INTRODUCTION TO RISK AND RETURN IN CAPITAL BUDGETING
Chapters 7-9

WE ALL KNOW: THE GREATER THE RISK THE GREATER THE REQUIRED (OR EXPECTED) RETURN...

...BUT HOW DO WE MEASURE RISK?
An Historical Look at Risk and Return

<table>
<thead>
<tr>
<th>Asset Class</th>
<th>Nominal</th>
<th>Real</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Cap</td>
<td>$2,843</td>
<td>$340</td>
</tr>
<tr>
<td>S &amp; P 500</td>
<td>$ 811</td>
<td>$ 97</td>
</tr>
<tr>
<td>Corporate Bonds</td>
<td>$ 38</td>
<td>$ 4.5</td>
</tr>
<tr>
<td>Treasury Bonds</td>
<td>$ 26</td>
<td>$ 3.1</td>
</tr>
<tr>
<td>T-Bills</td>
<td>$ 12</td>
<td>$ 1.5</td>
</tr>
<tr>
<td>Inflation</td>
<td>$ 7</td>
<td>---</td>
</tr>
</tbody>
</table>

$7 at the end of 1994 had the same purchasing power as $1 at the beginning of 1926

Source: Ibbotson Associates
THE U.S. STOCK MARKET HAS BEEN A PROFITABLE BUT VARIABLE INVESTMENT


ANNUAL MARKET RETURNS IN THE USA 1926 - 1992

Normal distribution is completely defined by its mean and standard deviation.

How much of the area of the curve lies within one standard deviation of the mean?

Within two standard deviations? ...within three?

**MEAN AND STANDARD DEVIATION**

- *mean measures average (or expected return)*

- *standard deviation (or variance) measures the spread or variability of returns*

- *risk averse investors prefer high mean & low standard deviation*
AVERAGE RETURNS AND STANDARD DEVIATIONS
1926 - 1994

<table>
<thead>
<tr>
<th>PORTFOLIO</th>
<th>Average nominal return</th>
<th>Average real return</th>
<th>Average risk premium</th>
<th>Standard deviation of returns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treasury bills</td>
<td>3.7%</td>
<td>0.6%</td>
<td>0%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Government bonds</td>
<td>5.2</td>
<td>2.1</td>
<td>1.4</td>
<td>8.7</td>
</tr>
<tr>
<td>Corporate bonds</td>
<td>5.7</td>
<td>2.7</td>
<td>2.0</td>
<td>8.3</td>
</tr>
<tr>
<td>Common stocks</td>
<td>12.2</td>
<td>8.9</td>
<td>8.4</td>
<td>20.2</td>
</tr>
<tr>
<td>Small-firm stocks</td>
<td>17.4</td>
<td>13.9</td>
<td>13.7</td>
<td>34.3</td>
</tr>
</tbody>
</table>


EXPECTED RETURN ON MARKET PORTFOLIO
(= expected return on average-risk US stock)

Expected market return = current interest rate + expected market risk premium

If expected risk premium = long-run average, then

Expected market return = interest rate + 8.4%
TOTAL RISK (STANDARD DEVIATION) 
FOR COMMON STOCKS, 1988 - 1992

<table>
<thead>
<tr>
<th>Stock</th>
<th>Standard deviation</th>
<th>Stock</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT&amp;T</td>
<td>21.5%</td>
<td>Ford Motor</td>
<td>27.7%</td>
</tr>
<tr>
<td>Bristol-Myers Squibb</td>
<td>18.0</td>
<td>Genentech</td>
<td>33.9</td>
</tr>
<tr>
<td>Delta Airlines</td>
<td>27.7</td>
<td>Microsoft</td>
<td>48.5</td>
</tr>
<tr>
<td>Digital Equipment</td>
<td>35.7</td>
<td>Polaroid</td>
<td>33.6</td>
</tr>
<tr>
<td>Exxon</td>
<td>12.1</td>
<td>Tandem Computer</td>
<td>44.3</td>
</tr>
</tbody>
</table>

Do these seem high? (The standard deviation of the S&P 500 over the same period was 15%.)

HOW DOES DIVERSIFICATION REDUCE RISK?

