FN241
Risk Management and Insurance
Risk and returns (1)

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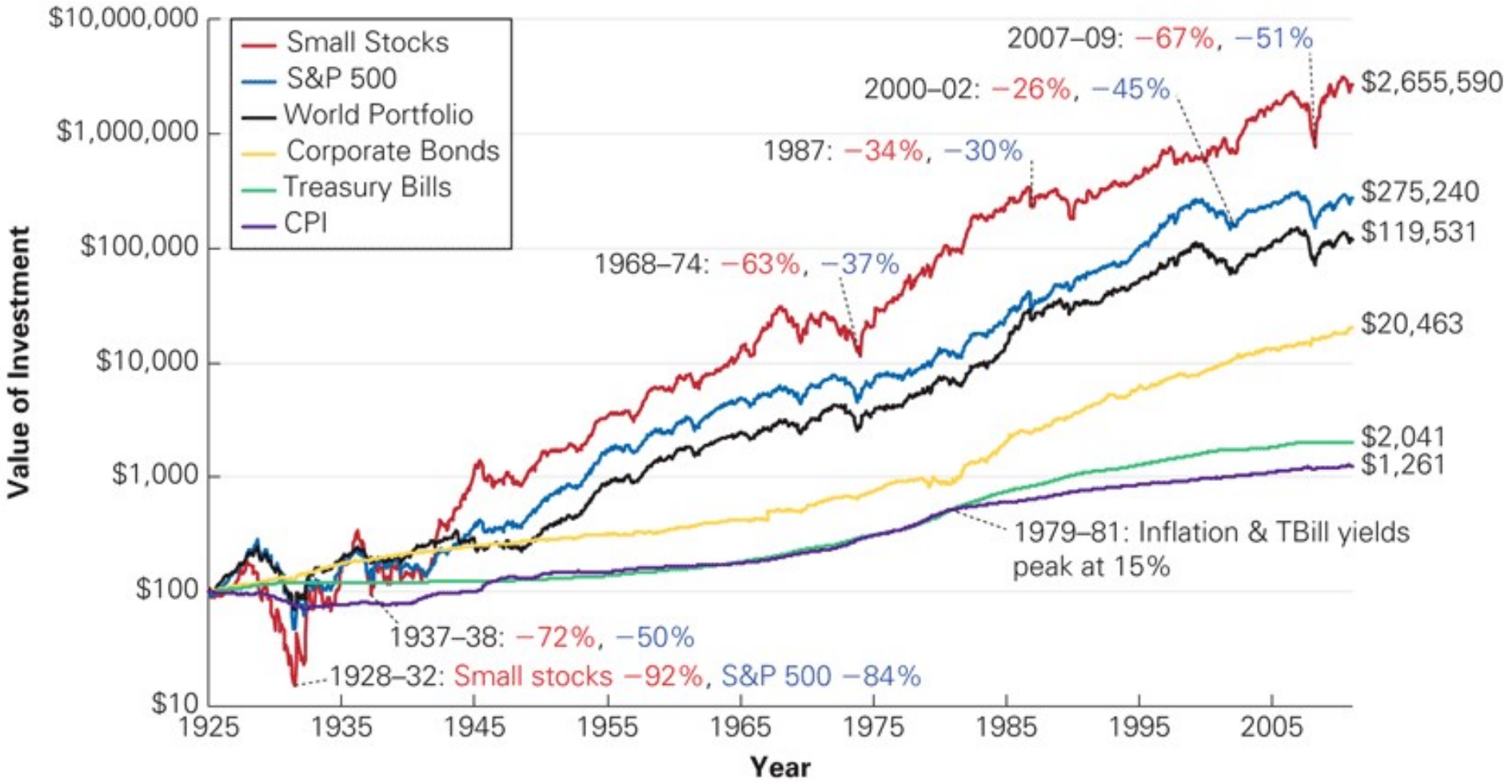
Risk and returns

- Investment stylized facts
- Expected returns and variance
- Trade-off between risk and return
- Diversification in stock portfolios
- Systematic risk and CAPM

