Econ-367: Logistics

- Professor: Jonathan Wright
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Tas	Email	Office Hour
Mingzuo Sun	msun27@jhu.edu	Mondays 9:30-10:30 Zoom Meeting Id: 977 4029 7873 Passcode: 656054
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Econ-367: Logistics

- Requirements
  - About 6 Homeworks 20%
  - Midterm 1 20%
  - Midterm 2 20%
  - Final 40%
- Exams
  - Midterm 1 October 5, in class
  - Midterm 2 November 4, in class
  - Final TBD
- The exams are at fixed times. If you cannot do them at these times, then the alternative is an oral exam with the professor.

Econ-367: Logistics

- Slides for projection

  http://www.econ.jhu.edu/courses/367/index.html

- The book

  "Investments" by Bodie, Kane and Marcus

Econ-367: Prerequisites

- Micro Theory
- Statistics (111 or 112)

Minor in Financial Economics

- Four required courses:
  - Elements of Macroeconomics
  - Elements of Microeconomics
  - Corporate Finance
  - **Investments and Portfolio Management**
- Two elective courses
- Plus the prerequisites for these courses
- Check CFE website for detailed rules on the minor

http://cfe.econ.jhu.edu/

Benefits of this Course

- Required for the financial economics minor
- Topics that are important in economics/finance
- Skills that are useful in interviews/jobs

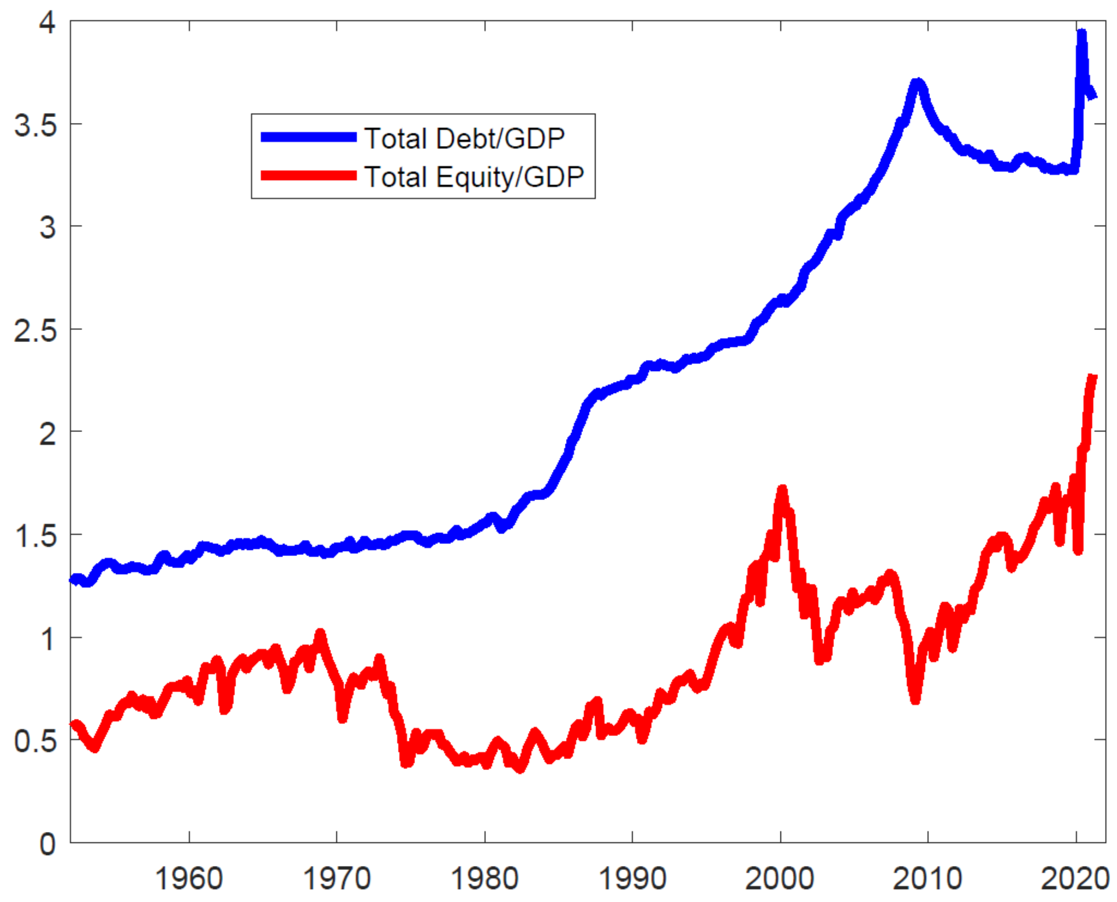
Important Notes

- There is no senior option.
- Anything covered in class can be on the exam. Attendance in class is highly recommended.
- Grades depend on exams/homework alone.
- All regrade requests must be submitted in writing within 2 weeks of the homework/exam being returned.

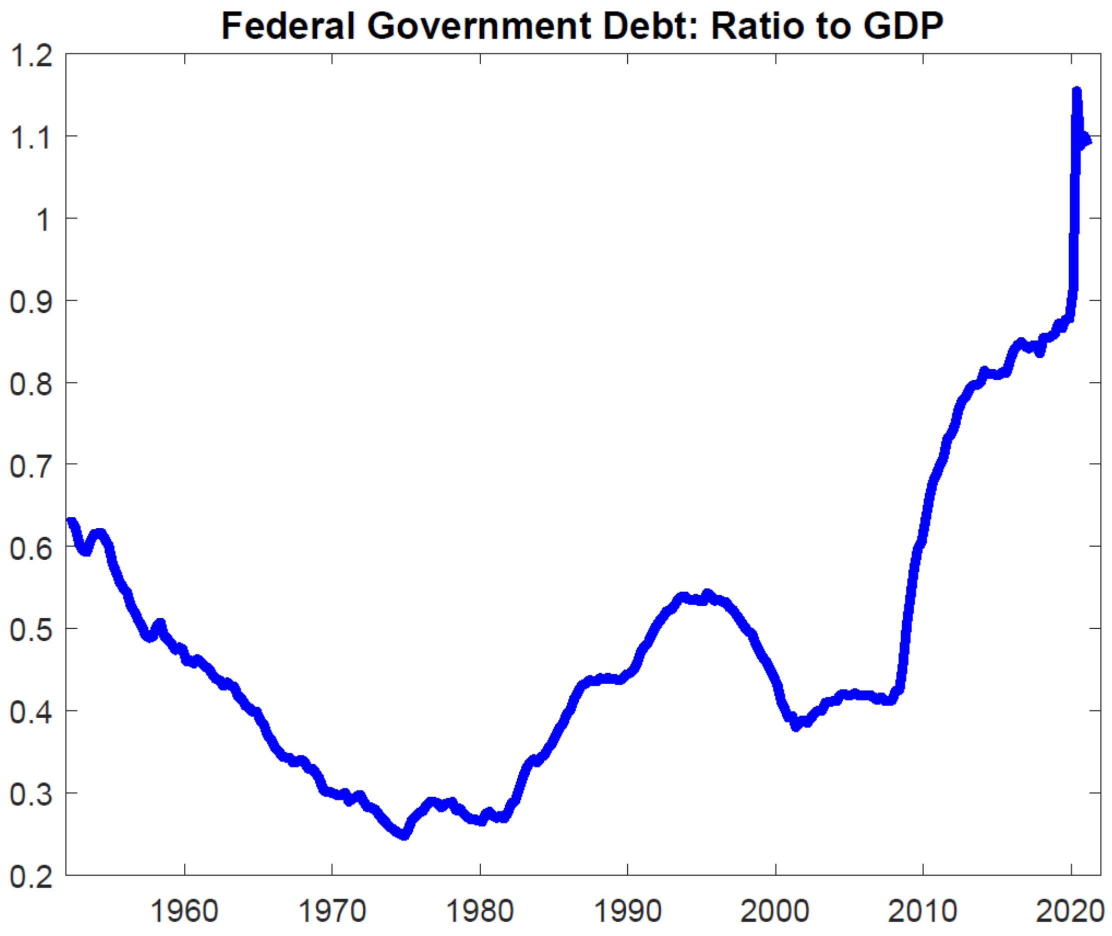
Major Classes of Financial Assets or Securities

- Money market
- Bond market
- Equity Securities
- Indexes
- Derivative markets

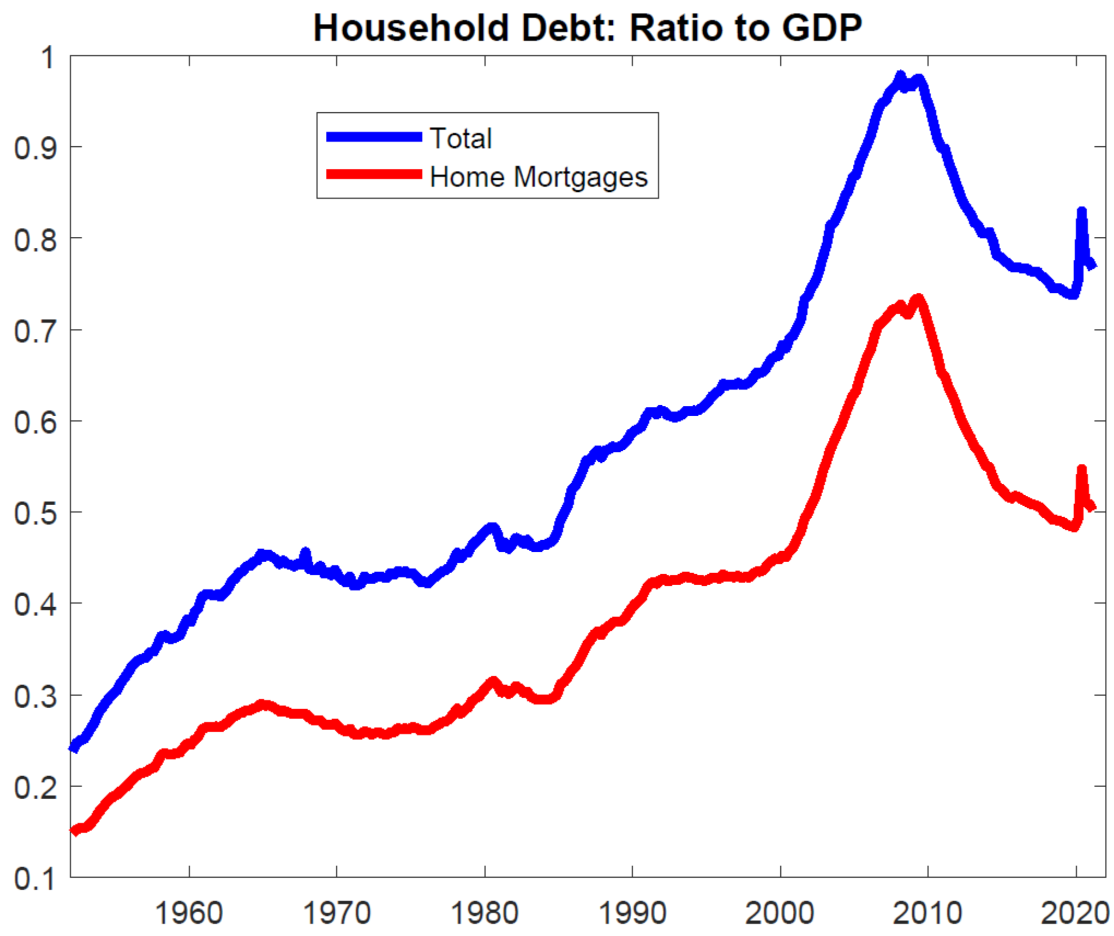
Debt and Equity (Relative to GDP)