Return on Security A:

Return on Security B:

Return on Portfolio of A & B
INDIVIDUAL STOCKS HAVE TWO KINDS OF RISK:

MARKET RISK

(OR SYSTEMATIC OR UNDIVERSIFIABLE RISK)  AFFECTS ALL STOCKS

UNIQUE RISK

( OR UNSYSTEMATIC OR DIVERSIFIABLE RISK)  AFFECTS INDIVIDUAL STOCKS OR SMALL GROUPS OF STOCKS (INDUSTRIES)

- UNIQUE RISK OF DIFFERENT FIRMS UNRELATED
- ELIMINATED BY DIVERSIFICATION
ADVANTAGE OF DIVERSIFICATION

SINGLE STOCK
- EXPOSED TO MARKET RISK AND UNIQUE RISK

DIVERSIFIED PORTFOLIO
- ONLY EXPOSED TO MARKET RISK
- MAJOR UNCERTAINTY IS WHETHER MARKET WILL RISE OR FALL
- MOST OF BENEFITS OF DIVERSIFICATION ACHIEVED WITH 10 - 20 STOCKS

RETURNS

<table>
<thead>
<tr>
<th></th>
<th>Recession Prob = .50</th>
<th>Boom Prob = .50</th>
<th>E (R)</th>
<th>o(R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security J</td>
<td>.06</td>
<td>.12</td>
<td>.09</td>
<td>.03</td>
</tr>
<tr>
<td>Security K</td>
<td>.15</td>
<td>.03</td>
<td>.09</td>
<td>.06</td>
</tr>
</tbody>
</table>
EXPECTED PORTFOLIO RETURNS

\[ E(R_p) = x_1 E(R_1) + x_2 E(R_2) \ldots + x_n E(R_n) \]

Expected return of a portfolio is the weighted sum of the expected returns of the individual stocks in the portfolio.

EXAMPLE:

- 60% of portfolio is in Bristol-Myers-Squibb, with an expected return of 15%
- 40% in Ford, with an expected return of 21%
- Expected portfolio return = \( .60 \times .15 + .40 \times .21 \)
  \[ = .174 \text{ or } 17.4\% \]

The variance of a two-stock portfolio is the sum of these four boxes:

\[
\begin{array}{c|c}
X_1^2 \delta_1^2 & X_1 X_2 \rho_{12} \delta_1 \delta_2 \\
\hline
X_1 X_2 \rho_{12} \delta_1 \delta_2 & X_2^2 \delta_2^2
\end{array}
\]

\( \delta_{12} = \text{covariance of returns} \)
\( \rho = \text{correlation of returns} \)
Portfolio Variance: Example

Std dev: Gen Mills 20%; Citicorp 30%. Correlation = 0.3
60% invested in Gen Mills; 40% in Citicorp.

<table>
<thead>
<tr>
<th></th>
<th>General Mills</th>
<th>Citicorp</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Mills</td>
<td>.6 \times .20^2</td>
<td>.6 \times .4 \times .3 \times 20 \times 30</td>
</tr>
<tr>
<td></td>
<td>- 144</td>
<td>- 43.2</td>
</tr>
<tr>
<td>Citicorp</td>
<td>.6 \times .4 \times .3 \times 20 \times 30</td>
<td>.4^2 \times 30^2</td>
</tr>
<tr>
<td></td>
<td>- 43.2</td>
<td>- 144</td>
</tr>
</tbody>
</table>

Variance = 144 + 144 + (2 \times 43.2) = 374.4
Std dev = \sqrt{374.4} = 19.3%
The matrix for an N-stock portfolio

The shaded boxes contain variance terms; the remainder contain covariance terms.

Preview of CAPM: How individual securities affect portfolio risk

The risk of a well-diversified portfolio depends on the market risk of the securities in that portfolio.

WHAT IS MARKET RISK?

BETA: MEASURES SENSITIVITY TO MARKET MOVEMENT

The average stock has a beta = 1.0

▲ Stocks with betas > 1.0 tend to amplify market movement
▲ Beta < 1.0 move in same direction as the market but not as much

Stocks with betas of 2.0 are twice as volatile as the market...
..stocks with betas of 0.5 are half as volatile.