Insights from 86 Years of Investor History

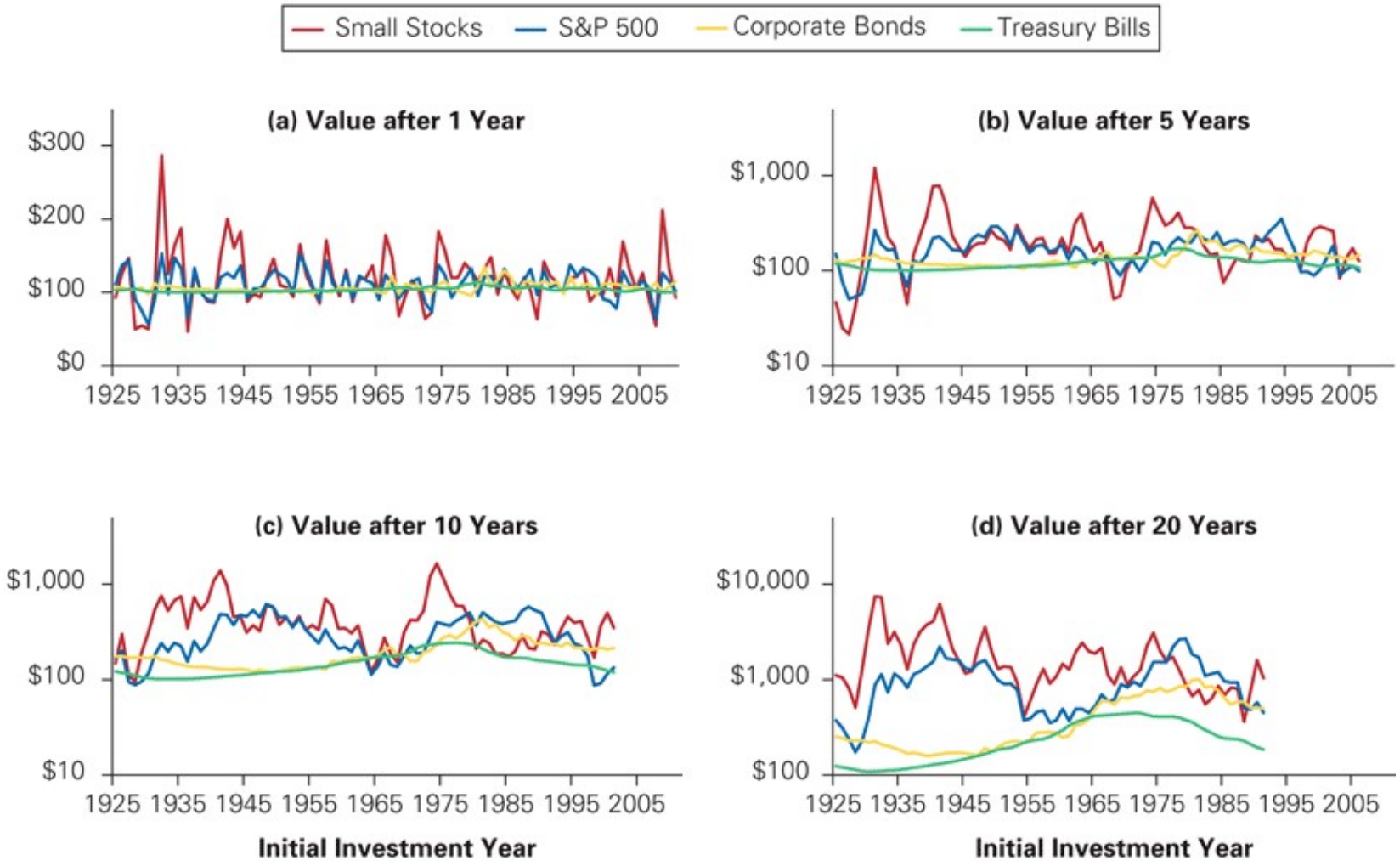
- How would $100 have grown if it were placed in one of the following investments?
  - Standard & Poor's 500: 90 U.S. stocks up to 1957 and 500 after that. Leaders in their industries and among the largest firms traded on U.S. Markets.
  - Small stocks: Securities traded on the NYSE with market capitalizations in the bottom 20%.
  - World Portfolio: International stocks from all the world's major stock markets in North America, Europe, and Asia.
  - Corporate Bonds: Long-term, AAA-rated U.S. corporate bonds with maturities of approximately 20 years.
  - Treasury Bills: An investment in three-month Treasury bills.

Value of $100 Invested at the End of 1925



Source: Chicago Center for Research in Security Prices, Standard and Poor's, MSCI, and Global Financial Data.

Value of $100 Invested for Alternative Investment Horizons



Source: Chicago Center for Research in Security Prices, Standard and Poor's, MSCI, and Global Financial Data.