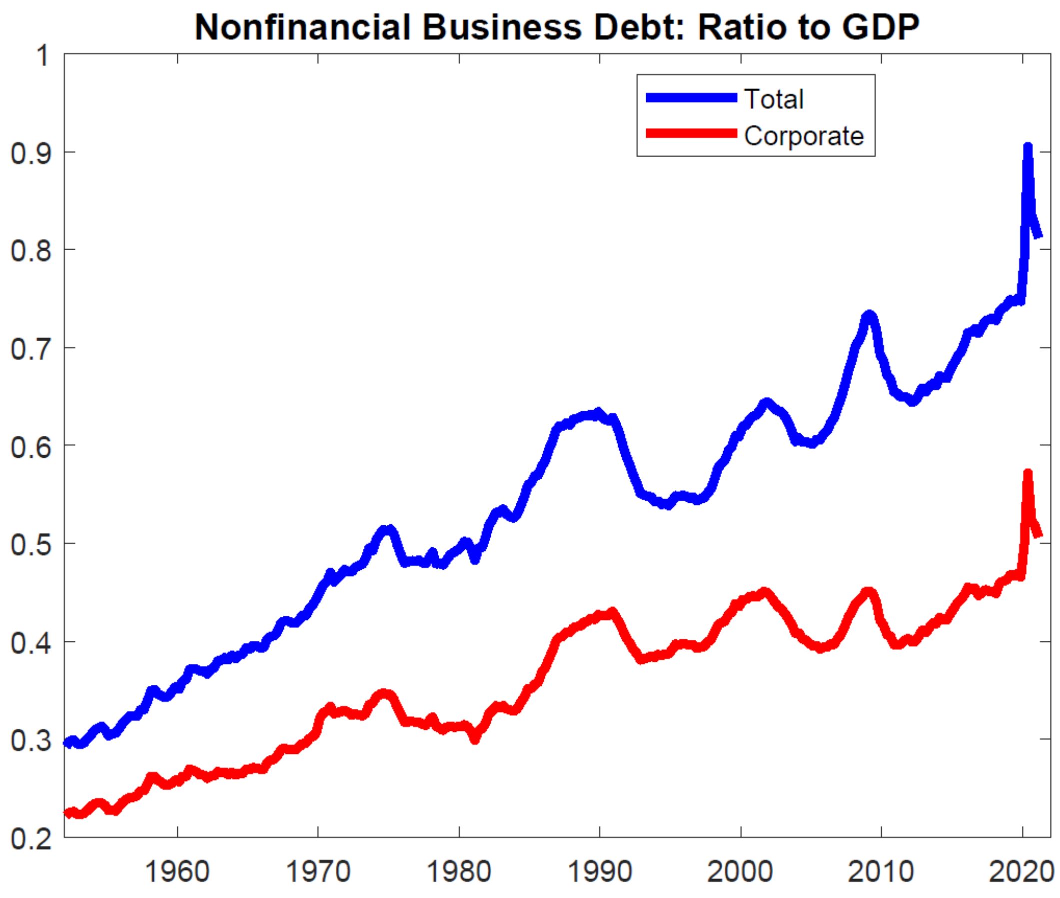
Federal Government Debt (Relative to GDP)



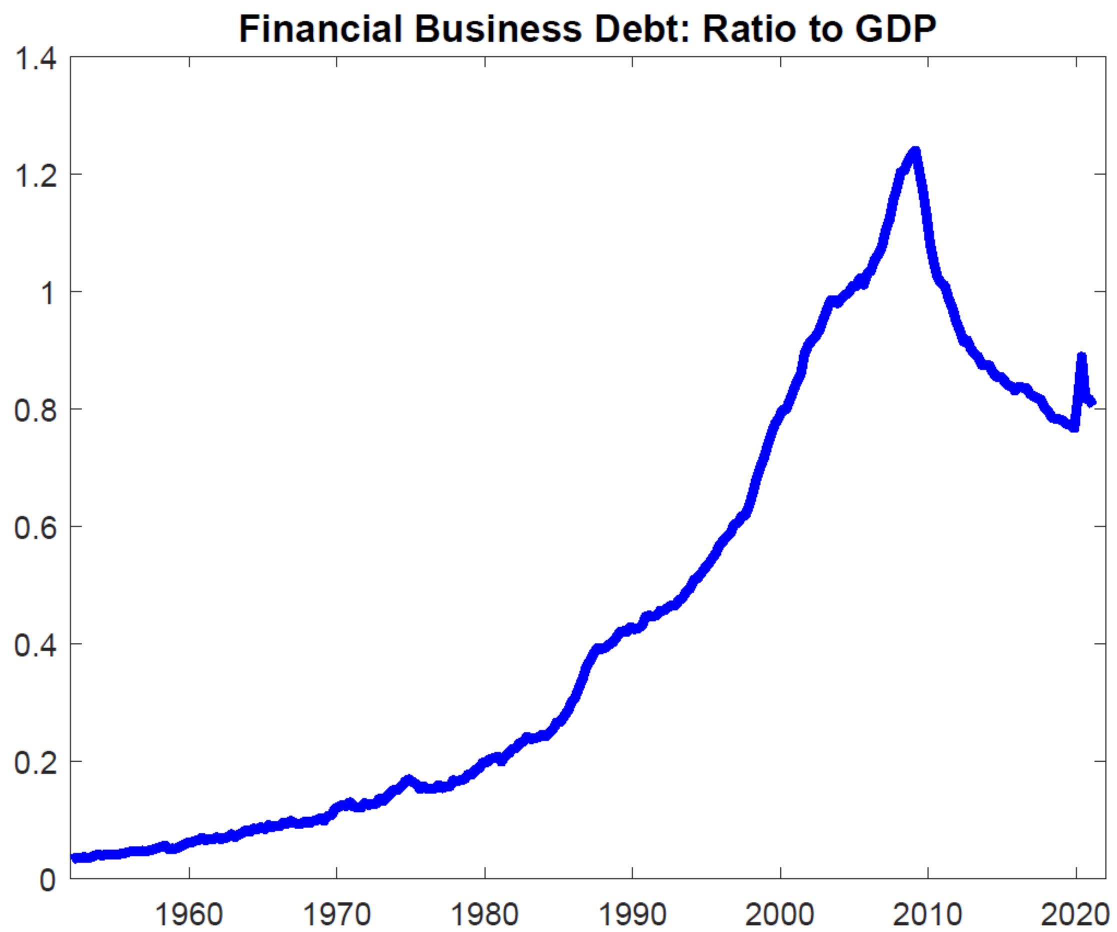
Household debt (relative to GDP)



Nonfinancial business debt (relative to GDP)



Financial business debt (relative to GDP)



The Money Market

- Treasury bills
- Certificates of Deposit
- Interbank Loans
  - Eurodollars
  - Federal Funds
- Commercial Paper
- Repurchase Agreements (RPs)

Bank Discount Rate (T-Bills)

$$r_{BD} = \frac{10,000 - P}{10,000} * \frac{360}{n}$$

r_{BD} = bank discount rate

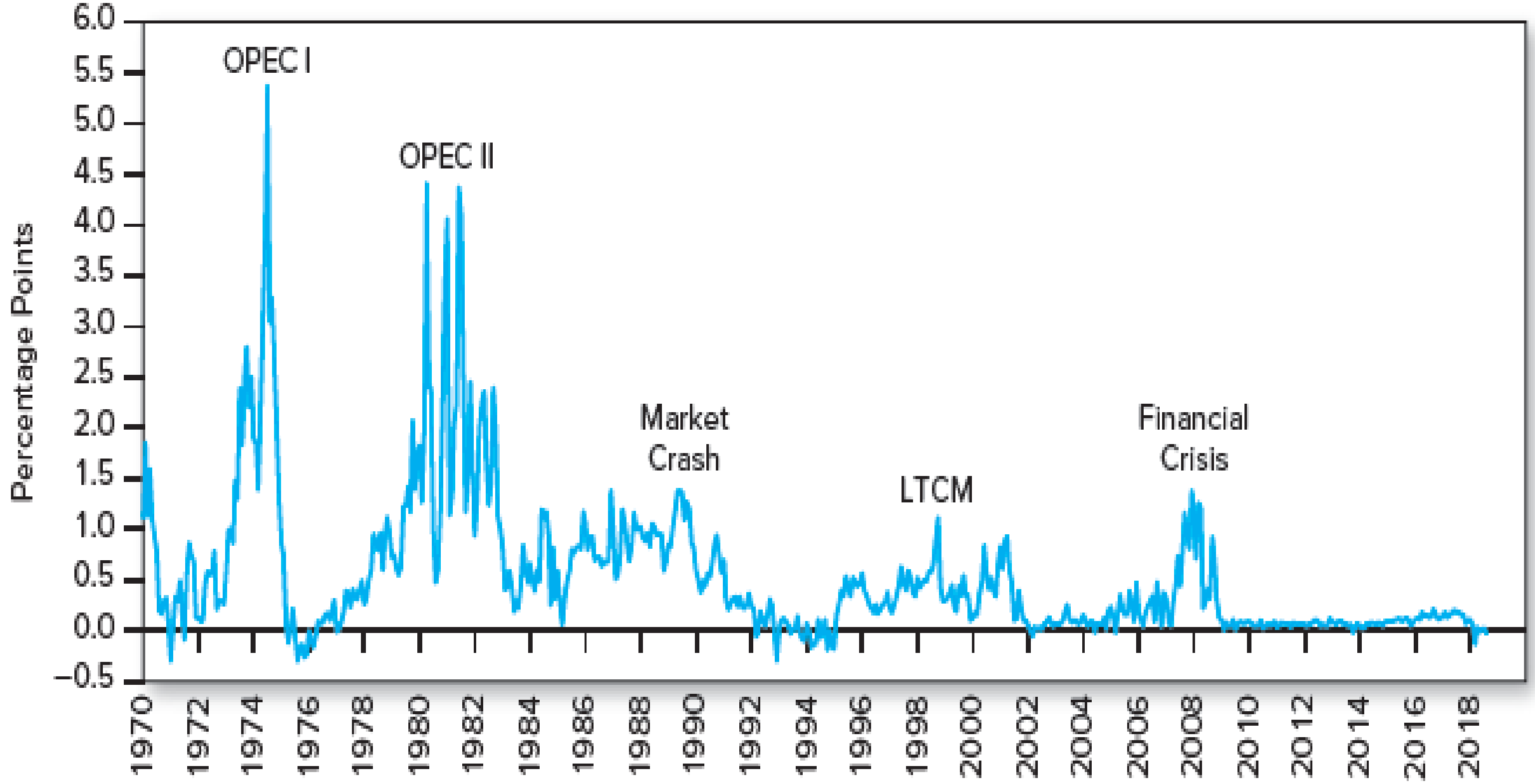
P = market price of the T-bill

n = number of days to maturity

Example: 90-day Tbill, P=9,875

$$r_{BD} = \frac{10,000 - 9,875}{10,000} * \frac{360}{90} = 5\%$$

The Spread between federal funds and Treasury Bill Rates



Repo Agreement

- Selling an asset with an explicit agreement to repurchase the asset after a set period of time
    1. Bank A sells a treasury security to Bank B at $\mathbf{P_0}$
    2. Bank A agrees to buy the treasury back at a higher price $\mathbf{P_f > P_0}$
    3. Bank B earns a rate of return implied by the difference in prices

$$i_{RA} = \frac{P_f - P_0}{P_0} \times \frac{360}{\text{days}}$$

Major Components of the Money Market

	$ Billion
Repurchase agreements	$1,141
Small-denomination time deposits and savings deposits*	7,202
Large-denomination time deposits*	1,603
Treasury bills	1,478
Commercial paper	1,445
Money market mutual funds	2,645

*Small denominations are less than $100,000.

Sources: *Economic Report of the President*, U.S. Government Printing Office, 2012; *Flow of Funds Accounts of the United States*, Board of Governors of the Federal Reserve System, September 2012.

The Bond Market

- Treasury Notes and Bonds
- Inflation-Protected Treasury Bonds
- Federal Agency Debt
- International Bonds
- Municipal Bonds
- Corporate Bonds
- Mortgages and Mortgage-Backed Securities

Treasury Notes and Bonds

- Maturities
  - Notes – maturities up to 10 years
  - Bonds – maturities in excess of 10 years
  - 30-year bond
- Par Value - $1,000
- Quotes – percentage of par

Lisiting of Treasury Issues

U.S. Treasury Quotes

TREASURY NOTES & BONDS

GO TO: Bills

Monday, August 29, 2016 Find Historical Data | WHAT'S THIS?

Treasury note and bond data are representative over-the-counter quotations as of 3pm Eastern time. For notes and bonds callable prior to maturity, yields are computed to the earliest call date for issues quoted above par and to the maturity date for issues below par.

