Chapter 11 Risk and Return

Key Concepts and Skills

- After studying this chapter, you should be able to:
  - Calculate expected returns.
  - Explain the impact of diversification.
  - Define the systematic risk principle.
  - Discuss the security market line and the risk-return trade-off.

Chapter Outline

Expected Returns

- Expected returns are based on the probabilities of possible outcomes.

$$E(R) = \sum_{i=1}^{n} p_i R_i$$

Where:

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p_i = the probability of state "i" occurring

R_i = the expected return on an asset in state i

Example: Expected Returns (1 of 2)

		E(R)	
		Stock A	Stock B
State (i)	p(i)	E(Ra)	E(Rb)
Recession	0.25	-20%	30%
Neutral	0.50	15%	15%
Boom	0.25	35%	-10%
	1.00		

$$\boxed{E(R) = \sum_{i=1}^{n} p_i R_i}$$

Example: Expected Returns (2 of 2)

		E(R)			
		Stock A		Stock B	
State (i)	p(i)	E(Ra)	p(i) x E(Ra)	E(Rb)	p(i) x E(Rb)
Recession	0.25	-20%	-5.0%	30%	7.5%
Neutral	0.50	15%	7.5%	15%	7.5%
Boom	0.25	35%	8.8%	-10%	-2.5%
E(R)			11.25%		12.50%

$$\boxed{E(R) = \sum_{i=1}^{n} p_i R_i}$$

Variance & Standard Deviation (1 of 2)

- Variance and standard deviation measure the volatility of returns.
- Variance = Weighted average of squared deviations
- Standard Deviation = Square root of variance

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

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Variance & Standard Deviation (2 of 2)

Variance & Standard Deviation

		Stock A		
State (i)	p(i)	E(R)	DEV^2	x p(i)
Recession	0.25	-20%	0.097656	0.0244141
Neutral	0.50	15%	0.001406	0.0007031
Boom	0.25	35%	0.056406	0.0141016
	1.00			
Expected Return		11.25%		
Variance				0.03921875
Standard Deviation				19.8%

		Stock B		
State (i)	p(i)	E(R)	DEV^2	x p(i)
Recession	0.25	30%	0.030625	0.0076563
Neutral	0.50	15%	0.000625	0.0003125
Boom	0.25	-10%	0.050625	0.0126563
	1.00			
Expected Return		12.50%		
Variance				0.0206
Standard Deviation				14.4%

Portfolios

- Portfolio = collection of assets
- An asset's risk and return impact how the stock affects the risk and return of the portfolio.
- The risk-return trade-off for a portfolio is measured by the portfolio expected return and standard deviation, just as with individual assets.

Portfolio Expected Returns

- The expected return of a portfolio is the weighted average of the expected returns for each asset in the portfolio.
- Weights (w_j) = % of portfolio invested in each asset

$$E(R_P) = \sum_{j=1}^{m} w_j E(R_j)$$

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Example: Portfolio Weights

Asset	Dollars Invested	% of Pf w(j)	E(Rj)	w(j) x E(Rj)
A	$15,000	30%	12.5%	3.735%
B	$8,600	17%	9.5%	1.627%
C	$11,000	22%	10.0%	2.191%
D	$9,800	20%	7.5%	1.464%
E	$5,800	12%	8.5%	0.982%
	$50,200	100%		10.000%

Expected Portfolio Return

Alternative Method

	A	B	C	D	E	F	G	H
1			Stock V	Stock W	Stock X	Stock Y	Stock Z	Portfolio
2		w(j)	30%	17%	22%	20%	12%	100%
3	State (i)	p(i)	Expected Return					
4	Recession	0.25	-20.0%	18.0%	5.0%	-8.0%	4.0%	-3%
5	Neutral	0.50	17.5%	15.0%	10.0%	11.0%	9.0%	13%
6	Boom	0.25	35.0%	-10.0%	15.0%	16.0%	12.0%	17%
7	E(R)	1.00	12.5%	9.5%	10.0%	7.5%	8.5%	10%

Steps:

1. Calculate expected portfolio return in each state.
2. Apply the probabilities of each state to the expected return of the portfolio in that state.
3. Sum the result of Step 2.

$$E(R_{P,i}) = \sum_{j=1}^{5} w_j E(R_j)$$

$$E(R_P) = \sum_{i=1}^{3} p_i E(R_{P,i})$$

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Portfolio Risk
Variance & Standard Deviation

- Portfolio standard deviation is **NOT** a weighted average of the standard deviation of the component securities' risk.
  - If it were, there would be no benefit to diversification.

