Chapter 14

Risk and Uncertainty

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Risk and Uncertainty

- Risk versus Uncertainty
- Sources of Business Risk
- The Measures of Risk
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Risk Versus Uncertainty

Risk refers to a situation in which possible future events can be defined and probabilities assigned.

Uncertainty refers to situations in which there is no viable method of assigning probabilities to future random events.

Risk Versus Uncertainty

Probabilities can be:

- a priori – obtained by repetition or based on general mathematical principles
- statistical – empirical, based on past events

Sources of Business Risk

- General economic conditions
- Industry-wide fluctuations
- Actions of competitors
- Technology
- Consumer demand
- Prices of factors of production
  - Materials
  - Services
  - Labor

The Measures of Risk

Probability: An expression of the chance that a particular event will occur

The probabilities of all possible events sum to 1.

Probability distribution: describes, in percentage terms, the chances of all possible occurrences

The Measures of Risk

Probability Distribution

Cash Inflow	Probability
3,000	0.1
4,000	0.2
5,000	0.4
6,000	0.2
7,000	0.1

The Measures of Risk

Expected value: The average of all possible outcomes weighted by their respective probabilities

$$\overline{R} = \sum_{i=1}^{n} R_i p_i$$

$\overline{R}$ = Expected value

p_i = probability in case i

n = number of possible outcomes

R_i = value in case i

The Measures of Risk

The **standard deviation** reflects the variation of possible outcomes from the average.

$$\sigma = \sqrt{\sum_{i=1}^{n} (R_i - \bar{R})^2 p_i}$$

The Measures of Risk

Based on statistical theory describing the normal curve:

- 34% of possible occurrences will be within 1 standard deviation of the mean.
- 47.4% will be within 2 standard deviations.
- 49.9% will be within 3 standard deviations.

The Measures of Risk

Businesspeople tend to be **risk averse**, therefore if the expected values of two projects are the same, the one with the lower risk (lower standard deviation) would be accepted.

The Measures of Risk

Coefficient of Variation: A measure of risk relative to expected value

CV is used to compare standard deviations or projects with unequal expected values.

$$CV = \sigma / \overline{R}$$

σ = standard deviation $\overline{R}$ = expected value

Capital Budgeting under Conditions of Risk

To incorporate risk into a capital budgeting problem:

1. Calculate expected NPV
2. Calculate the standard deviation of NPV

Capital Budgeting under Conditions of Risk

$$\overline{\overline{\text{NPV}}} = \sum_{t=1}^{n} \frac{\overline{R}_t}{(1+r_f)^t} - O_0$$

NPV = Expected net present value

O_0 = initial investment

r_f = risk-free interest rate

$\overline{R}_t$ = expected value of cash flows in period

t = time period

n = final year of the project

Capital Budgeting under Conditions of Risk

$$\sigma = \sqrt{\sum_{t=1}^{n} \frac{\sigma_t^2}{(1+r_f)^{2t}}}$$

σ = standard deviation of NPV

σ_t = standard deviation of cash flow in period t

Two Other Methods

Two common techniques for accounting for risk without the use of standard deviation are:

1. Risk-adjusted discount rate
2. Certainty equivalent

Two Other Methods

Risk-Adjusted Discount Rate (RADR): A value equal to the risk-free interest rate plus a risk premium.

The risk premium represents a judgment as to the additional return necessary to compensate for additional risk.

With the RADR method, the risk adjustment is made in the denominator of the present-value calculation.

Two Other Methods

Risk adjusted discount rate

$$K = r_f + RP$$

K = risk adjusted discount rate

r_f = risk-free rate (short-term U.S. Treasury securities)

RP = risk premium

Two Other Methods

Certainty Equivalent: a certain (risk-free) cash flow that would be acceptable as opposed to the expected value of a risky cash flow.

With the Certainty Equivalent method, the risk adjustment is made in the numerator of the present-value calculation.

Two Other Methods

Certainty Equivalent

$$r_{ce} = r_r \times CEF$$

r_{ce} = value of certain cash flow
r_r = value of risky cash flow
CEF = certainty equivalent factor (depends on the decision maker's attitude toward risk)

Two Other Methods

RADR and Certainty Equivalents

The methods arrive at identical results if the calculations and adjustments are made in a consistent manner.

RADR is more frequently used and easier to estimate.

Sensitivity Analysis

Sensitivity Analysis: A method for estimating project risk that involves identifying the key variables that affect the results and then changing each variable to measure the impact.

Sensitivity Analysis

1. Decide on the key factors affecting results.
2. Decide on the range of changes in the variables and on the intervals to use.
3. Compute results for changes in individual variable at each interval.
4. Compare results to determine how sensitive results are to changes in the various key factors.

Sensitivity Analysis

Example

Change (%)	Sales	Sales Price	Cost	Variable Expenses
+40	7,524	15,731	−4,655	2,493
+30	6,531	12,687	−2,603	2,758
+20	5,538	9,642	−552	3,023
+10	4,545	6,597	1,500	3,287
0	3,552	3,552	3,552	3,552
−10	2,559	507	5,604	3,817
−20	1,567	−2,537	7,656	4,082
−30	574	−5,582	9,708	4,347
−40	−419	−8,627	11,760	4,611

Simulation

Simulation Analysis: A method for estimating project risk that assigns a probability distribution to each of the key variables and uses random numbers to simulate a set of possible outcomes to arrive at an expected value and dispersion.