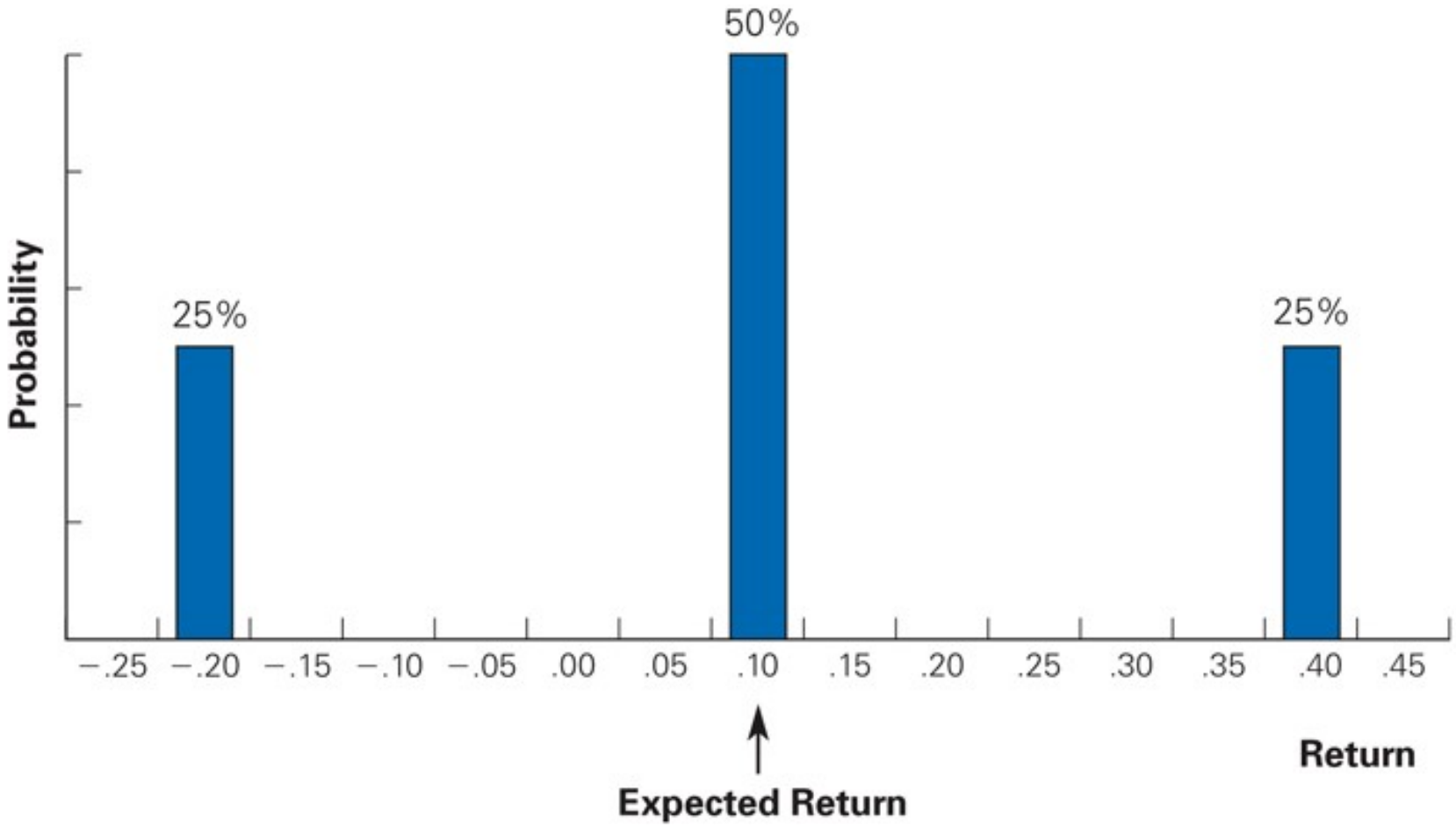
Common Measures of Risk and Return

- Probability Distributions
  - When an investment is risky, there are different returns it may earn. Each possible return has some likelihood of occurring.
  - This information is summarized with a probability distribution, which assigns a probability, P_R , that each possible return, R , will occur.
    - Assume ABC stock currently trades for $100 per share. In one year, there is a 25% chance the share price will be $140, a 50% chance it will be $110, and a 25% chance it will be $80.

Probability Distribution of Returns for ABC

Current Stock Price ($)	Stock Price in One Year ($)	Probability Distribution	
		Return, R	Probability, P_R
	140	0.40	25%
100	110	0.10	50%
	80	−0.20	25%

Probability Distribution of Returns for ABC



Expected Return

- Expected (Mean) Return
  - Calculated as a weighted average of the possible returns, where the weights correspond to the probabilities.

$$\text{Expected Return} = E[R] = \sum_R P_R \times R$$

$$E[R_{ABC}] = 25\%(-0.20) + 50\%(0.10) + 25\%(0.40) = 10\%$$

Variance and Standard Deviation

- Variance
  - The expected squared deviation from the mean

$$Var(R) = E\left[\left(R - E[R]\right)^2\right] = \sum_R P_R \times \left(R - E[R]\right)^2$$

- Standard Deviation
  - The square root of the variance

$$SD(R) = \sqrt{Var(R)}$$

- Both are measures of the risk of a probability distribution

Variance and Standard Deviation

- For ABC stock, the variance and standard deviation are:

In finance, the SD of a return is also referred to as its **volatility**. The SD is easier to interpret because it is in the same units as the returns themselves.