Portfolio Variance

- Compute portfolio return for each state:

$$R_{P,i} = w_1 R_{1,i} + w_2 R_{2,i} + \ldots + w_m R_{m,i}$$

- Compute the overall expected portfolio return using the same formula as for an individual asset.
- Compute the portfolio variance and standard deviation using the same formulas as for an individual asset.

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Portfolio Risk

		Portfolio			
State (i)	p(i)	E(R)	Dev	Dev^2	x p(i)
Recession	0.25	-3%	-13%	0.01663	0.00416
Neutral	0.50	13%	3%	0.00101	0.00050
Boom	0.25	17%	7%	0.00428	0.00107
E(R)	1.00	10%		VAR(Pf)	0.0057326
				Std(Pf)	0.0757138
				Std(Pf) as %	7.6%

1. Calculate Expected Portfolio Return in each state of the economy and overall (Slide 11-12).
2. Compute the deviation (DEV) of expected portfolio return in each state from total expected portfolio return.
3. Square the deviations (DEV^2) found in Step 2.
4. Multiply the squared deviations from Step 3 times the probability of each state occurring (x p(i)).
5. The sum of the results from Step 4 = Portfolio Variance.

Announcements, News, and Efficient Markets

- Announcements and news contain both expected and surprise components.
- The surprise component affects stock prices.
- Efficient markets result from investors trading on unexpected news.
  - The easier it is to trade on surprises, the more efficient markets should be.
- Efficient markets involve random price changes because we cannot predict surprises.

Systematic Risk

- Factors that affect a large number of assets
- "Non-diversifiable risk"
- "Market risk"
- Examples: changes in GDP, inflation, interest rates, etc.

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Unsystematic Risk

- = Diversifiable risk
- Risk factors that affect a limited number of assets
- Risk that can be eliminated by combining assets into portfolios
- "Unique risk"
- "Asset-specific risk"
- Examples: labor strikes, part shortages, etc.

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Returns

- Total Return = Expected return + Unexpected return

  $R = E(R) + U$

- Unexpected return (U) = Systematic portion (m) + Unsystematic portion (ε)
- Total Return = Expected return $E(R)$ + Systematic portion m

  + Unsystematic portion ε

  $= E(R) + m + \varepsilon$

The Principle of Diversification

- Diversification can substantially reduce risk without an equivalent reduction in expected returns.
  - Reduces the variability of returns
  - Caused by the offset of worse-than-expected returns from one asset by better-than-expected returns from another
- Minimum level of risk that cannot be diversified away = *systematic portion*

Standard Deviations of Annual Portfolio Returns Table 11.7

TABLE 11.7

Standard deviations of annual portfolio returns

(1) Number of Stocks in Portfolio	(2) Average Standard Deviation of Annual Portfolio Returns	(3) Ratio of Portfolio Standard Deviation to Standard Deviation of a Single Stock
1	49.24%	1.00
2	37.36	.76
4	29.69	.60
6	26.64	.54
8	24.98	.51
10	23.93	.49
20	21.68	.44
30	20.87	.42
40	20.46	.42
50	20.20	.41
100	19.69	.40
200	19.42	.39
300	19.34	.39
400	19.29	.39
500	19.27	.39
1,000	19.21	.39

Sources: These figures are from Table 1 in Statman, Meir, "How Many Stocks Make a Diversified Portfolio?" *Journal of Financial and Quantitative Analysis*, vol. 22, September 1987, 353–64. They were derived from Elton, E. J. and Gruber, M. J., "Risk Reduction and Portfolio Size: An Analytical Solution," *Journal of Business*, vol. 50, October 1977, 415–37.

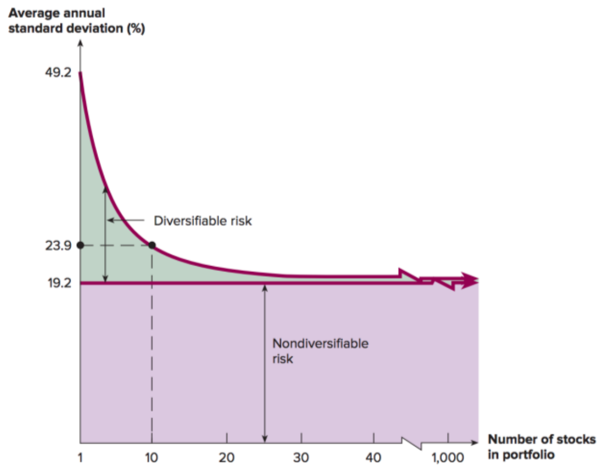
Portfolio Conclusions

- As more stocks are added, each new stock has a smaller risk-reducing impact on the portfolio.
  - σ_p falls very slowly after about 40 stocks are included
  - The lower limit for $\sigma_p \approx 20\% = \sigma_M$

➡ Forming well-diversified portfolios can eliminate about half the risk of owning a single stock.