An investor in a high beta stock will expect a higher return than an investor in a low beta stock
RISK OF A WELL-DIVERSIFIED PORTFOLIO IS PROPORTIONAL TO THE PORTFOLIO BETA

- Randomly selected 500-stock portfolio has $\mu_p = 1$ and standard deviation $\delta_p = \delta_M$

- Randomly selected 500-stock portfolio made up of stocks with average $\mu = 1.5$ has standard deviation $\delta_p = 1.5 \delta_M$

- Randomly selected 500-stock portfolio made up of stocks with average $\mu = 0.5$ has standard deviation $\delta_p = 0.5 \delta_M$

**FIGURE 7-9**

(a) A randomly selected 500-stock portfolio ends up with $\mu = 1$ and a standard deviation equal to the market’s --in this case 20 percent.

(b) A 500-stock portfolio constructed with stocks with average $\mu = 1.5$ has a standard deviation of about 30 percent --150 percent of the market’s.

(c) A 500-stock portfolio constructed with stocks with average $\mu = 0.5$ has a standard deviation of about 10 percent --half the market’s.
THE STANDARD DEVIATION OF A PORTFOLIO HAS NO SIMPLE RELATIONSHIP TO THE STANDARD DEVIATIONS OF THE INDIVIDUAL STOCKS IN THE PORTFOLIO.

But the beta of a portfolio is the simple weighted average of the betas of the stocks in the portfolio

\[ P = x_1 + x_2 + \ldots + x_n \]

MAJOR INVESTORS HOLD DIVERSIFIED PORTFOLIOS, WITH LITTLE OR NO DIVERSIFIABLE OR UNIQUE RISK

THE RETURN ON A PORTFOLIO, DIVERISIFIED OR NOT, DEPENDS ONLY ON THE MARKET RISK OF THE PORTFOLIO

- The market doesn’t reward us for taking unique risks we can avoid at very little cost by diversification
MEAN & STANDARD DEVIATION:
PORTFOLIO OF MERCK & MCDONALD’S

EXPECTED
RETURN %

STANDARD DEVIATION %

100% Merck

40% Merck

100% McDonald's

EFFECT OF CHANGING CORRELATIONS:
PORTFOLIO OF MERCK & MCDONALD’S

EXPECTED
RETURN %

STANDARD DEVIATION %

100% Merck

correlation = -1

100% McDonald's

correlation = 1

correlation = .4
The set of portfolios when there are 2 risky assets

Assumes correlation of .30

The set of portfolios when there are many (N) risky assets

The set of portfolios between A and B are efficient portfolios
The set of portfolios when there are N risky assets and 1 risk-free asset

By investing in portfolio S and lending or borrowing at $r_f$, an investor can achieve any point along the straight line.

\[ r = r_f + \beta (r_m - r_f) \]

**CAPITAL ASSET PRICING MODEL**
COST OF CAPITAL

WHAT DISCOUNT RATE TO USE?

ONE VIEW: "TURN VALUATION ON ITS HEAD"

EXAMPLE: FIRM "A" PRODUCES SAFETY PINS.
STOCK PRICE = $22.22
CURRENT DIVIDEND = $2.00
EXPECTED GROWTH RATE = 0

• What is the market capitalization rate?
• What discount rate should we use for safety pin capital budgeting?

COST OF CAPITAL

ANOTHER VIEW: “USE THE CAPM”

Example (continued):
Let $r_f = .07$ and $E(R_m) = .11$

Suppose we estimate $B_a$ and find it equal to .5

Then

COST OF CAPITAL = $R_a = R_f + B_a (r_m - r_f)$

= .07 + .5 (.04)

= .09

Note: BOTH APPROACHES SHOULD YIELD SAME RESULT.
NOW CONSIDER A SECOND COMPANY 
FIRM “B” THAT PRODUCES HULA HOOPS

SAY THAT: \( B_b = 1.5 \)

WHAT IS FIRM B’s COST OF CAPITAL? 
WHAT DISCOUNT SHOULD BE USED ON HOOP PROJECTS?

NEXT CONSIDER: A MERGER OF FIRMS A & B

IF VALUE OF FIRM A = VALUE OF FIRM B THEN:

• WHAT IS THE MERGED FIRM’S BETA?
• WHAT IS THE COMPANY COST OF CAPITAL?
• WHAT WILL THE COMPANY COST OF CAPITAL BE USED FOR?

LESSONS...