Risk and return example

- **Problem**
  - Stock A has the following probability distribution:

Probability	Return
.25	8%
.55	10%
.20	12%

  - **What are its expected return and standard deviation?**

Historical Returns of Stocks and Bonds

- Computing Historical Returns
  - Realized Return
    - The return that actually occurs over a particular time period.

$$R_{t+1} = \frac{Div_{t+1} + P_{t+1}}{P_t} - 1 = \frac{Div_{t+1}}{P_t} + \frac{Div_{t+1} - P_t}{P_t}$$

$$= \text{Dividend Yield} + \text{Capital Gain Rate}$$

Historical Returns of Stocks and Bonds

- Computing Historical Returns
  - If you hold the stock beyond the date of the first dividend, then to compute your return you must specify how you invest any dividends you receive in the interim. Let's assume that *all dividends are immediately reinvested and used to purchase additional shares of the same stock or security*.
  - If a stock pays dividends at the end of each quarter, with realized returns $R_{Q1}, \ldots, R_{Q4}$ each quarter, then its annual realized return, R_{annual}, is computed as:

$$1 + R_{\text{annual}} = (1 + R_{Q1})(1 + R_{Q2})(1 + R_{Q3})(1 + R_{Q4})$$

Realized return example

- **Problem:**
  - What were the realized annual returns for this stock in 2008 and in 2012?

Date	Price ($)	Dividend ($)	Return	Date	Price ($)	Dividend ($)	Return
12/31/2007	58.69			12/31/2011	6.73	0	
1/31/2008	61.44	0.26		3/31/2012	5.72	0	
4/30/2008	63.94	0.26		6/30/2012	4.81	0	
7/31/2008	48.5	0.26		9/30/2012	5.2	0	
10/31/2008	54.88	0.29		12/21/2012	2.29	0	
12/31/2008	53.31						

Realized Return for the S&P 500, Microsoft, and Treasury Bills, 2001–2011

Year End	S&P 500 Index	Dividends Paid*	S&P 500 Realized Return	Microsoft Realized Return	1-Month T-Bill Return
2001	1148.08				
2002	879.82	14.53	−22.1%	−22.0%	1.6%
2003	1111.92	20.80	28.7%	6.8%	1.0%
2004	1211.92	20.98	10.9%	8.9%	1.2%
2005	1248.29	23.15	4.9%	−0.9%	3.0%
2006	1418.30	27.16	15.8%	15.8%	4.8%
2007	1468.36	27.86	5.5%	20.8%	4.7%
2008	903.25	21.85	−37.0%	−44.4%	1.5%
2009	1115.10	27.19	26.5%	60.5%	0.1%
2010	1257.64	25.44	15.1%	−6.5%	0.1%
2011	1257.60	26.59	2.1%	−4.5%	0.0%

*Total dividends paid by the 500 stocks in the portfolio, based on the number of shares of each stock in the index, adjusted until the end of the year, assuming they were reinvested when paid.

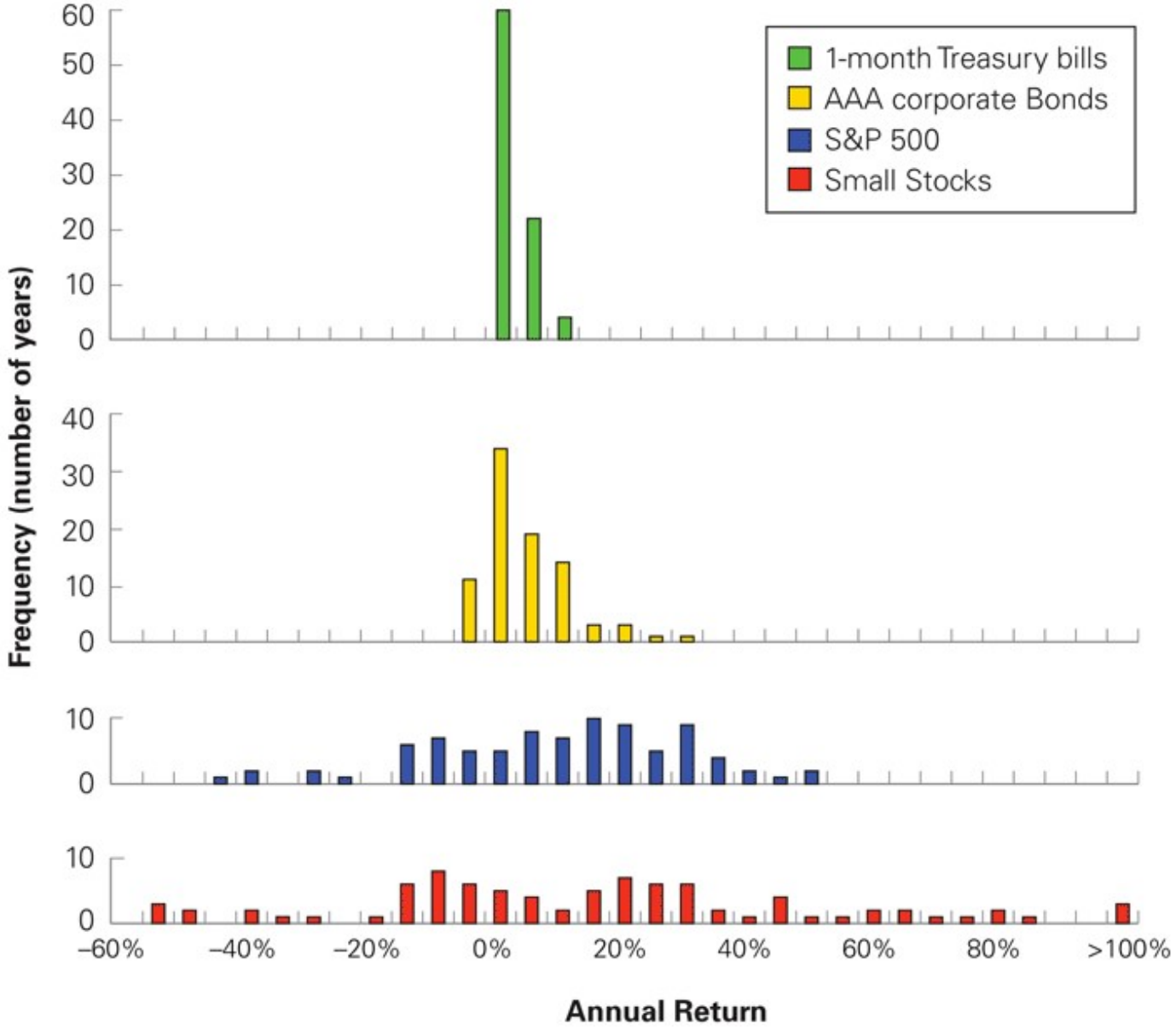
Source: Standard & Poor's, Microsoft and U.S. Treasury Data