Maturity	Coupon	Bid	Asked	Chg	Asked yield
8/31/2016	0.500	99.9688	99.9844	-0.0391	6.333
8/31/2016	1.000	99.9844	100.0000	unch.	0.998
8/31/2016	3.000	99.9688	99.9844	-0.0313	8.810
9/15/2016	0.875	99.9922	100.0078	-0.0156	0.694
9/30/2016	0.500	99.9922	100.0078	-0.0078	0.407
9/30/2016	1.000	100.0313	100.0469	-0.0078	0.445
9/30/2016	3.000	100.1953	100.2109	-0.0234	0.503
10/15/2016	0.625	100.0078	100.0234	-0.0156	0.438
10/31/2016	0.375	99.9688	99.9844	-0.0234	0.468
10/31/2016	1.000	100.0781	100.0938	-0.0156	0.442
10/31/2016	3.125	100.4297	100.4453	-0.0313	0.475

Government Sponsored Enterprises Debt

- Major issuers
  - Federal Home Loan Bank
  - Federal National Mortgage Association
  - Government National Mortgage Association
  - Federal Home Loan Mortgage Corporation

Municipal Bonds

- Issued by state and local governments
- Types
  - General obligation bonds
  - Revenue bonds
    - Industrial revenue bonds
- Maturities – range up to 30 years

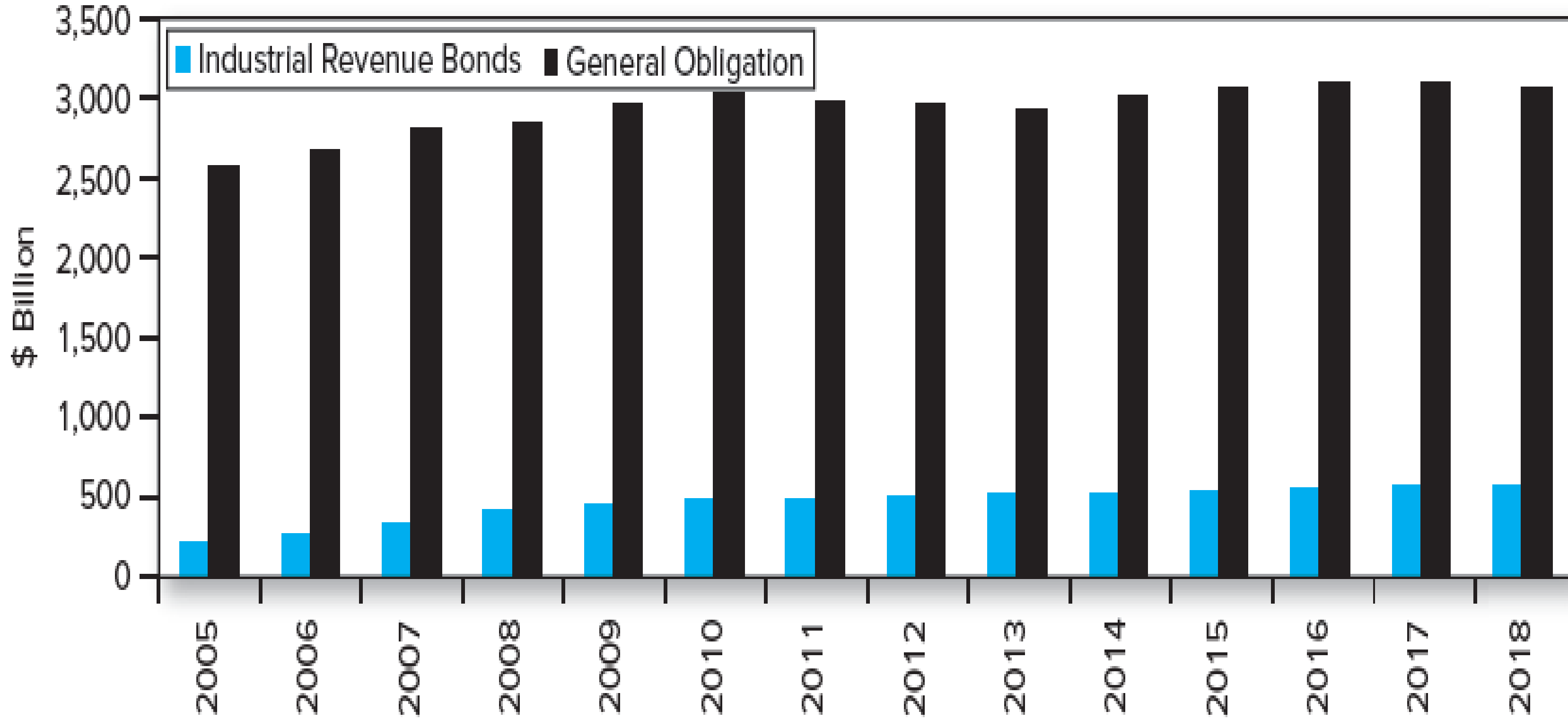
Municipal Bond Yields

- Interest income on municipal bonds is not subject to federal and sometimes not to state and local tax
- To compare yields on taxable securities a Taxable Equivalent Yield is constructed

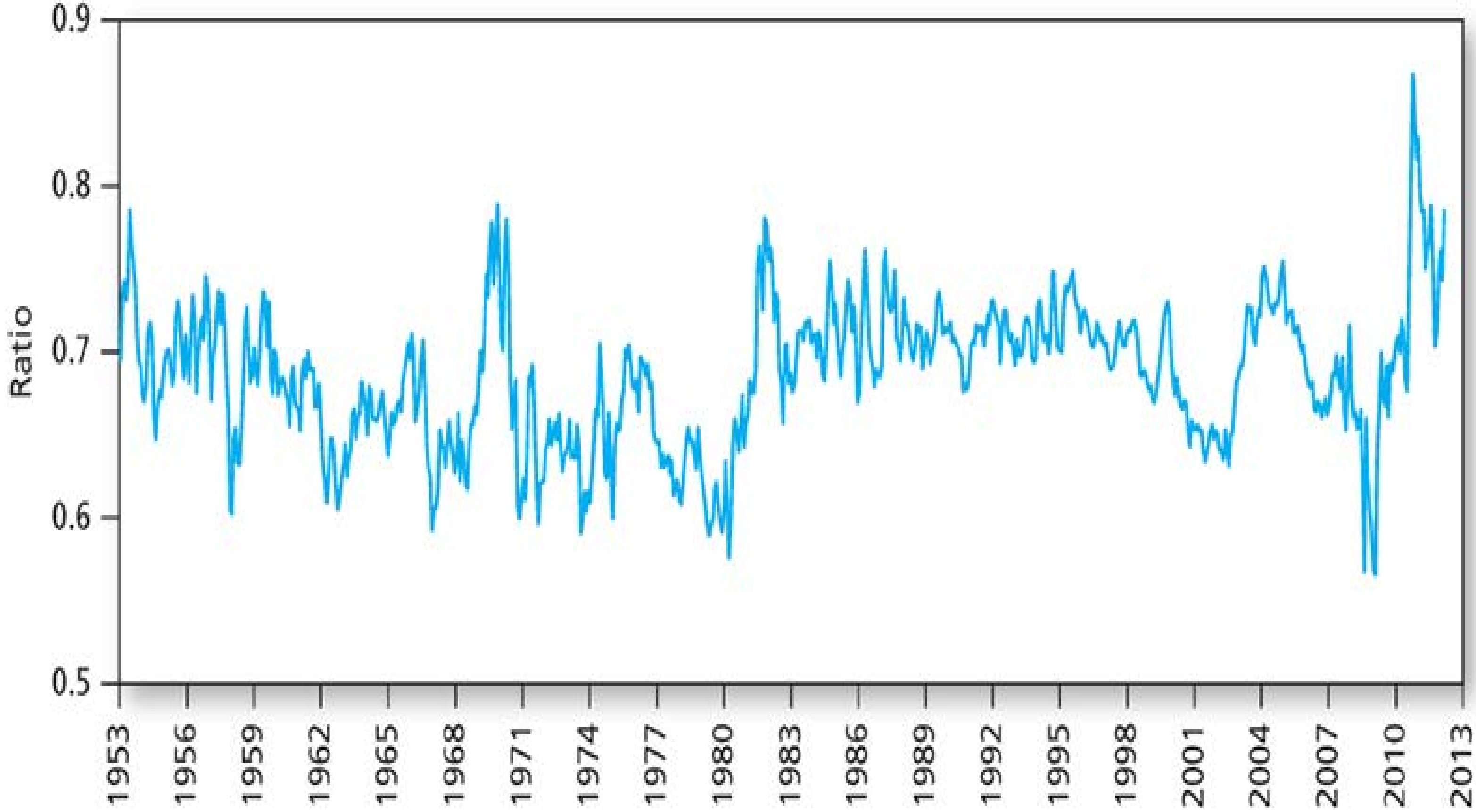
Equivalent Taxable Yields Corresponding to Various Tax-Exempt Yields

	Tax-Exempt Yield				
Marginal Tax Rate	1%	2%	3%	4%	5%
20%	1.25%	2.50%	3.75%	5.00%	6.25%
30	1.43	2.86	4.29	5.71	7.14
40	1.67	3.33	5.00	6.67	8.33
50	2.00	4.00	6.00	8.00	10.00

Size of the municipal bond market



Ratio of Yields on Muni to Corporate Bonds



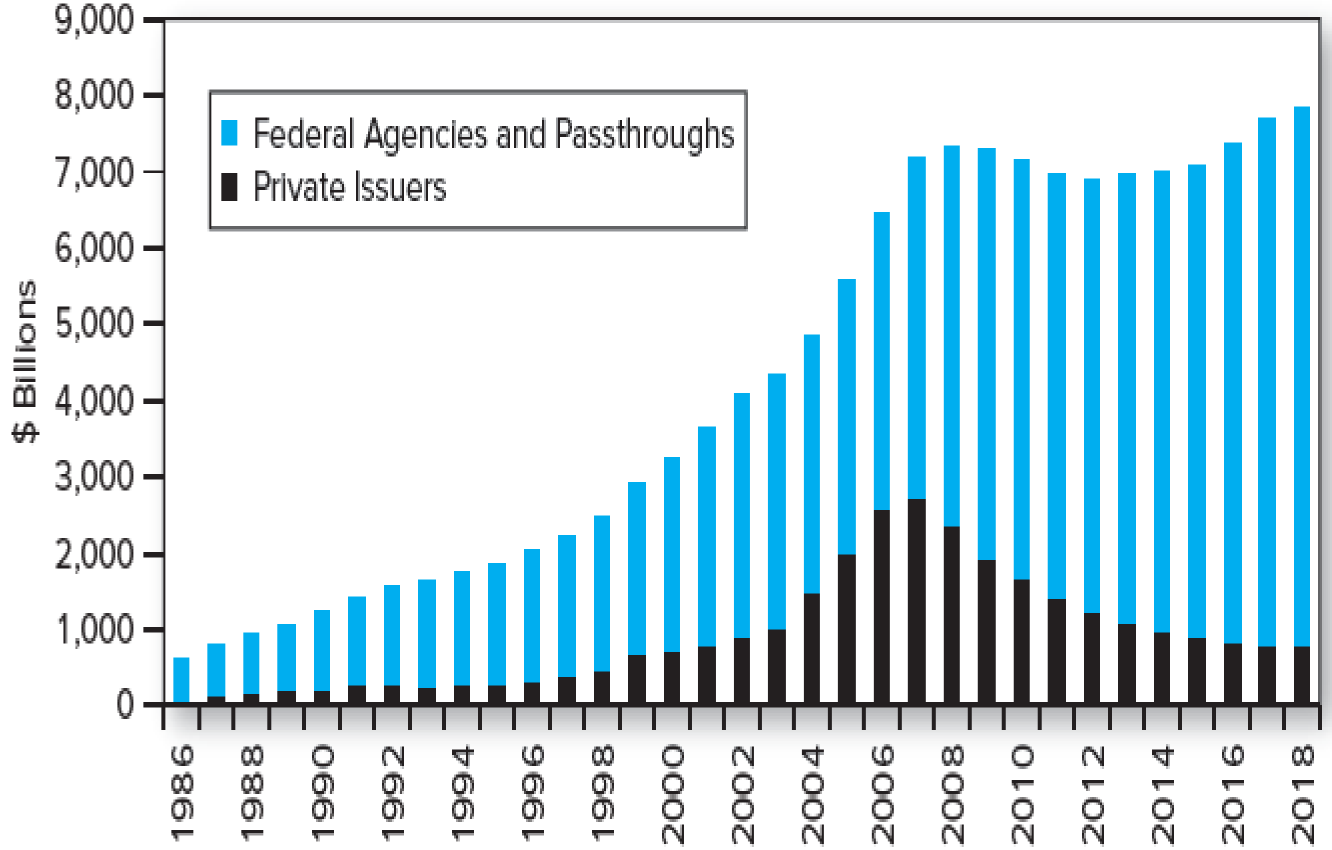
Corporate Bonds

- Issued by private firms
- Semi-annual interest payments
- Subject to larger default risk than government securities
- Options in corporate bonds
  - Callable
  - Convertible