• BETA OF THE FIRM IS A WEIGHTED AVERAGE OF THE BETAS OF THE INDIVIDUAL PROJECTS

• EACH PROJECT SHOULD BE JUDGED ACCORDING TO ITS OWN RISK.

...& QUESTIONS

• Is diversification “good” for firms?

• How do we find individual project betas?
How Capital Structure Affects the Cost of Capital

\[ \text{Company Cost of Capital} = \frac{\text{Weighted Avg Cost of Capital}}{\text{Weighted Avg}} = \frac{\text{debt}}{\text{debt} + \text{equity}} (r_{\text{debt}}) + \frac{\text{equity}}{\text{debt} + \text{equity}} (r_{\text{equity}}) \]

**Rationale for WACC - Example**

Firm is 50% debt, 50% equity
\[ r_d = .04 \quad r_e = .10 \]
\[ \text{WACC} = .50 (.04) + .50 (.10) = .07 = 7\% \]

Consider 3 Investment Scenarios:

<table>
<thead>
<tr>
<th></th>
<th>CF₀</th>
<th>CF₁</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100</td>
<td>108</td>
<td>NPV &gt; 0</td>
</tr>
<tr>
<td>B</td>
<td>100</td>
<td>107</td>
<td>NPV = 0</td>
</tr>
<tr>
<td>C</td>
<td>100</td>
<td>106</td>
<td>NPV &lt; 0</td>
</tr>
</tbody>
</table>

**How Capital Structure Affects Beta**

\[ \text{assets} = \frac{D}{V} \text{debt} + \frac{E}{V} \text{equity} \]

From previous example, suppose \( D = .2 \) and \( E = 1.4 \)
\[ \text{assets} = .5 (2) + .5 (1.4) = 0.8 \]

\[ \text{Beta} \]

\[ r_{\text{equity}} = .10 \]
\[ r_{\text{assets}} = .07 \]
\[ r_{\text{debt}} = .04 \]
risk-free rate .03

\[ .20 \quad .80 \quad 1.4 \]

\[ \text{debt} \quad \text{assets} \quad \text{equity} \]
What discount rate would you use if you owned all the debt and equity of the firm?

OR,

What should an, otherwise similar, all-equity firm use as the appropriate discount rate?

Since investors in the levered firm require a total return of 7% on the package of debt and equity, you should also use 7% as the discount rate.

*** The appropriate discount rate depends on the riskiness of the firm's investment projects, not on the method of financing. *****

HOW WOULD YOU RESPOND TO THE FOLLOWING:

“Our firm is all-equity and currently stockholders require a 7% rate of return. Since prospective bondholders only require a 4% return, we should issue debt. This will increase firm value since our hurdle rate on new investments (capital budgeting projects) will fall from 7% to 4.”
POINT: Can not simply look at equity betas

EXAMPLE: RJR Nabisco wants to figure the appropriate discount rate for capital budgeting decisions in its cereal division.

They see that Kellogg company has an equity beta equal to .95 . . .

. . . but Kellogg also has debt in its capital structure (D/V = .20) with a beta of .30.

Thus, the beta of Kellogg’s assets
\[ = (.80) (.95) + (.20) (.30) = .82 \]

Assuming a risk-free rate of 3% and a market risk premium of 8%, the CAPM implies that the required return on Kellogg assets equals

\[ .03 + .82 (.08) = .0956, \text{ or } 9.56\% \]

Thus, RJR should use this rate for its capital budgeting decisions in the cereal division.

WHAT TO DO IF YOU CAN’T FIND BETA

1. Avoid fudge factors
2. Consider determinants of asset betas
A FEW OBSERVATIONS ON LEVERAGE, RISK AND THE COST OF CAPITAL

- The company cost of capital is the relevant discount rate for capital budgeting decisions, not the expected return on the common stock.

- The company cost of capital is a weighted average of the returns that investors expect from the various debt and equity securities issued by the firm.

- The company cost of capital is related to the firm’s asset beta, not to the beta of the common stock.

A FEW OBSERVATIONS ON LEVERAGE, RISK AND THE COST OF CAPITAL

- The asset beta can be calculated as a weighted average of the betas of the various securities.

- When the firm changes its financial leverage, the risk and expected returns of the individual securities change. The asset beta and the company cost of capital do NOT change.