Simulation

1. Assign probability distributions to each of the key variables.
2. Generate a random number for each of the key variables.
3. Calculate NPV based on the assigned probability distribution and the random numbers generated.
4. Repeat a large number of times (1000 or more).
5. Use the trials to form a frequency distribution of NPV's.

Decision Trees

Decision tree: a method for evaluating project risk used with sequential decision making in which a diagram points out graphically the order in which decisions must be made and compares the value of the various actions that can be undertaken.

Decision Trees

Decision points are designated with squares on a decision tree.

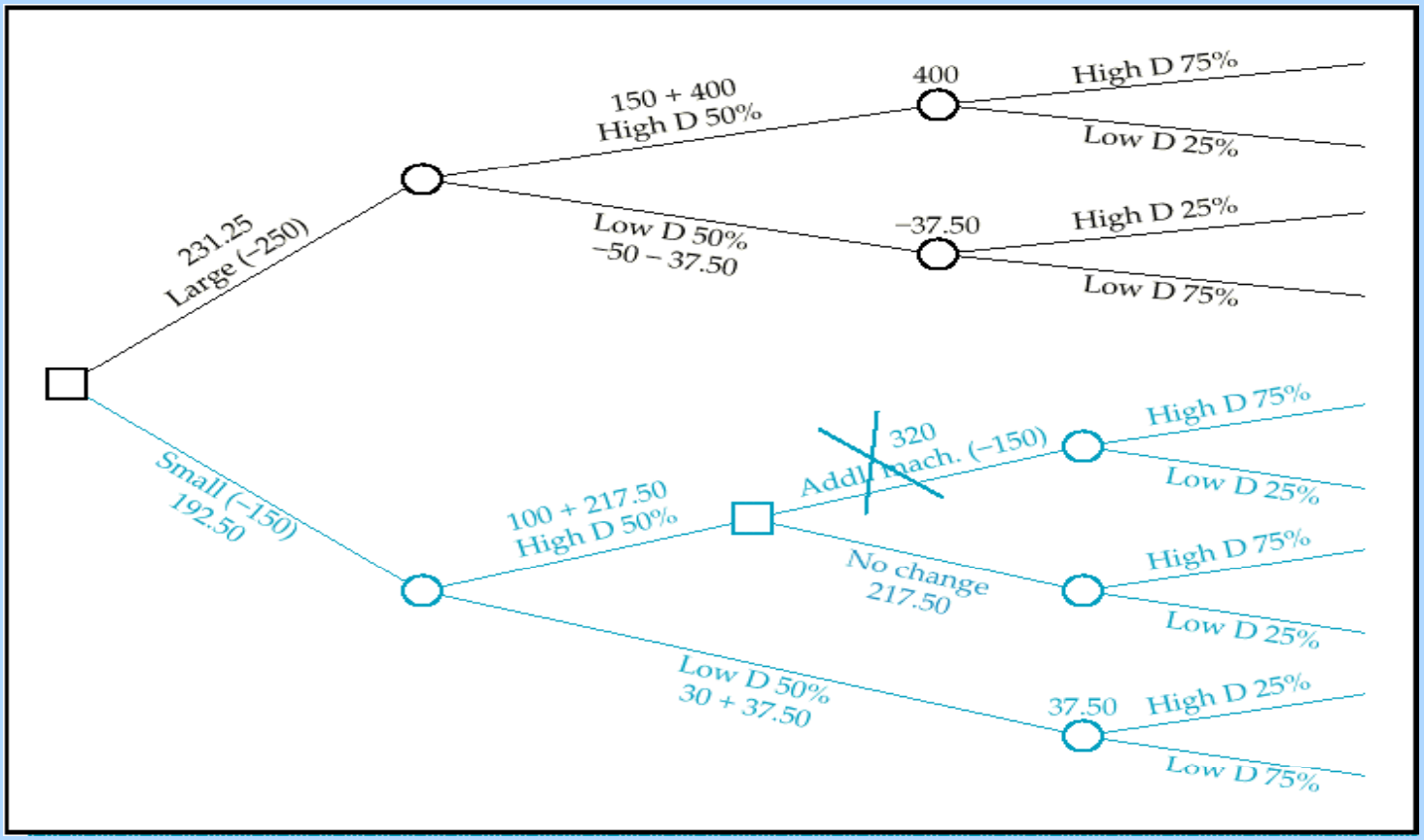
Chance events are designated with circles and are assigned certain probabilities.

Decision Trees

- Convert all flows to present values
- Set up all the branches of the decision tree.
- Move back from right to left, calculating the expected value of each branch.
- Eliminate branches corresponding to poor decisions (i.e. losses).
- Compare the net expected value of the final remaining alternatives to arrive at a solution.

Decision Trees

Example



Real Options in Capital Budgeting

Real Option: An opportunity to make adjustments in a capital budgeting project in response to changing circumstances potentially resulting in improved results.

Real Options in Capital Budgeting

Real options may increase the value of a project.

The value of the option is the difference between the project's value with and without the option.

Value of the project = NPV + option value

Real Options in Capital Budgeting

Forms of real options:

1. Option to vary output
2. Option to vary inputs
3. Option to abandon
4. Option to postpone
5. Option to introduce future products