nu_A = \frac{70.71}{500} = 0.14 \]

Project B

\[ \nu_B = \frac{212.13}{500} = 0.42 \]
Utility Theory

• Risk Averse
  – Must be compensated for taking on risk
  – Diminishing marginal utility of money

• Risk Neutral
  – Are indifferent to risk
  – Constant marginal utility of money

• Risk Seeking
  – Prefer to take on risk
  – Increasing marginal utility of money
Utility Theory

![Utility of money vs. Money or wealth graph](image.png)

- Increasing
- Constant
- Diminishing marginal utility
Utility Theory

Utility Function of a Risk Averse Manager
Adjusting Value for Risk

- Value of the Firm = Net Present Value

\[ NPV = \sum_{t=1}^{n} \frac{\pi_t}{(1 + r)^t} \]

- Risk-Adjusted Discount Rate

\[ k = r + \text{Risk Premium} \quad NPV = \sum_{t=1}^{n} \frac{\pi_t}{(1 + k)^t} \]
Adjusting Value for Risk
Adjusting Value for Risk

• Certainty Equivalent Approach

\[ NPV = \sum_{t=1}^{n} \frac{\alpha R_t}{(1 + r)^t} \]

• Certainty Equivalent Coefficient

\[ \alpha = \frac{\text{equivalent certain sum}}{\text{expected risky sum}} = \frac{R_t^*}{R_t} \]
Other Techniques

• Decision Trees
  – Sequence of possible managerial decisions and their expected outcomes
  – Conditional probabilities

• Simulation
  – Sensitivity analysis
Uncertainty

• Maximin Criterion
  – Determine worst possible outcome for each strategy
  – Select the strategy that yields the best of the worst outcomes
Uncertainty: Maximin

The payoff matrix below shows the payoffs from two states of nature and two strategies.

<table>
<thead>
<tr>
<th>State of Nature</th>
<th>Strategy</th>
<th>Success</th>
<th>Failure</th>
<th>Maximin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invest</td>
<td></td>
<td>20,000</td>
<td>-10,000</td>
<td>-10,000</td>
</tr>
<tr>
<td>Do Not Invest</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Uncertainty: Maximin

The payoff matrix below shows the payoffs from two states of nature and two strategies.

For the strategy “Invest” the worst outcome is a loss of 10,000. For the strategy “Do Not Invest” the worst outcome is 0. The maximin strategy is the best of the two worst outcomes - Do Not Invest.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>State of Nature</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Success</td>
<td>Failure</td>
<td>Maximin</td>
</tr>
<tr>
<td>Invest</td>
<td>20,000</td>
<td>-10,000</td>
<td>-10,000</td>
</tr>
<tr>
<td>Do Not Invest</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Uncertainty: Minimax Regret

The payoff matrix below shows the payoffs from two states of nature and two strategies.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>State of Nature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Success</td>
</tr>
<tr>
<td>Invest</td>
<td>20,000</td>
</tr>
<tr>
<td>Do Not Invest</td>
<td>0</td>
</tr>
</tbody>
</table>
Uncertainty: Minimax Regret

The regret matrix represents the difference between the given strategy and the payoff of the best strategy under the same state of nature.

<table>
<thead>
<tr>
<th>State of Nature</th>
<th>Regret Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy</td>
<td>Success</td>
</tr>
<tr>
<td>Invest</td>
<td>20,000</td>
</tr>
<tr>
<td>Do Not Invest</td>
<td>0</td>
</tr>
</tbody>
</table>
Uncertainty: Minimax Regret

For each strategy, the maximum regret is identified. The minimax regret strategy is the one that results in the minimum value of the maximum regret.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>State of Nature</th>
<th>Regret Matrix</th>
<th>Maximum Regret</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invest</td>
<td>Success 20,000</td>
<td>Success 0</td>
<td>10,000</td>
</tr>
<tr>
<td></td>
<td>Failure -10,000</td>
<td>Failure 10,000</td>
<td></td>
</tr>
<tr>
<td>Do Not Invest</td>
<td>0</td>
<td>20,000</td>
<td>20,000</td>
</tr>
</tbody>
</table>
Uncertainty: Informal Methods

- Gather Additional Information
- Request the Opinion of an Authority
- Control the Business Environment
- Diversification
Foreign-Exchange Risk

• Foreign-Exchange Rate
  – Price of a unit of a foreign currency in terms of domestic currency

• Hedging
  – Covering foreign exchange risk
  – Typically uses forward currency contracts
Foreign-Exchange Risk

• Forward Contract
  – Agreement to purchase or sell a specific amount of a foreign currency at a rate specified today for delivery at a specified future date.

• Futures Contract
  – Standardized, and more liquid, type of forward contract for predetermined quantities of the currency and selected calendar dates.
Information and Risk

• Asymmetric Information
  – Situation in which one party to a transaction has less information than the other with regard to the quality of a good

• Adverse Selection
  – Problem that arises from asymmetric information
  – Low-quality goods drive high-quality goods out of the market
Information and Risk

• Moral Hazard
  – Tendency for the probability of loss to increase when the loss is insured

• Methods of Reducing Moral Hazard
  – Specifying precautions as a condition for obtaining insurance
  – Coinsurance