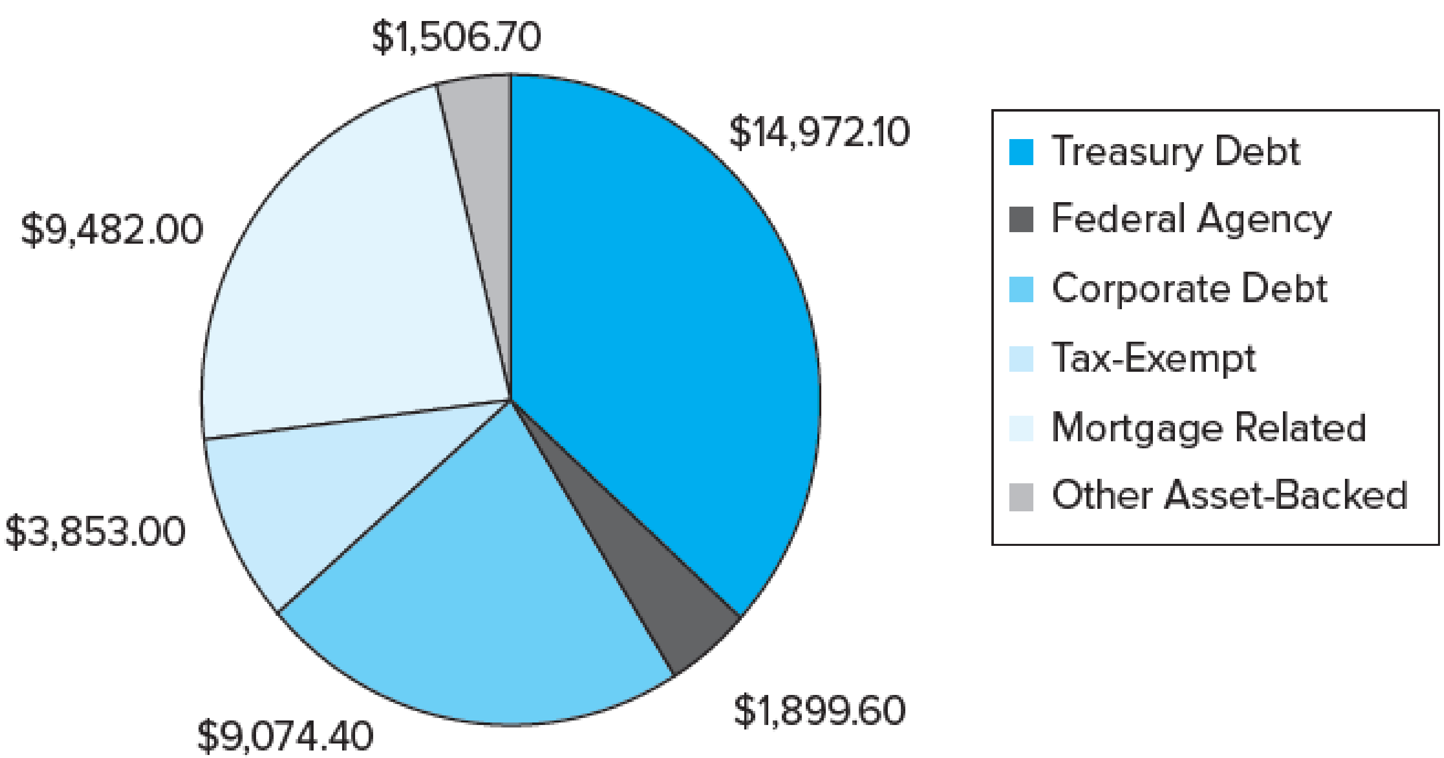
Mortgages and Mortgage-Backed Securities

- Developed in the 1970s to help liquidity of financial institutions
- Proportional ownership of a pool or a specified obligation secured by a pool

Agency RMBS Securities outstanding



Major Components of the Bond Market



Equity Securities

- Represent ownership shares in a corporation
- Each share entitles owner to one vote
- Corporation controlled by board of directors elected by shareholders
- **Residual claim**
  - Stockholders are last in line of all who have a claim on the assets and income of the corporation
- **Limited liability**
  - Most shareholders can lose in the event of failure of the corporation is their original investment

Equity Securities: Stock Market Listings

- **Dividend yield**
  - Annual dividend payment expressed as a percent of the stock price
- **Capital gains**
  - Amount by which the sale price of a security exceeds the purchase price
- **Price-earnings ratio**
  - Ratio of a stock's price to its earnings per share

Equity Securities: Preferred Stock

- Preferred stock has features similar to both equity and debt
  - Like a bond, promises to pay a fixed amount of income each year
  - Does not convey voting power regarding the management of the firm
  - Contractual obligation to pay interest, but not dividends
  - Preferred stock payments are treated as dividends rather than interest, so they are not a tax-deductible expense for the firm

Stocks Traded on the NYSE

NAME	SYMBOL	CLOSE	NET CHG	VOLUME	52 WK HIGH	52 WK LOW	DIV	YIELD	P/E	YTD% CHG
Gencorp	GY	13.59	–0.29	491,300	20.75	12.02	....	....	dd	–3.1
Genentech	DNA	83.68	–0.35	3,986,300	94.46	75.58	....	....	49	3.1
General Cable	BGC	42.67	–1.11	679,700	45.41	20.3	....	....	23	–2.4
General Dynamics	GD	74.59	0.17	1,497,300	77.98	56.68	0.92	1.2	16	0.3
General Electric	GE	37.56	–0.19	26,907,700	38.49	32.06	1.12	3	23	0.9
General Gwth Prop	GGP	51.51	–0.8	1,308,200	56.14	41.92	1.8	3.5	215	–1.4
General Maritime	GMR	34.56	–0.83	597,400	40.64	30.34	4.8	13.9	5	–1.8
General Mills	GIS	56.97	–0.42	1,355,600	59.23	47.05	1.48	2.6	18	–1.1
General Motors	GM	30.24	0.6	10,477,600	36.56	19	1	3.3	dd	–1.6
Genesco Inc	GCO	36.75	–0.9	127,900	43.72	25.5	....	....	15	–1.5
Genesee & Wyoming	GWR	25.86	–0.5	364,500	36.75	21	....	....	9	–1.4
Genesis Lease	GLS	23.6	0.1	298,500	24.4	23	....	....	....	0.4
Genuine Parts co.	GPC	46.86	–0.51	384,400	48.34	40	1.35	2.9	17	–1.2
Genworth Financial	GNW	33.79	–0.32	1,414,900	36.47	31	0.36	1.1	13	–1.2
Geo Group Inc	GEO	37.57	–1.53	157,500	40.3	14.69	....	....	35	0.1
Georgia Gulf	GGC	18.69	–0.38	479,000	34.65	18.36	0.32	1.7	6	–3.2
Gerber Scientific	GRB	12.32	–0.07	243,200	16.8	9	....	....	27	–1.9
Gerdau Ameristeel	GNA	8.59	–0.04	446,200	11.02	5.85	0.08	0.9	7	–3.7
Gerdau S.A. Ads	GGB	15.57	–0.56	1,729,100	18.16	11.27	0.58	3.7	....	–2.7

Stock Market Indexes

- There are several broadly based indexes computed and published daily

Dow Jones Industrial Average

- Includes 30 large blue-chip corporations
- Computed since 1896
- Price-weighted average

Standard & Poor’s Indexes

- Broadly based index of 500 firms
- Market-value-weighted index
- Index funds
- Exchange Traded Funds (ETFs)

Other U.S. Market-Value Indexes

- NASDAQ Composite
- NYSE Composite
- Wilshire 5000

Investing in an index

- Investor may buy stocks
- Or an index tracking mutual fund
- Or an Exchange-traded fund (ETF) designed to match the index
  - Spiders (S&P Depository Receipt) tracks S&P 500
  - Cube track Nasdaq 100
- ETFs consist of a share in a basket of securities corresponding to the relevant index
- There is a redemption procedure

Derivatives Markets

Options

- Basic Positions
  - Call (Buy)
  - Put (Sell)
- Terms
  - Exercise Price
  - Expiration Date
  - Assets

Futures

- Basic Positions
  - Long (Buy)
  - Short (Sell)
- Terms
  - Delivery Date
  - Assets

Trading Data on IBM Options

PRICES AT CLOSE, July 17, 2012

IBM (IBM)		Underlying stock price: 183.65					
		Call			Put		
Expiration	Strike	Last	Volume	Open Interest	Last	Volume	Open Interest
Jul	180.00	5.50	620	1998	2.11	3080	8123
Aug	180.00	6.85	406	2105	3.70	847	3621
Oct	180.00	9.70	184	424	6.85	245	4984
Jan	180.00	12.58	52	2372	10.25	76	3196
Jul	185.00	2.80	2231	3897	4.20	2725	7370
Aug	185.00	4.10	656	2656	6.26	634	3367
Oct	185.00	6.99	843	969	9.10	783	2692
Jan	185.00	9.75	135	3156	12.01	243	10731

Listing of Selected Futures Contracts

Agriculture Futures

	OPEN	HIGH	LOW	SETTLE	CHG	OPEN INT
Corn (CBT)-5,000 bu.; cents per bu.						
March	371.00	372.50	360.50	**362.25**	-8.25	591,430
Dec	361.75	366.00	357.00	**359.00**	-3.00	311,690
Oats (CBT)-5,000 bu.; cents per bu.						
March	261.75	265.75	258.25	**261.25**	-.75	8,823
Dec	233.00	234.25	232.50	**233.75**	.75	3,907
Soybeans (CBT)-5,000 bu.; cents per bu.						
Jan	667.00	675.00	659.75	**662.75**	-6.50	9,947
March	681.00	687.75	672.50	**675.50**	-6.50	220,362

Currency Futures

Japanese Yen (CME)-¥12,500,000; $ per 100¥						
March	.8456	.8485	.8447	**.8479**	.0016	275,282
June	.8561	.8579	.8545	**.8577**	.0016	5,119
British Pound (CME)-£62,500; $ per £						
March	1.9516	1.9537	1.9403	**1.9448**	-.0063	136,995
June	1.9446	1.9531	1.9402	**1.9443**	-.0063	191

Index Futures

DJ Industrial Average (CBT)-$10 x index						
March	12543	12575	12470	**12549**	19	64,555
June	12629	12647	12601	**12647**	18	44
S&P 500 Index (CME)-$250 x index						
March	1425.20	1431.50	1417.00	**1427.50**	2.70	601,655
June	1432.00	1444.50	1430.50	**1440.10**	2.60	13,287

Quoting Conventions APR

Suppose that interest of 1 percent is paid every month

The “APR” with monthly compounding will be 12 percent

APR = Annual Percentage Rate
(periods in year) X (rate for period)

Quoting Conventions
EAR

Suppose again that interest of 1 percent is paid every month

The "EAR" will be how much interest is earned on $1 after 1 year.

EAR = Effective Annual Rate

$$(1+ \text{rate for period})^{\text{Periods per yr}} - 1$$

In this case EAR = $(1.01)^{12} - 1 = 12.68\%$

After n years $1 turns becomes $\$(1+EAR)^n$

Quoting Conventions
Relationship between APR and EAR

For annual compounding they are the same thing

For compounding n times a year

$$EAR = (1 + \frac{APR}{n})^n - 1$$

$$APR = n * \{[1 + EAR]^{1/n} - 1\}$$

Quoting Conventions
Continuous Compounding

Suppose that I compound every second

Let r be the APR with continuous compounding

$$EAR = \lim_{n\to\infty}(1+\frac{r}{n})^n - 1 = \exp(r) - 1$$

After 1 year, the value of $1 is $\$\exp(r)$

After n years, the value of $1 is $\$\exp(r)^n = \$\exp(rn)$

Quoting Conventions
Continuous Compounding

Suppose that an asset is worth V(0) today and V(n) in years

$$V(n) = V(0) * \exp(rn)$$

Inverting this yields

$$r = \frac{\ln(V(n)) - \ln(V(0))}{n}$$

Quoting Conventions: Example

Say we want to get an EAR of 5.8%.

What APR do we need at different compounding frequencies?

$$APR = n * \{[1 + EAR]^{1/n} - 1\}$$

Frequency	Periods per year	Rate
Annual	1	5.80
Quarterly	4	5.68
Monthly	12	5.65
Daily	365	5.64

Continuous Compounding: Example

- Start with \$1 and after 1 year have \$1.058

- APR with continuous compounding is

$$\frac{\ln(1.058)-\ln(1)}{1}=0.0564$$

Continuous compounding and adding up

- A stock is worth \$10 in year 1, \$20 in year 2 and \$10 in year 3.

- Q1. What is the return from year 1 to year 2?
  - $\ln(20)-\ln(10)=0.69$
- Q2. What is the return from year 2 to year 3?
  - $\ln(10)-\ln(20)=-0.69$
- Q3. What is the return from year 1 to year 3?
  - $\{\ln(10)-\ln(10)\}/2=0$

- Continuous compounded returns have the useful feature that they "add up"

Present value

- Suppose that we have a stream of cash flows and let r be the constant EAR

Time (years)	Amount
1	C(1)
2	C(2)
:	
T	C(T)

- Present value:

$$PV = \frac{C(1)}{1+r} + \frac{C(2)}{(1+r)^2} \dots + \frac{C(T)}{(1+r)^T}$$

- NPV function in Excel

Present value example

- Let the EAR be 5% and consider the following cash flow:

Time (years)	Amount
1	$75
2	$50
3	$100

- Present value:

$$PV = \frac{75}{1.05} + \frac{50}{1.05^2} + \frac{100}{1.05^3} = 203.16$$

Another Present value example

- Consider the following two projects

	t=0	t=1	t=2	t=3
Project A	-200	50	50	120
Project B	100	50	50	-220

- What are their present values at 1% and 10% interest rates?