Source: BD Table 10.2

Historical Returns of Stocks and Bonds

- Computing Historical Returns
  - By counting the number of times a realized return falls within a particular range, we can estimate the underlying probability distribution.
  - Empirical Distribution
    - When the probability distribution is plotted using historical data

The Empirical Distribution of Annual Returns, 1926–2011



Average Annual Returns for U.S. Small Stocks, Large Stocks (S&P 500), Corporate Bonds, and Treasury Bills, 1926–2011

Investment	Average Annual Return
Small stocks	18.7%
S&P 500	11.7%
Corporate bonds	6.6%
Treasury bills	3.6%

Average Annual Return

$$\bar{R} = \frac{1}{T}\left(R_1 + R_2 + \cdots + R_T\right) = \frac{1}{T}\sum_{t=1}^{T} R_t$$

- Where R_t is the realized return of a security in year t, for the years 1 through T
  - Using the data from the previous table, the average annual return for the S&P 500 from 2002 - 2011 is:

The Variance and Volatility of Returns

- Variance Estimate Using Realized Returns

$$Var(R) = \frac{1}{T - 1} \sum_{t=1}^{T} \left(R_t - \bar{R} \right)^2$$

  - The estimate of the standard deviation is the square root of the variance.

Volatility of U.S. Small Stocks, Large Stocks (S&P 500), Corporate Bonds, and Treasury Bills, 1926–2011

Investment	Return Volatility (Standard Deviation)
Small stocks	39.2%
S&P 500	20.3%
Corporate bonds	7.0%
Treasury bills	3.1%

Estimation Error: Using Past Returns to Predict the Future

- We can use a security's historical average return to estimate its actual expected return.
- However, the average return is just an estimate of the expected return.
  - Standard Error (SE) - A statistical measure of the degree of estimation error
  - The SE provides an indication of how far the sample average might deviate from the expected return

Estimation Error: Using Past Returns to Predict the Future

- Standard Error of the Estimate of the Expected Return

$$SD(\text{Average of Independent, Identical Risks}) = \frac{SD(\text{Individual Risk})}{\sqrt{\text{Number of Observations}}}$$

- 95% Confidence Interval

$$\text{Historical Average Return} \pm (2 \times \text{Standard Error})$$

- For the S&P 500 (1926–2004)