Portfolio Diversification
Figure 11.1

FIGURE 11.1
Portfolio diversification



Total Risk = Stand-Alone Risk

Total risk = Systematic risk + Unsystematic risk

– The standard deviation of returns is a measure of total risk.

- For well-diversified portfolios, unsystematic risk is very small.
  - ➡Total risk for a diversified portfolio is essentially equivalent to the systematic risk.

Systematic Risk Principle

- There is a reward for bearing risk.
- There is no reward for bearing risk unnecessarily.
- The expected return (market required return) on an asset depends only on that asset's systematic or market risk.

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Market Risk for Individual Securities

- The contribution of a security to the overall riskiness of a portfolio
- Relevant for stocks held in well-diversified portfolios
- Measured by a stock's beta coefficient, β_j
- Measures the stock's volatility relative to the market

Interpretation of Beta

- If β = 1.0, stock has average risk
- If β > 1.0, stock is riskier than average
- If β < 1.0, stock is less risky than average
- Most stocks have betas in the range of 0.5 to 1.5.
- Beta of the market = 1.0
- Beta of a T-Bill = 0

Beta Coefficients for Selected Companies Table 11.8

TABLE 11.8

Beta coefficients for selected companies

Company	Beta Coefficient (β)
Macy's	.54
Facebook	.81
Ford	.85
Pfizer	.93
Costco	1.05
Home Depot	1.06
Apple	1.15
Prudential	1.46
Amazon	1.70

Source: finance.yahoo.com, 2018.

Click on this link to access Yahoo finance.

Example: Work the Web

- Many sites provide betas for companies.
- Yahoo! Finance provides beta, plus a lot of other information under its profile link.
- Click on this link to go to Yahoo! Finance.
  - Enter a ticker symbol and get a basic quote.
  - Click on key statistics.
  - Beta is reported under stock price history.

Portfolio Beta

β_p = Weighted average of the Betas of the assets in the portfolio

Weights (w_j)= % of portfolio invested in asset j

$$\boxed{\beta_p = \sum_{j=1}^{n} w_j \beta_j}$$

Quick Quiz:
Total vs. Systematic Risk

- Consider the following information:

	Standard Deviation	Beta
Security C	20%	1.25
Security K	30%	0.95

- Which security has more total risk?
- Which security has more systematic risk?
- Which security should have the higher expected return?

Beta and the Risk Premium

- Risk premium = E(R) – R_f
- The higher the beta, the greater the risk premium should be
- Can we define the relationship between the risk premium and beta so that we can estimate the expected return?
  - YES!

SML and Equilibrium

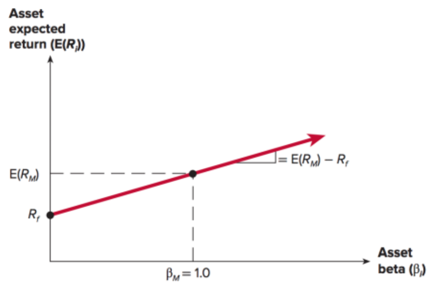


FIGURE 11.4

The security market line, or SML

The slope of the security market line is equal to the market risk premium, i.e., the reward for bearing an average amount of systematic risk. The equation describing the SML can be written:

$$E(R_i) = R_f + [E(R_M) - R_f] \times \beta_i$$

This is the capital asset pricing model, or CAPM.

Reward-to-Risk Ratio

- Reward-to-Risk Ratio: $\boxed{\dfrac{E(R_j) - R_f}{\beta_j}}$
- = Slope of line on graph
- In equilibrium, ratio should be the same for all assets
- When E(R) is plotted against *β* for all assets, the result should be a straight line

Market Equilibrium

- In equilibrium, all assets and portfolios must have the same reward-to-risk ratio
- Each ratio must equal the reward-to-risk ratio for the market

$$\frac{E(R_A) - R_f}{\beta_A} = \frac{E(R_M - R_f)}{\beta_M}$$

Security Market Line

- The security market line (SML) is the representation of market equilibrium.
- The slope of the SML = reward-to-risk ratio:

$$(E(R_M) - R_f) / \beta_M$$

- Slope = $E(R_M) - R_f$ = market risk premium
  - Since β of the market is always 1.0