	1%	10%
PV of A	15	-23
PV of B	-15	21

Internal rate of return

- Suppose that we have a stream of cash flows for which an investor is willing to pay P today. The value of r that solves the equation

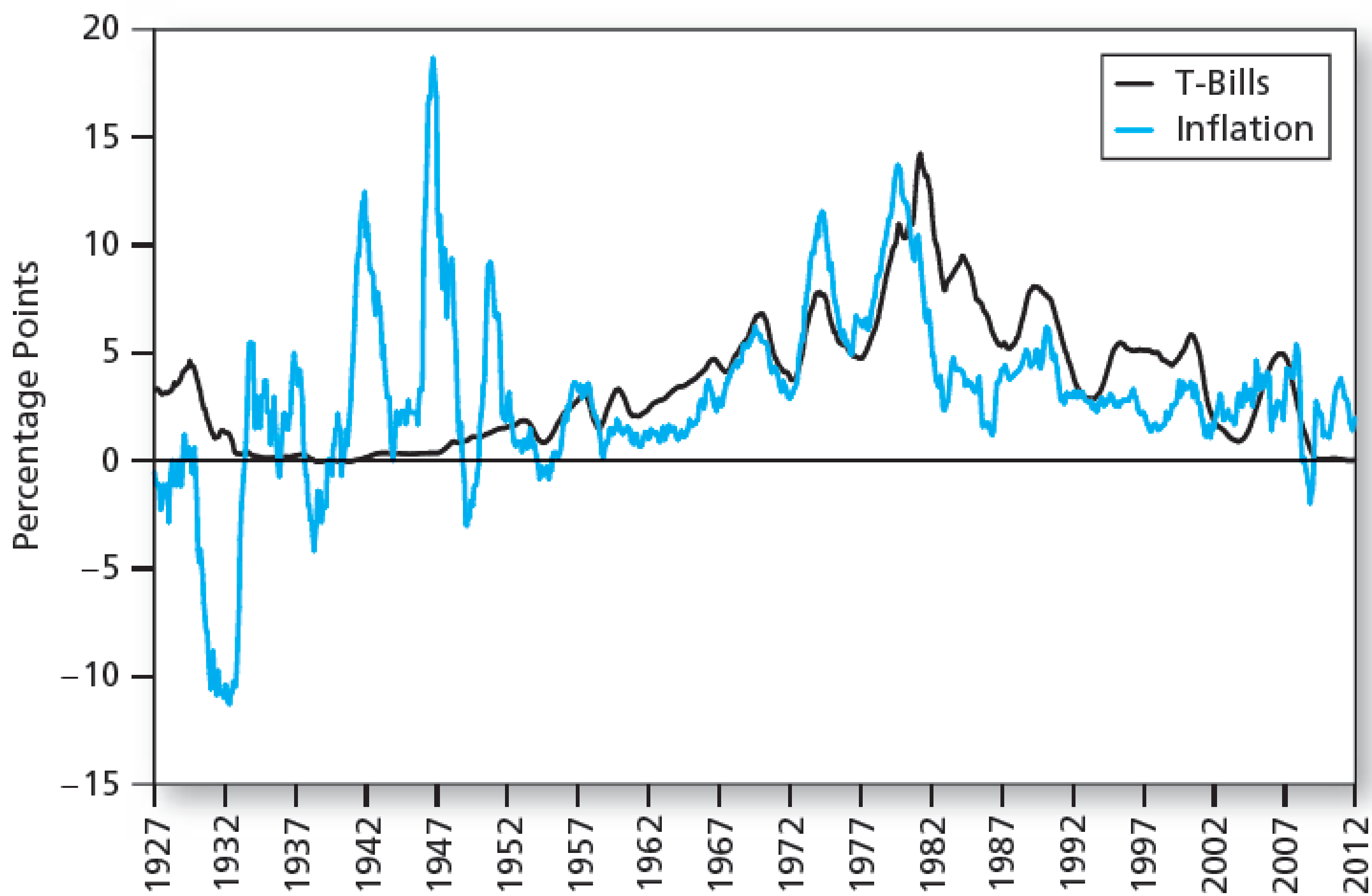
$$P = \frac{C(1)}{1+r} + \frac{C(2)}{(1+r)^2} \dots + \frac{C(T)}{(1+r)^T}$$

is called the *internal rate of return*.

History of T-bill Rates, Inflation and Real Rates, 1926-2012

	Annualized Average Rates		
	T-Bills	Inflation	Real T-Bill
All months	3.55	3.04	0.52
First half	1.79	1.74	0.10
Recent half	5.35	4.36	0.95

Interest Rates and Inflation, 1926-2012



Risk and Risk Premiums

Rates of Return: Single Period

$$HPR = \frac{P_1 - P_0 + D_1}{P_0}$$

HPR = Holding Period Return

P_0 = Beginning price

P_1 = Ending price

D_1 = Dividend during period one

Rates of Return: Single Period Example

Ending Price =	48
Beginning Price =	40
Dividend =	2

$HPR = (48 - 40 + 2) / (40) = 25\%$

Expected Return and Standard Deviation

Expected returns

$$E(r) = \Sigma_s \, p(s) r(s)$$

***p*(*s*) = probability of a state**
***r*(*s*) = return if a state occurs**
***s* = state**

Scenario Returns: Example

State	Prob. of State	*r* in State
1	.1	-.05
2	.2	.05
3	.4	.15
4	.2	.25
5	.1	.35

$E(r) = (.1)(-.05) + (.2)(.05) \ldots + (.1)(.35)$

$E(r) = .15$

Variance or Dispersion of Returns

Variance:

$$Var = \Sigma_s p(s)[r(s) - E(\mathrm{r})]^2$$

Standard deviation = [variance]$^{1/2}$

Using Our Example:

Var =[(.1)(-.05-.15)^2+(.2)(.05- .15)^2…+ .1(.35-.15)^2]
Var= .012
S.D.= [.012] $^{1/2}$ = .1095

Covariance and correlation

- Let r(1) and r(2) be two random variables
- The covariance between them is

$$E([r(1)-E(r(1))][r(2)-E(r(2))])$$

- Need the joint probabilities of r(1) and r(2) to work this out

Covariance Example

- Let r(1) and r(2) be two returns with the following joint distribution

	r(1)=0	r(1)=0.1	r(1)=0.3
r(2)=0	0.05	0.3	0.15
r(2)=0.2	0.35	0.1	0.05

Covariance Example

- First need the means

	r(1)=0	r(1)=0.1	r(1)=0.3	
r(2)=0	0.05	0.3	0.15	0.5
r(2)=0.2	0.35	0.1	0.05	0.5
	0.4	0.4	0.2	

- E(r(1))=(0.4*0)+(0.4*0.1)+(0.2*0.3)=0.1
- E(r(2))=(0.5*0)+(0.5*0.2)=0.1

Covariance Example

- Possible outcomes for

$[r(1)-E(r(1))]*[r(2)-E(r(2))]$

- Weight each of them by their probability
- Add up
- Covariance is -0.005

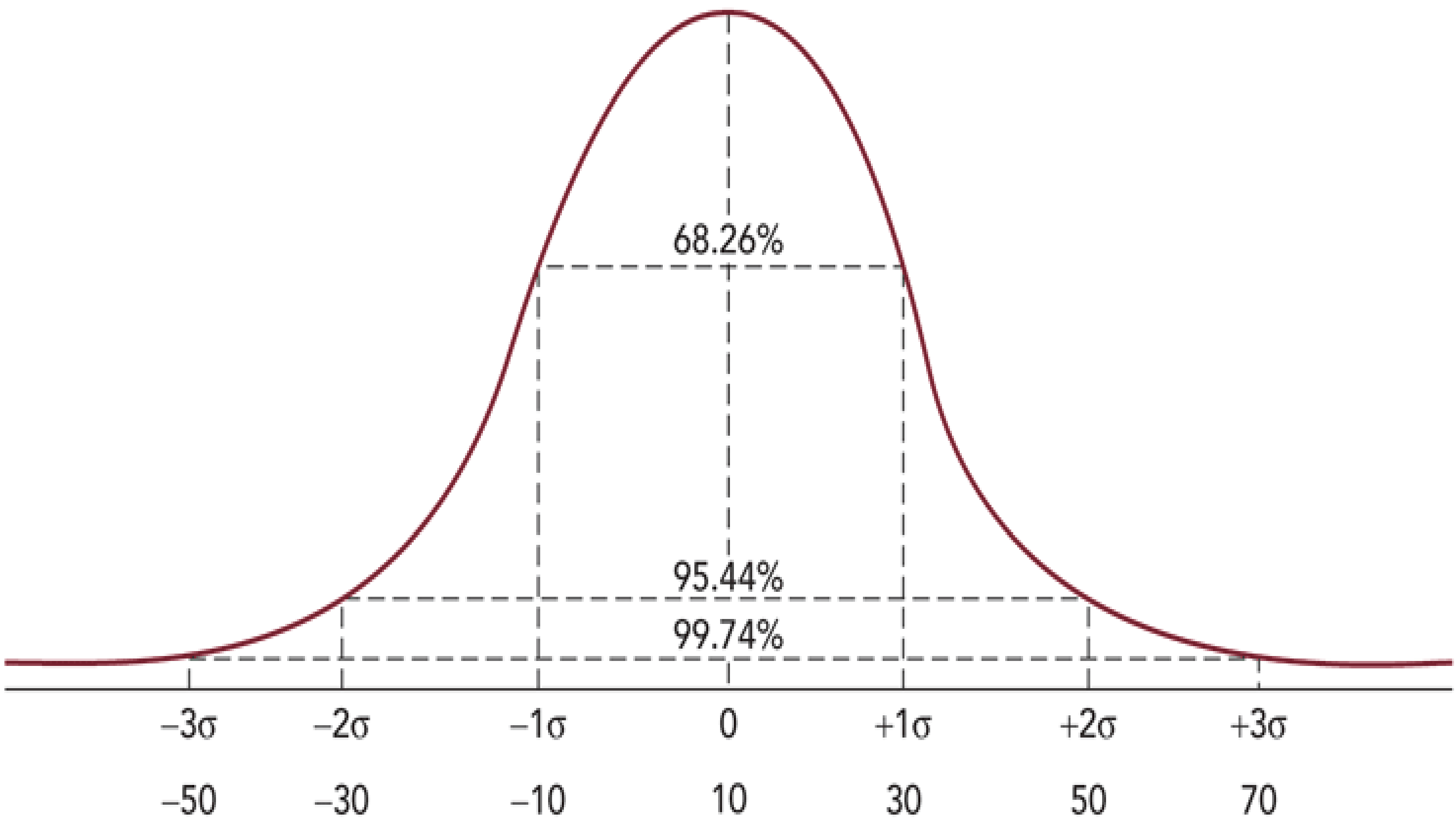
Covariance and correlation

- Covariance is measured in units that are hard to interpret
- Correlation avoids this problem. The correlation between r(1) and r(2) is