$$12.3\% \pm 2\left(\frac{20.36\%}{\sqrt{79}}\right) = 12.3\% \pm 4.6\%$$

- Or a range from 7.7% to 19.9%

Estimation Error Example

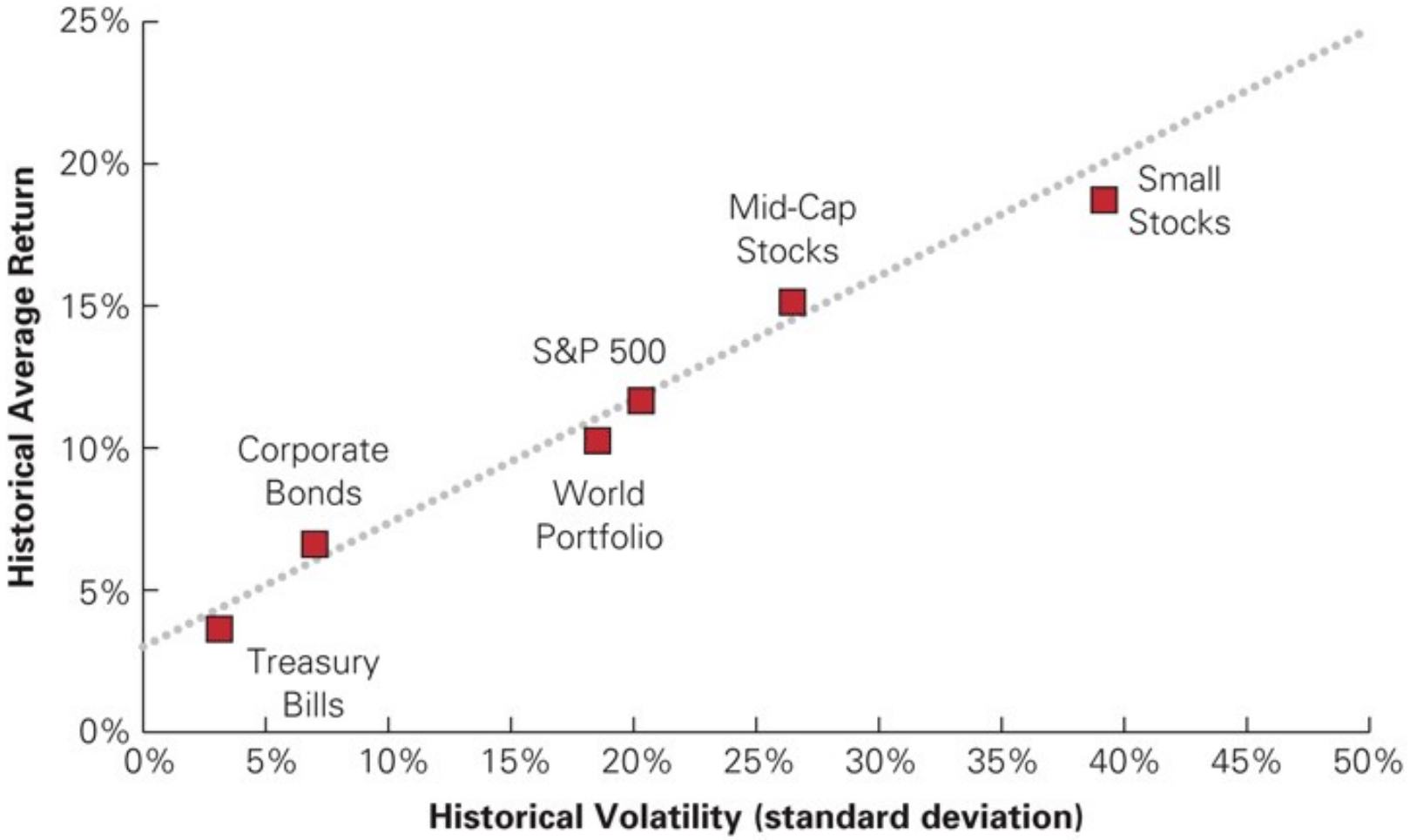
- Using the returns for the S&P 500 from 2002-2011, what is the 95% confidence interval you would estimate for the S&P 500's expected return?

The Historical Tradeoff Between Risk and Return

- The Returns of Large Portfolios
  - Excess Returns
    - The difference between the average return for an investment and the average return for T-Bills