The SML and Required Return

- The Security Market Line (SML) is part of the Capital Asset Pricing Model (CAPM).

$$\boxed{\begin{aligned} E(R_j) &= R_f + \left(E(R_M) - R_f\right)\beta_j \\ E(R_j) &= R_f + \left(RP_M\right)\beta_j \end{aligned}}$$

R_f = Risk-free rate (T-Bill or T-Bond)
R_M = Market return ≈ S&P 500
RP_M = Market risk premium = $E(R_M) - R_f$
$E(R_j)$ = "Required Return of Asset *j*"

Capital Asset Pricing Model

- The capital asset pricing model (CAPM) defines the relationship between risk and return.

$$E(R_A) = R_f + (E(R_M) - R_f)\beta_A$$

- If an asset's systematic risk (β) is known, CAPM can be used to determine its expected return.

SML Example

Expected vs Required Return				
Stock	E(R)	Beta	Req R	
A	14%	1.3	13.4%	Undervalued
B	10%	0.8	11.1%	Overvalued
Assume:	Market Return =		12.0%	
	Risk-free Rate =		7.5%	

$$\boxed{E(R_j) = R_f + \left(E(R_M) - R_f\right)\beta_j}$$

Factors Affecting Required Return

$$E(R_j) = R_f + \left(E(R_M) - R_f\right)\beta_j$$

- R_f measures the pure time value of money
- $RP_M = (E(R_M)-R_f)$ measures the reward for bearing systematic risk
- β_j measures the amount of systematic risk

Quick Quiz (1 of 2)

1. How do you compute the expected return and standard deviation:
   - For an individual asset? (Slide 11-4 and Slide 11-7)
   - For a portfolio? (Slide 11-10 and Slide 11-14)
2. What is the difference between systematic and unsystematic risk? (Slide 11-18 and Slide 11-19)
3. What type of risk is relevant for determining the expected return? (Slide 11-25)

Quick Quiz (2 of 2)

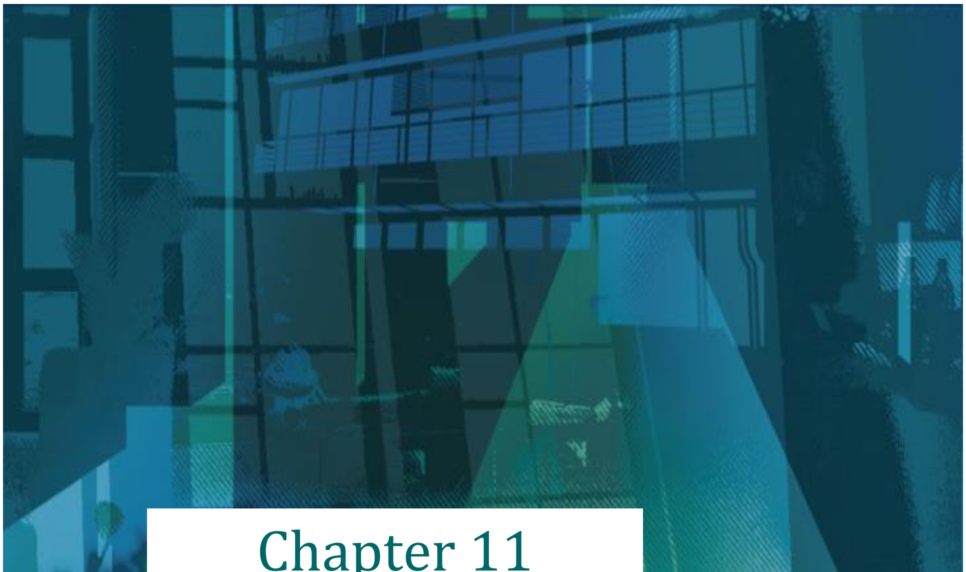
4. Consider an asset with a beta of 1.2, a risk-free rate of 5%, and a market return of 13%.
   – What is the reward-to-risk ratio in equilibrium?

$$\frac{E(R_A)-R_f}{\beta_A}=\frac{E(R_M-R_f)}{\beta_M}=\frac{13\%-5\%}{1.0}$$

$$0.08\times 1.2=E(R_A)-R_f=.096+.05=E(R_A)$$

$$E(R_A)=14.6\%$$

   – What is the expected return on the asset?
     - E(R) = 5% + (13% - 5%) × 1.2 = 14.6%



Chapter 11

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