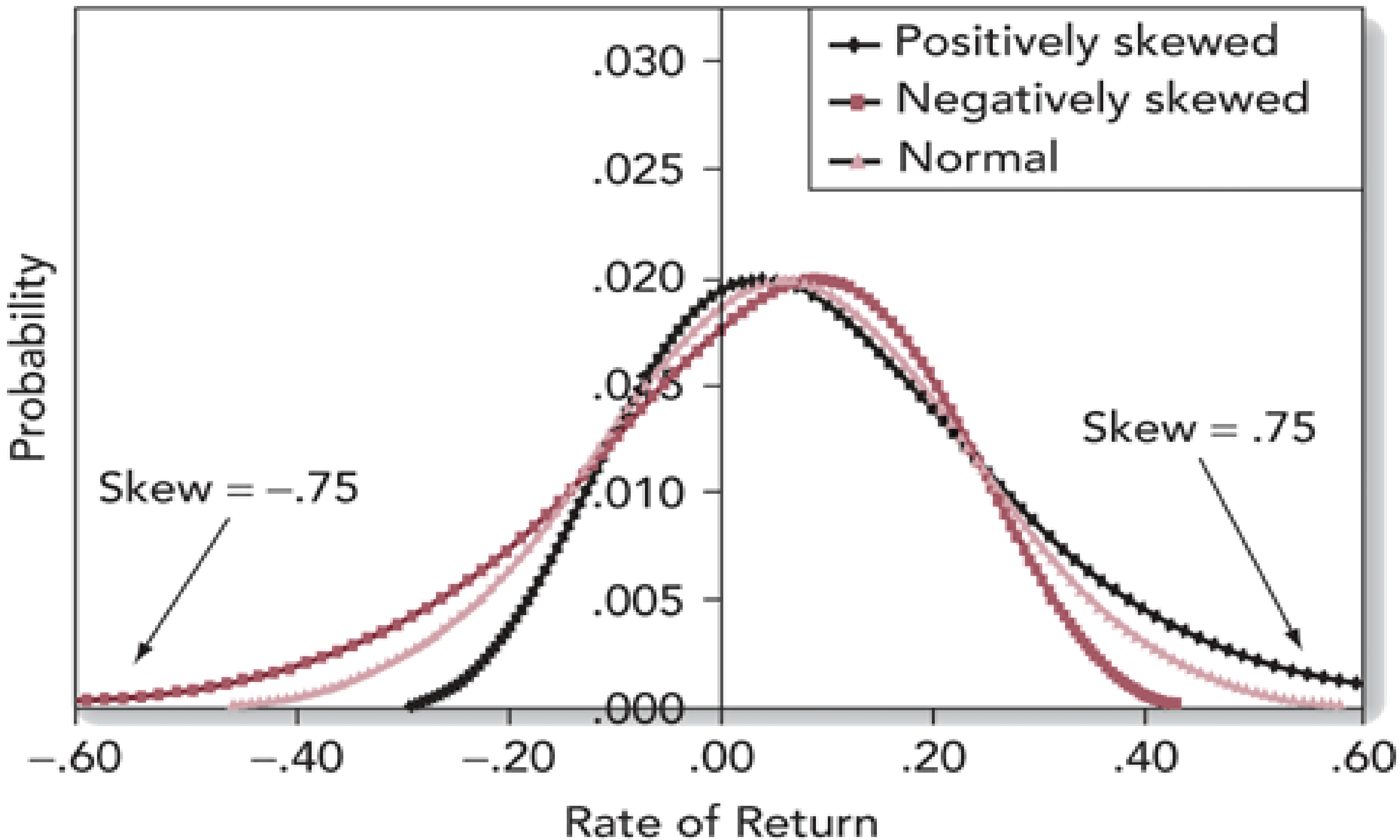
$$\frac{Cov(r(1), r(2))}{\sqrt{Var(r(1))Var(r(2))}}$$

- It must be between -1 and +1

The Normal Distribution



A Normal and Skewed Distributions (mean = 6% SD = 17%)



Properties of stock returns

- Excess return on S&P is about 0.07
- Standard deviation of S&P is about 0.17
- Negative skewness
- Fat tails

The Reward-to-Volatility (Sharpe) Ratio

$$\text{Sharpe Ratio for Portfolios} = \frac{\text{Risk Premium}}{\text{SD of Excess Return}}$$

Risk Premium: Average Excess Return

For stocks, Sharpe Ratio is about 0.4

How Firms Issue Securities

- Firms requiring new capital can raise funds by borrowing money or selling shares in the firm
  - **Primary market** is the market in which new issues of securities are offered to the public
  - **Secondary market** involves already existing securities being bought and sold on the exchanges or in the OTC market
- Shares of *publicly listed* firms trade continually in markets such as the NYSE or NASDAQ, but the shares of *private corporations* are held by small numbers of managers and investors

How Firms Issue Securities

Privately Held Firms

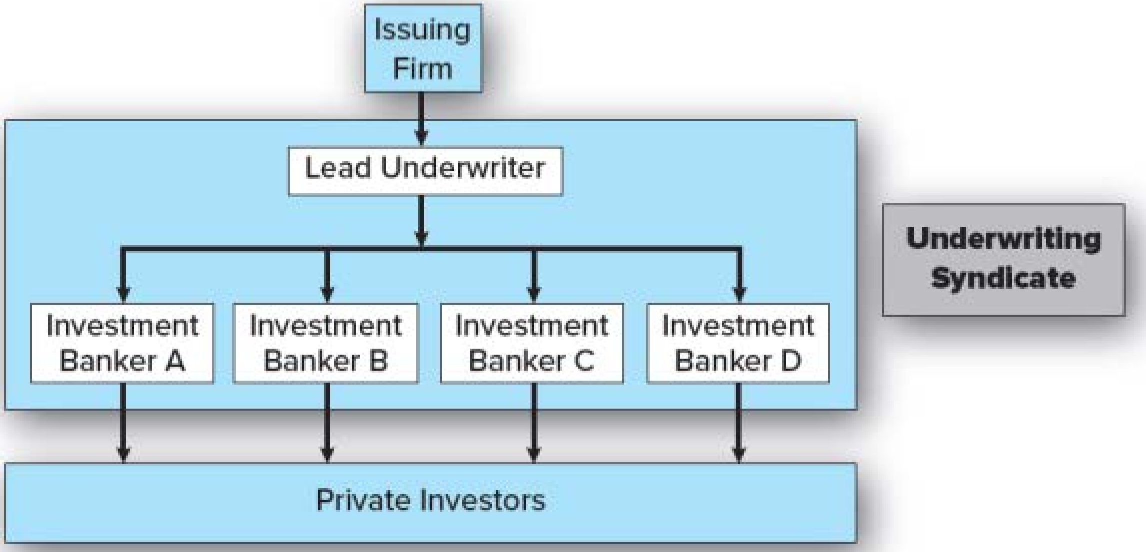
- Owned by a relatively small number of shareholders
- Fewer obligations to release information to the public
- Jumpstart Our Business Startups (JOBS) of 2012 allows up to 2,000 shareholders
- Raise funds through **private placement**

How Firms Issue Securities

Publicly Traded Companies

- **Initial public offering**, or **IPO**
  - A firm's first issue of shares to the public
- *Seasoned equity offering*
  - The sale of additional shares in firms that already are publicly traded
- Public offerings of both stocks and bonds typically are marketed by **underwriters**
  - Advises the firm regarding the terms on which it should attempt to sell the securities

Relationships Among a Firm Issuing Securities, the Underwriters, and the Public



How Firms Issue Securities

Shelf Registration

- Shelf registration
  - Rule 415 was introduced in 1982
    - Allows firms to register securities and gradually sell them to the public for three years following the initial registration
    - Shares can be sold on short notice and in small amounts without incurring high floatation costs
  - These securities are referred to as "on the shelf"

How Firms Issue Securities

Initial Public Offerings

- Initial public offerings
  - *Road shows* to publicize new offering
  - *Bookbuilding* to determine demand
    - Degree of investor interest provides valuable pricing information
    - Shares of IPOs are allocated across investors in part based on the strength of each investor’s expressed interest

How Firms Issue Securities

Initial Public Offerings (Continued)

- Underwriter bears price risk
  - IPOs are commonly underpriced compared to the price they could be marketed
    - Example: Dropbox
  - Some IPOs are overpriced
    - Example: Facebook
  - Others cannot be fully sold

Types of Markets

- *Direct search market*
  - Least organized
  - Buyers and sellers seek each other out directly
- *Brokered markets*
  - Brokers offer search services to buyers and sellers
- **Dealer markets**
  - Traders specializing in particular assets buy and sell assets for their own accounts
- **Auction markets**
  - All traders in an asset meet (physically or electronically) at one place to buy and sell

Bid and Ask Prices

Bid Price

- Bids are offers to buy
- In dealer markets, the bid price is the price at which the dealer is willing to buy
- Investors "sell to the bid"

Ask Price

- Ask prices are sell offers
- In dealer markets, the ask price is the price at which the dealer is willing to sell
- Investors must pay the ask price to buy the security

Bid-asked spread is the difference between a dealer's bid and ask price

Types of Orders

- Market orders
  - Buy or sell orders that are to be executed immediately
  - Trader receives current market price
- Price-contingent orders
  - Traders specify buying or selling price
  - **Limit buy (sell) order** instructs the broker to buy (sell) shares if and when those shares are at or below (above) a specified price

Price-Contingent Order: Example

Microsoft Corporation (MSFT) ★ **Watchlist**

NasdaqGS - NasdaqGS Real Time Price. Currency in USD

101.50 –0.07 (–0.07%) As of 1:21PM EST. Market open.

Order Book

Top of Book

Bid		Ask	
Price	**Size**	**Price**	**Size**
101.46	100	101.47	199
101.45	357	101.48	600
101.44	200	101.49	300
101.43	400	101.50	700
101.42	427	101.51	400

Trading Mechanisms

- Dealer markets
  - **Over-the-counter (OTC) market** is an informal network of brokers and dealers where securities can be traded (not a formal exchange)
- **Electronic communication networks (ECNs)**
  - Computer-operated trading network
  - Register with the SEC as broker-dealers
- Specialist/DMM markets
  - **Designated market maker (DMM)** accepts the obligation to commit its own capital to provide quotes and help maintain a "fair and orderly market"

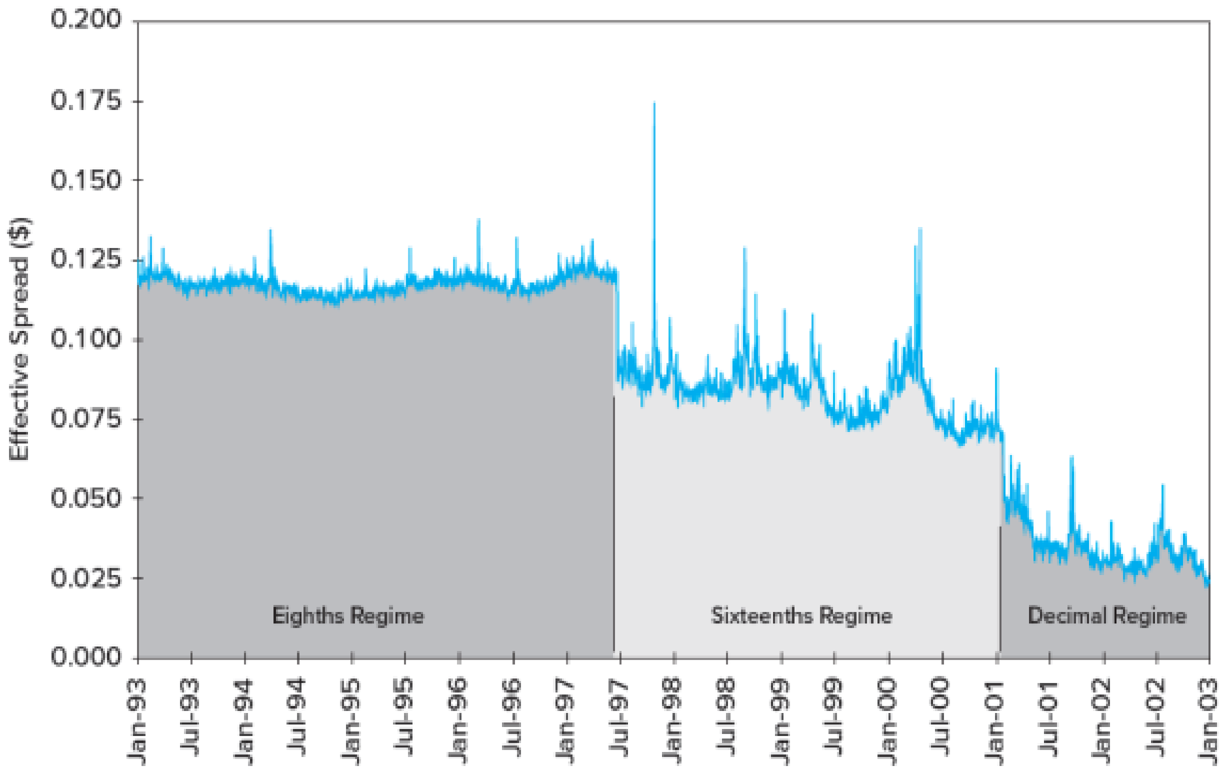
The Rise of Electronic Trading
(1 of 2)

- 1975: Elimination of fixed commissions on the NYSE
- 1994: New order-handling rules on NASDAQ, leading to narrower bid-ask spreads
- 1997: Reduction of minimum tick size from one-eighth to one-sixteenth
- 2000s: In the US, the share of electronic trading rose from 16% to 80% in 2000s

The Rise of Electronic Trading
(2 of 2)

- 2000: Emergence of NASDAQ Stock Market
- 2001: Decimalization allowed the tick size to fall to 1 cent
- 2005: SEC adopted Regulation NMS
- 2006: NYSE acquired electronic Archipelago Exchange and renamed it NYSE Arca
- 2007: NMS fully implemented

The Effective Spread Fell Dramatically as the Minimum Tick Size Fell



U.S. Markets: NASDAQ

- NASDAQ
  - Lists about 3,000 firms
  - NASDAQ's Market Center consolidates NASDAQ's previous electronic markets into one integrated system
  - Three levels of subscribers