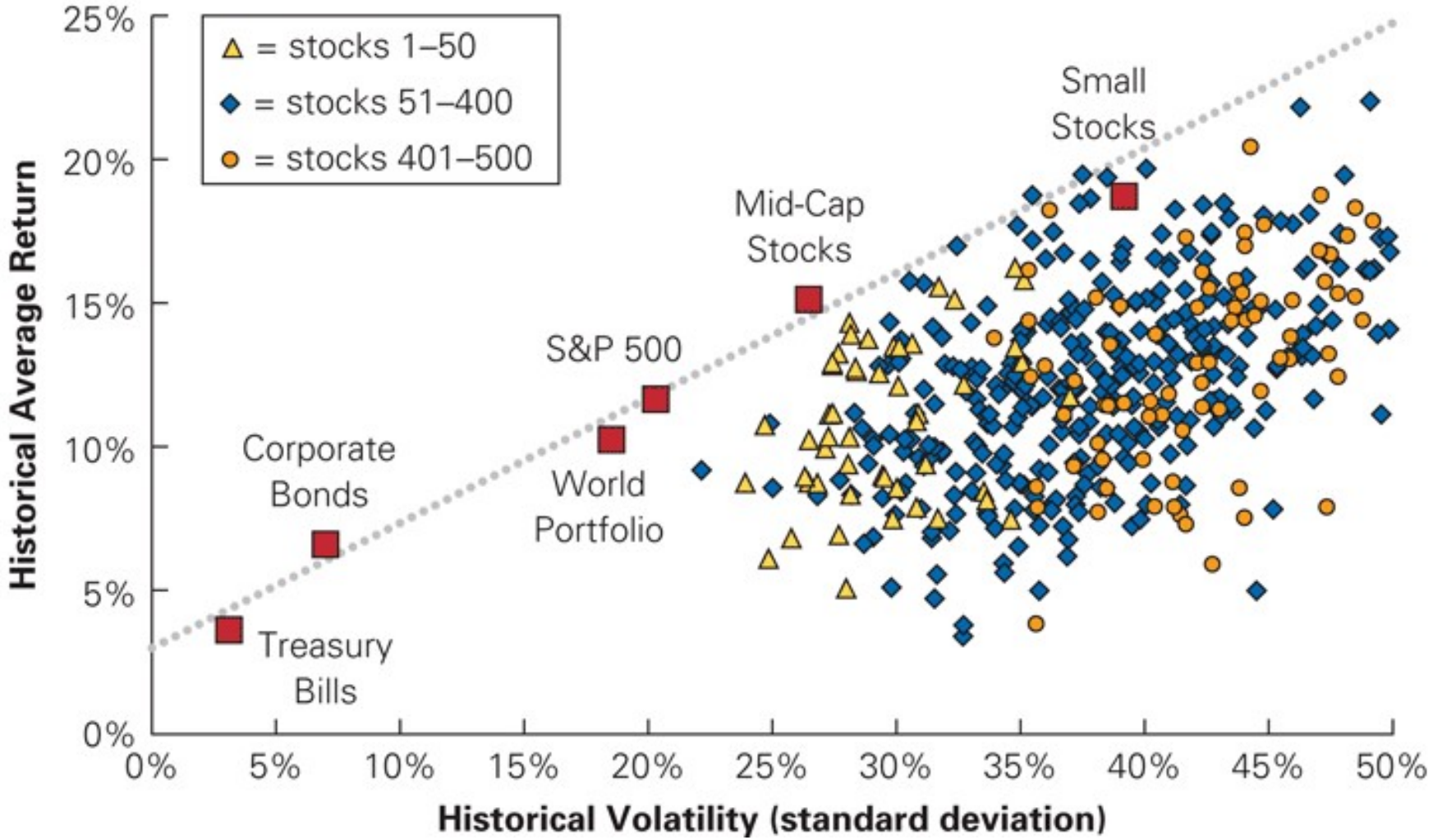
Investment	Return Volatility (Standard Deviation)	Excess Return (Average Return in Excess of Treasury Bills)
Small stocks	39.2%	15.1%
S&P 500	20.3%	8.1%
Corporate bonds	7.0%	3.0%
Treasury bills	3.1%	0.0%

The Historical Tradeoff Between Risk and Return in Large Portfolios



Source: CRSP, Morgan Stanley Capital International

Is there a positive relationship between volatility and average returns for individual stocks?



Diversification in Stock Portfolios

- Firm-specific vs. systematic risk
  - Firm specific
    - Good or bad news about an individual company
    - aka idiosyncratic, unsystematic, or diversifiable risk
  - Market-wide
    - News that affects all stocks, such as news about the economy
    - aka systematic, non-diversifiable, or market risk
- When many stocks are combined in a large portfolio, the firm-specific risks for each stock will average out and be diversified.
- The systematic risk, however, will affect all firms and will not be diversified.

No Arbitrage and the Risk Premium

- *The risk premium for diversifiable risk is zero, so investors are not compensated for holding firm-specific risk.*
  - If the diversifiable risk of stocks were compensated with an additional risk premium, then investors could buy the stocks, earn the additional premium, and simultaneously diversify and eliminate the risk.

No Arbitrage and the Risk Premium

- By doing so, investors could earn an additional premium without taking on additional risk. This opportunity to earn something for nothing would quickly be exploited and eliminated.
- Because investors can eliminate firm-specific risk “for free” by diversifying their portfolios, they will not require or earn a reward or risk premium for holding it.

No Arbitrage and the Risk Premium

- *The risk premium of a security is determined by its systematic risk and does not depend on its diversifiable risk.*
  - This implies that a stock's volatility, which is a measure of total risk (that is, systematic risk plus diversifiable risk), is not especially useful in determining the risk premium that investors will earn.

No Arbitrage and the Risk Premium

- SD is not an appropriate measure of risk for an individual security. There should be no clear relationship between volatility and average returns for individual securities.
- Consequently, to estimate a security's expected return, we need to find a measure of a security's systematic risk.

Diversifiable or firm-specific?

- Which of the following risks are firm-specific? Which are likely to be systematic? Which risks will affect the risk premium that investors will demand?
  - The risk that the founder and CEO retires
  - The risk that oil prices rise, increasing production costs
  - The risk that a product design is faulty
  - The risk that the economy slows, reducing demand for the firm's product

Measuring Systematic Risk

- To measure the systematic risk of a stock, determine how much of the variability of its return is due to systematic risk vs. unsystematic risk.
    - To determine how sensitive a stock is to systematic risk, look at the average change in the return for each 1% change in the return of a portfolio that fluctuates solely due to systematic risk.