U.S. Markets: NYSE

- Largest U.S. **stock exchange**, as measure by market value of listed stocks
- Automatic electronic trading runs side-by-side with broker/specialist system
  - 1976 (and later) – DOT and SuperDot
  - 2000 - Direct+
  - 2006 – NYSE Hybrid
    - Allowed NYSE to qualify as a fast market for the purposes of Regulation NMS, but still offered advantages of human interaction for complex trades

U.S. Markets: ECNs

- **Electronic communication networks (ECNs)** are computer-operated trading network for trading securities
  - Some registered as formal stock exchanges, while others are considered part of the OTC market
  - Compete in terms of the speed they can offer
    - **Latency** refers to the time it takes to accept, process, and deliver a trading order
      - Example: CBOE Global Markets advertises average latency times of around 100 microseconds

New Trading Strategies

(1 of 2)

- **Algorithmic trading** is the use of computer programs to make trading decisions
- **High-frequency trading** is a subset of algorithmic trading that relies on computer programs to make extremely rapid decisions
- **Dark pools** are private trading systems in which participants can buy or sell large blocks of securities without showing their hand

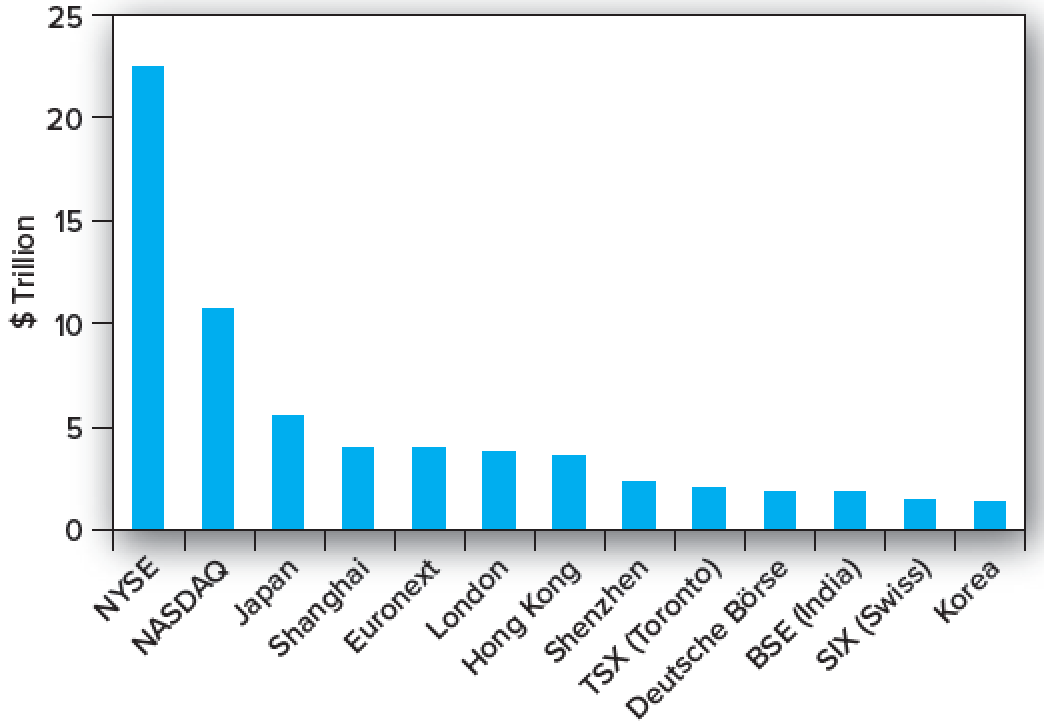
New Trading Strategies
(2 of 2)

- Bond trading
  - Vast majority of bond trading takes place in the OTC market among bond dealers
  - Market for many bond issues is "thin" and is subject to liquidity risk
  - One impediment to heavy electronic trading is lack of standardization in the bond market
    - A single company may have dozens of outstanding bond issues, differing by coupon, maturity and seniority

Globalization of Stock Markets

- Pressure in recent years to make international alliances or merges
  - Much of the pressure is due to the impact of electronic trading
- Wave of mergers has lead to a few giant security exchanges
  - ICE, NASDAQ, the LSE, Deutsche Boerse, the CME Group, TSE, and HKEX

Biggest Stock Markets in the World



Trading Costs

- Explicit cost - brokerage commissions
  - Full-service versus discount brokers
  - Execute orders, hold securities for safe-keeping, extend margin loans, facilitate short sales, and provide information and advice about investment alternatives
- Implicit costs
  - Dealer's bid-ask spread
  - Price concession an investor may be forced to make for trading in quantities greater than those associated with the posted bid or ask price

Buying on Margin
(1 of 2)

- Investors have easy access to a source of debt financing called *broker's call loans*
  - *Buying on margin* means the investor borrows part of the purchase price of the stock
  - **Margin** in the account is the portion of the purchase price contributed by the investor; remainder is borrowed from the broker
- Board of Governors of the Federal Reserve System limits the use of margin loans

Buying on Margin
(2 of 2)

- Current initial margin requirement is 50%
- *Maintenance margin*
  - Minimum equity that must be kept in the margin account
- *Margin call* is made if value of securities falls below maintenance level

Buying on Margin
(2 of 2)

- Current initial margin requirement is 50%

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  - Minimum equity that must be kept in the margin account

- *Margin call* is made if value of securities falls below maintenance level

Short Sales

- **Short sales** allows investors to profit from a decline in a security's price
- Mechanics
  1. Investor borrows stock from a broker and sells it
  2. Must then purchase a share of the same stock in order to replace the one that was borrowed
     - Referred to as *covering the short position*
- Proceeds from a short sale must be kept on account with the broker, per exchange rules
- Regulation T applies

Short Sale Mechanics

Purchase of Stock		
Time	**Action**	**Cash Flow***
0	Buy share	− Initial price
1	Receive dividend, sell share	Ending price + Dividend
Profit = (Ending price + Dividend) − Initial price		

Short Sale of Stock		
Time	**Action**	**Cash Flow***
0	Borrow share; sell it	+ Initial price
1	Repay dividend and buy share to replace the share originally borrowed	− (Ending price + Dividend)
Profit = Initial price − (Ending price + Dividend)		

*A negative cash flow implies a cash *outflow*.

Table 3.2

Cash flows from purchasing versus short-selling shares of stock

Regulation of Securities Markets
(1 of 2)

- Major governing legislation
  - Securities Act of 1933
  - Securities Exchange Act of 1934
  - Securities Investor Protection Act of 1970
  - *Blue sky laws*
- Self-Regulation
  - Financial Industry Regulatory Authority (FINRA)
  - CFA Institute
    - Standards of professional conduct

Regulation of Securities Markets (2 of 2)

- Sarbanes-Oxley Act
  - 2000-2002 scandals centered on three broad practices
    - Allocations of shares in IPOs
    - Tainted securities research and recommendations
    - Misleading financial statements and accounting practices
  - Key provisions
    - Public Company Accounting Oversight Board
    - Independent financial experts to serve on audit committees of a firm's board of directors
    - CEOs and CFOs personally certify firms' financial reports
    - Auditors may no longer provide several other services to clients
    - Boards must have independent directors

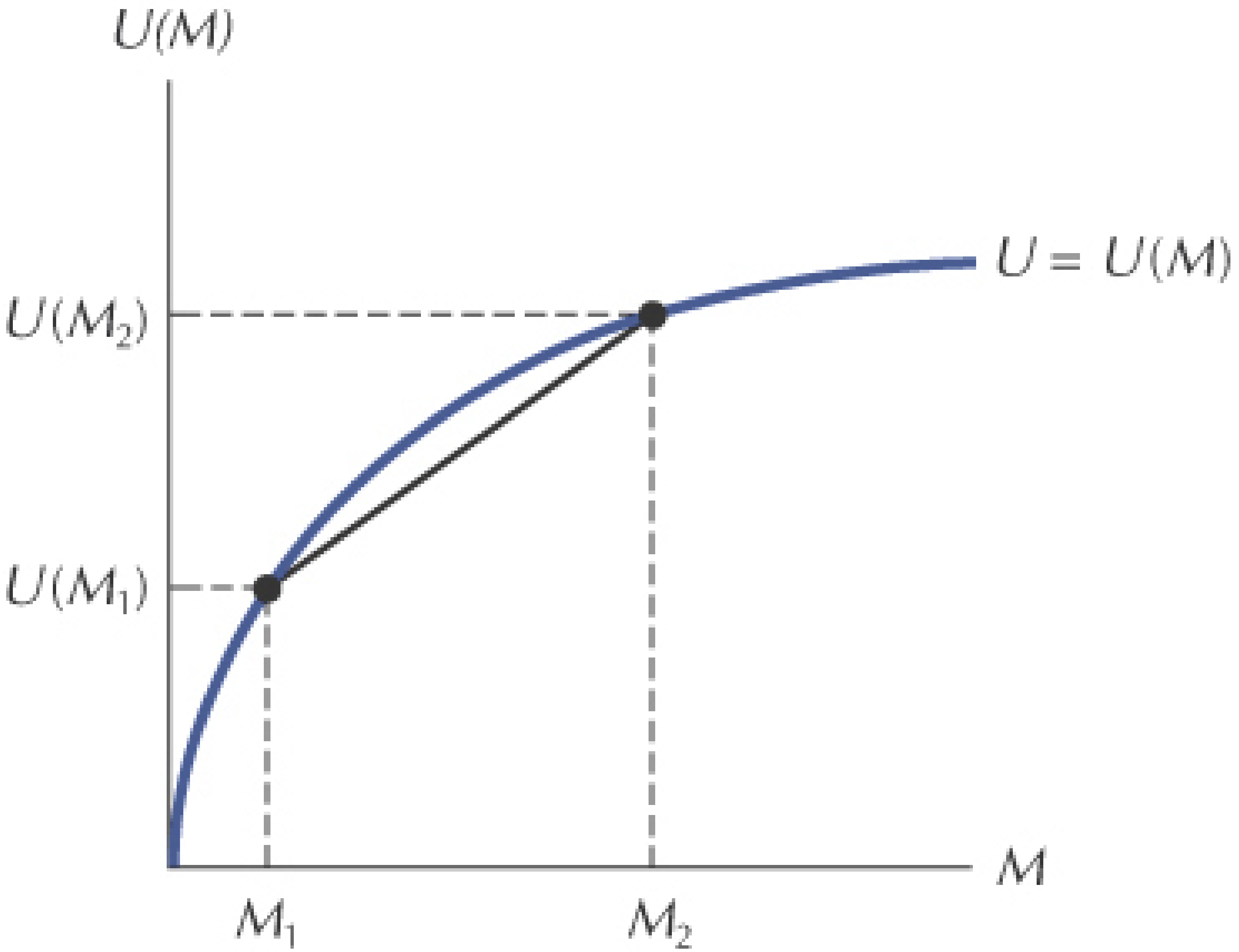
Insider Trading

- Regulations prohibit trading on **inside information**
- SEC requires officers, directors, and major stockholders to report all transactions in their firm's stock
- Insiders *do* exploit their knowledge
  - Well-publicized convictions of principals in insider trading schemes
  - Considerable evidence of "leakage"
  - Documented abnormal returns on trades by insiders

Decision Making Under Uncertainty: Utility and Risk Aversion

- A utility function measures happiness as a function of consumption/wealth
- Investors care about **expected utility**, not **expected wealth** per se.
- Generally think that utility function is concave
  - Risk Aversion