Measuring Systematic Risk

- Efficient Portfolio
  - A portfolio that contains only systematic risk. There is no way to reduce the volatility of the portfolio without lowering its expected return.
- Market Portfolio
  - An efficient portfolio that contains all shares and securities in the market
    - The S&P 500 is often used as a proxy for the market portfolio.

Measuring Systematic Risk

- Sensitivity to Systematic Risk: Beta (β)
  - *The expected percent change in the excess return of a security for a 1% change in the excess return of the market portfolio.*
    - Beta differs from volatility. Volatility measures total risk (systematic plus unsystematic risk), while beta is a measure of only systematic risk.

Betas with Respect to the S&P 500 for Individual Stocks (based on monthly data for 2007–2012)

Company	Ticker	Industry	Equity Beta
General Mills	GIS	Packaged Foods	0.20
Consolidated Edison	ED	Utilities	0.28
The Hershey Company	HSY	Packaged Foods	0.28
Abbott Laboratories	ABT	Pharmaceuticals	0.31
Newmont Mining	NEM	Gold	0.32
Wal-Mart Stores	WMT	Superstores	0.35
Clorox	CLX	Household Products	0.39
Kroger	KR	Food Retail	0.42
Altria Group	MO	Tobacco	0.43
Amgen	AMGN	Biotechnology	0.44
McDonald's	MCD	Restaurants	0.47
Procter & Gamble	PG	Household Products	0.47
Pepsico	PEP	Soft Drinks	0.51
Coca-Cola	KO	Soft Drinks	0.54
Johnson & Johnson	JNJ	Pharmaceuticals	0.59
PetSmart	PETM	Specialty Stores	0.75
Molson Coors Brewing	TAP	Brewers	0.78
Nike	NKE	Footwear	0.91
Microsoft	MSFT	Systems Software	1.01
Southwest Airlines	LUV	Airlines	1.09
Intel	INTC	Semiconductors	1.09
Whole Foods Market	WFM	Food Retail	1.10
Foot Locker	FL	Apparel Retail	1.11
Oracle	ORCL	Systems Software	1.12
Amazon.com	AMZN	Internet Retail	1.13
Google	GOOG	Internet Software and Services	1.14

Betas with Respect to the S&P 500 for Individual Stocks (based on monthly data for 2007–2012)

Company	Ticker	Industry	Equity Beta
Starbucks	SBUX	Restaurants	1.20
Walt Disney	DIS	Movies and Entertainment	1.21
Cisco Systems	CSCO	Communications Equipment	1.23
Apple	AAPL	Computer Hardware	1.26
PulteGroup	PHM	Homebuilding	1.28
Dell	DELL	Computer Hardware	1.41
salesforce.com	CRM	Application Software	1.47
Marriott International	MAR	Hotels and Resorts	1.48
eBay	EBAY	Internet Software and Services	1.48
Coach	COH	Apparel and Luxury Goods	1.60
Macy's	M	Department Stores	1.67
Juniper Networks	JNPR	Communications Equipment	1.71
Williams-Sonoma	WSM	Home Furnishing Retail	1.72
Tiffany & Co.	TIF	Apparel and Luxury Goods	1.80
Caterpillar	CAT	Construction Machinery	1.85
Ethan Allen Interiors	ETH	Home Furnishings	1.95
Autodesk	ADSK	Application Software	2.14
Harley-Davidson	HOG	Motorcycle Manufacturers	2.23
Advanced Micro Devices	AMD	Semiconductors	2.24
Ford Motor	F	Automobile Manufacturers	2.38
Sotheby's	BID	Auction Services	2.39
Wynn Resorts Ltd.	WYNN	Casinos and Gaming	2.41
United States Steel	X	Steel	2.52
Saks	SKS	Department Stores	2.57

Source: CapitalIQ

Measuring Systematic Risk

- Interpreting Beta (β)
  - A security's beta is related to how sensitive its underlying revenues and cash flows are to general economic conditions.
  - Stocks in cyclical industries are likely to be more sensitive to systematic risk and have higher betas than stocks in less sensitive industries.

Beta and the Cost of Capital

- Estimating the Risk Premium
  - Market risk premium
    - The market risk premium is the reward investors expect to earn for holding a portfolio with a beta of 1.

$$\text{Market Risk Premium} = E\left[R_{Mkt}\right] - r_f$$

Beta and Cost of Capital

- Adjusting for Beta
  - Estimating a Traded Security's Cost of Capital of an investment from Its Beta

$$E\left[R\right] = \text{Risk-Free Interest Rate} + \text{Risk Premium}$$
$$= r_f + \beta \times (E\left[R_{Mkt}\right] - r_f)$$

  - This equation is often referred to as the **Capital Asset Pricing Model (CAPM)**. It is the most important method for estimating the cost of capital that is used in practice.

CAPM Example

- **Problem**
  - Assume the economy has a 60% chance of the market return will 15% next year and a 40% chance the market return will be 5% next year.
  - Assume the risk-free rate is 6%.
  - **If Microsoft's beta is 1.18, what is its expected return next year?**