A Concave Utility Function



Risk averse investors and risk premia

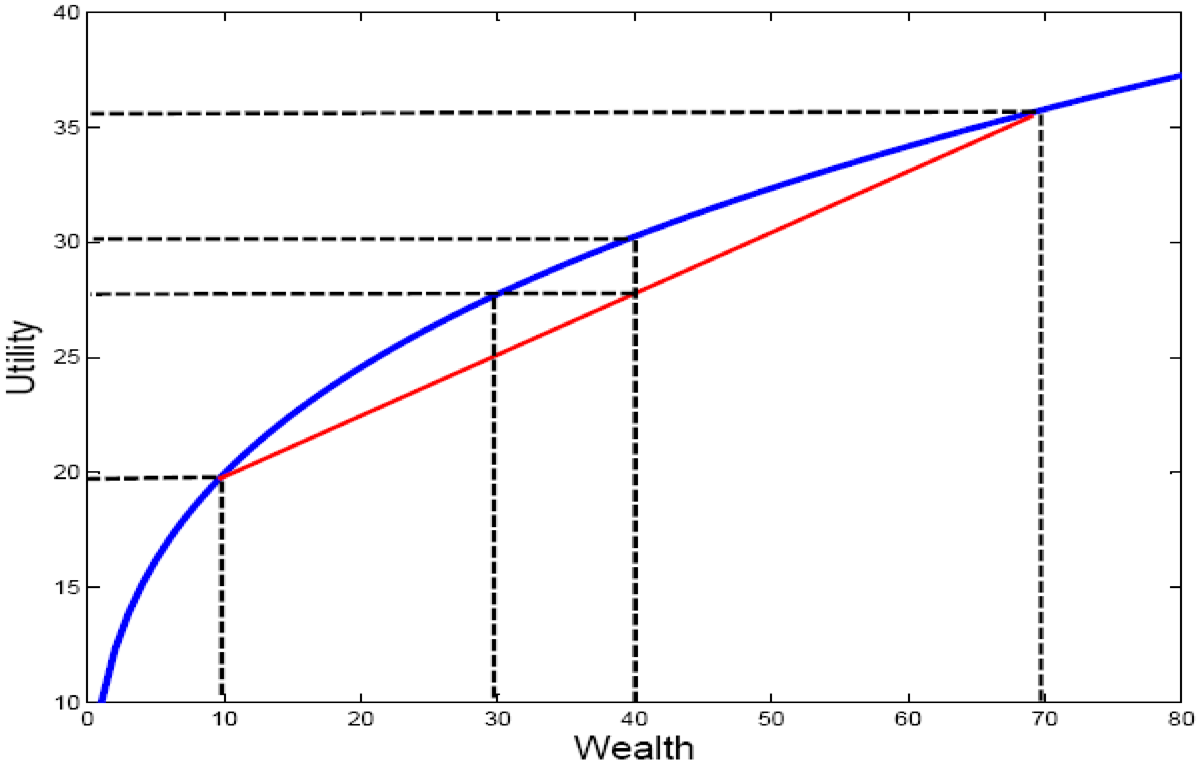
- Have diminishing marginal utility of wealth
- Reject investment portfolios that are fair games or worse
- Consider only risk-free or speculative prospects with positive risk premiums
  - Expected return has to be bigger than risk-free rate
  - This is the **risk premium**

Certainty Equivalent Value

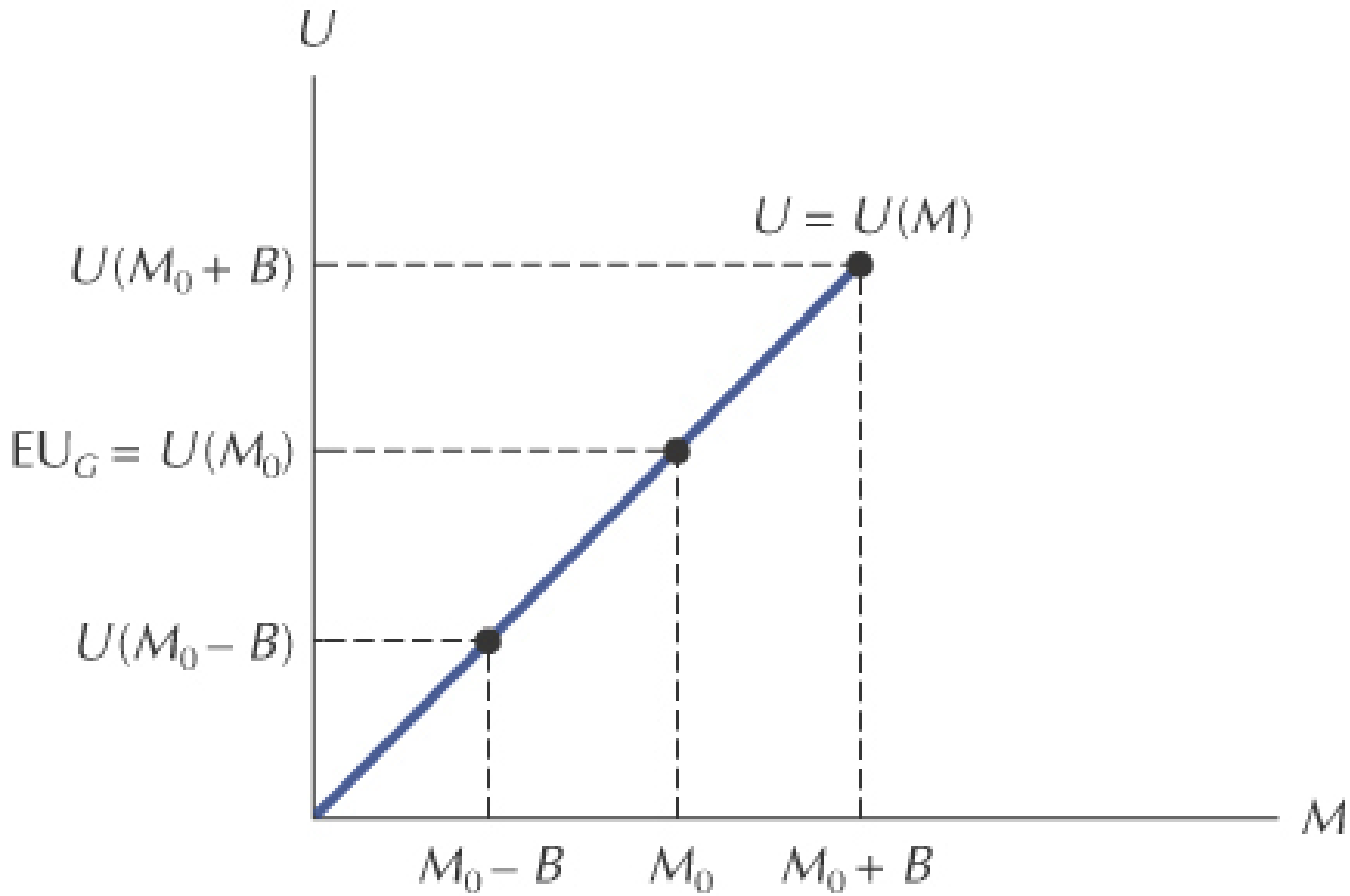
- The certainty equivalent value is the sum of money for which an individual would be indifferent between receiving that sum and taking the gamble.
- The certainty equivalent value of a gamble is less than the expected value of a gamble for someone who is risk averse.

Certainty Equivalence Example

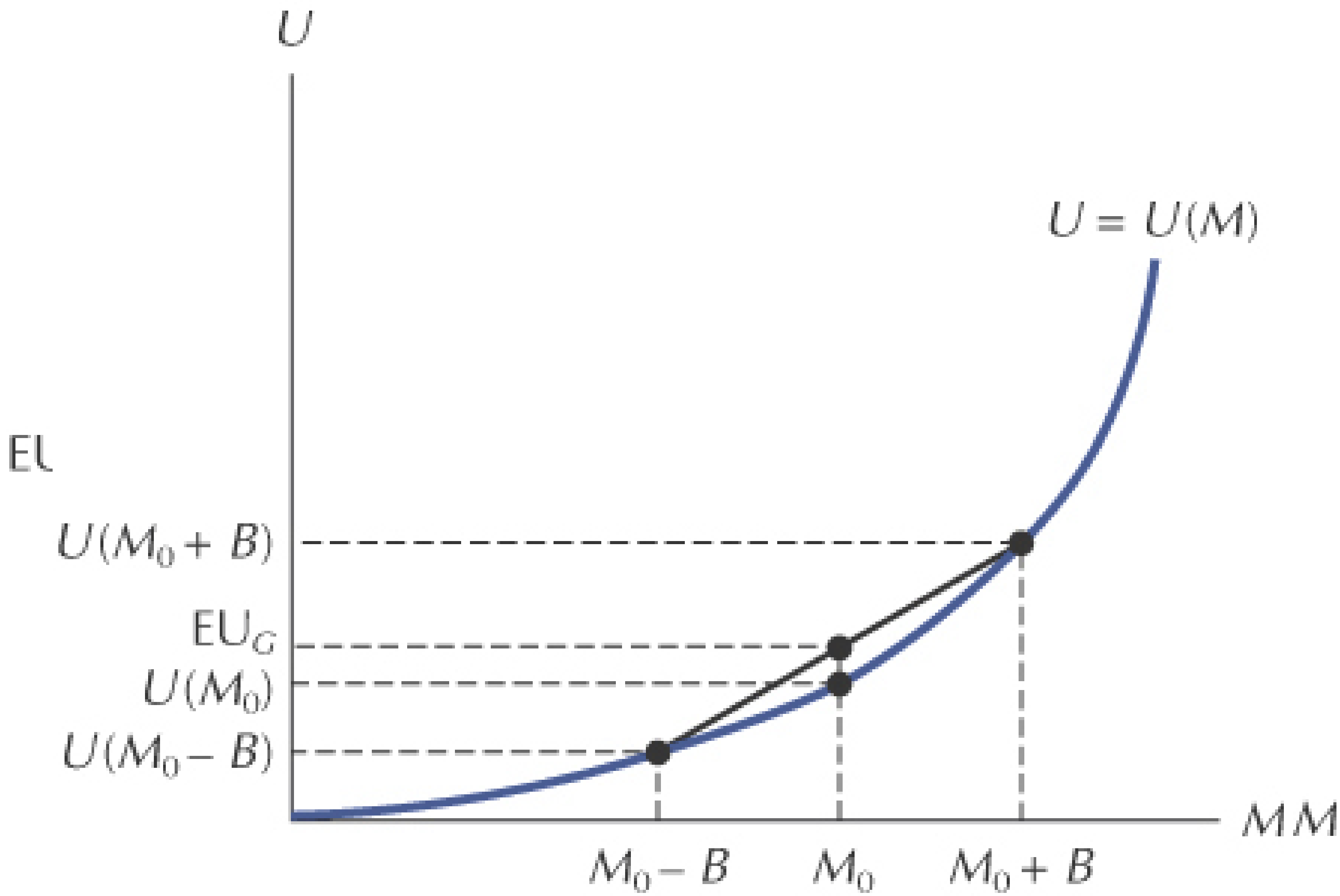
Expected Value	**40**
Certainty Equivalent	**30**
Risk Premium	**10**



Risk Neutrality



Risk Seeking



Expected Utility

- Basic premise of standard decision making under uncertainty is that agents maximize expected utility.
- Say the utility function is $W^{1/2}$
- Wealth is 1 or 9 each w.p. ½
- Expected utility is $0.5*1+0.5*3=2$

Example

- An investors utility function is $5w^{1/2}$ where w is wealth in dollars. She currently has $100 but can purchase any number x (including fractional amounts) of an asset for $20 apiece that pays off the following amount in the three possible states of the world.

State of World	Payoff	Probability
A	$60	40%
B	$0	20%
C	$20	40%

Example continued

- Q. What is expected holding period return on the asset?
- A. (2*0.4)+((-1)*0.2)+(0*0.4)=0.6
- Q. What is the standard deviation of the return?
- A. Variance is (1.4*1.4*0.4)+(1.6*1.6*0.2)+(0.6*0.6*0.4)=1.44

so standard deviation is 1.2

Example continued

- Q. How many units should investor buy to maximize expected utility?

State of the world	Payoff	Probability	Wealth	Utility
A	\$60	40%	100+40x	$5(100+40x)^{1/2}$
B	\$0	20%	100-20x	$5(100-20x)^{1/2}$
C	\$20	40%	100	$5(100)^{1/2}$

- Expected utility is $2\sqrt{100+40x}+\sqrt{100-20x}+20$
- First Order Condition $2*\frac{40}{\sqrt{100+40x}}-\frac{20}{\sqrt{100-20x}}=0$
- x=25/6

Coefficient of Risk Aversion

- Coefficient of Absolute Risk Aversion is $-\frac{u''(W)}{u'(W)}$
- Consider the utility function $u(W) = -\frac{\exp(-AW)}{A}$
- This has a coefficient of risk aversion of A
  - Constant Absolute Risk Aversion (CARA)

Uncertainty about fixed dollar amount

- Consider asset that pays $\$x$ or $\$x+1$ when investor has CARA utility.
- Certainty Equivalent solves

$$-\frac{\exp(-AC)}{A} = -0.5\frac{\exp(-Ax)}{A} - 0.5\frac{\exp(-A(x+1))}{A}$$

- After a little algebra

$$C = x + \frac{1}{A}\ln\left(\frac{2}{1+\exp(-A)}\right)$$

Coefficient of Relative Risk Aversion

- Coefficient of Relative Risk Aversion is $-\frac{Wu''(W)}{u'(W)}$

- Consider the utility functions

$$u(W) = \ln(W)$$

$$u(W) = \frac{W^{1-\rho}}{1-\rho}$$

What is the certainty equivalent of

- $100,000 wp 0.5

- $50,000   wp 0.5

What is the certainty equivalent of
- $100,000 wp 0.5
- $50,000 wp 0.5

Rel. Risk Aversion	Certainty Equivalent
1	70,711
2	66,667
5	58,566
10	53.991
30	51,210

Utility Function

$$U = E(r) - \frac{1}{2}A\sigma^2$$

Where

U = utility

$E(r)$ = expected return on the asset or portfolio

A = coefficient of risk aversion

σ^2 = variance of returns

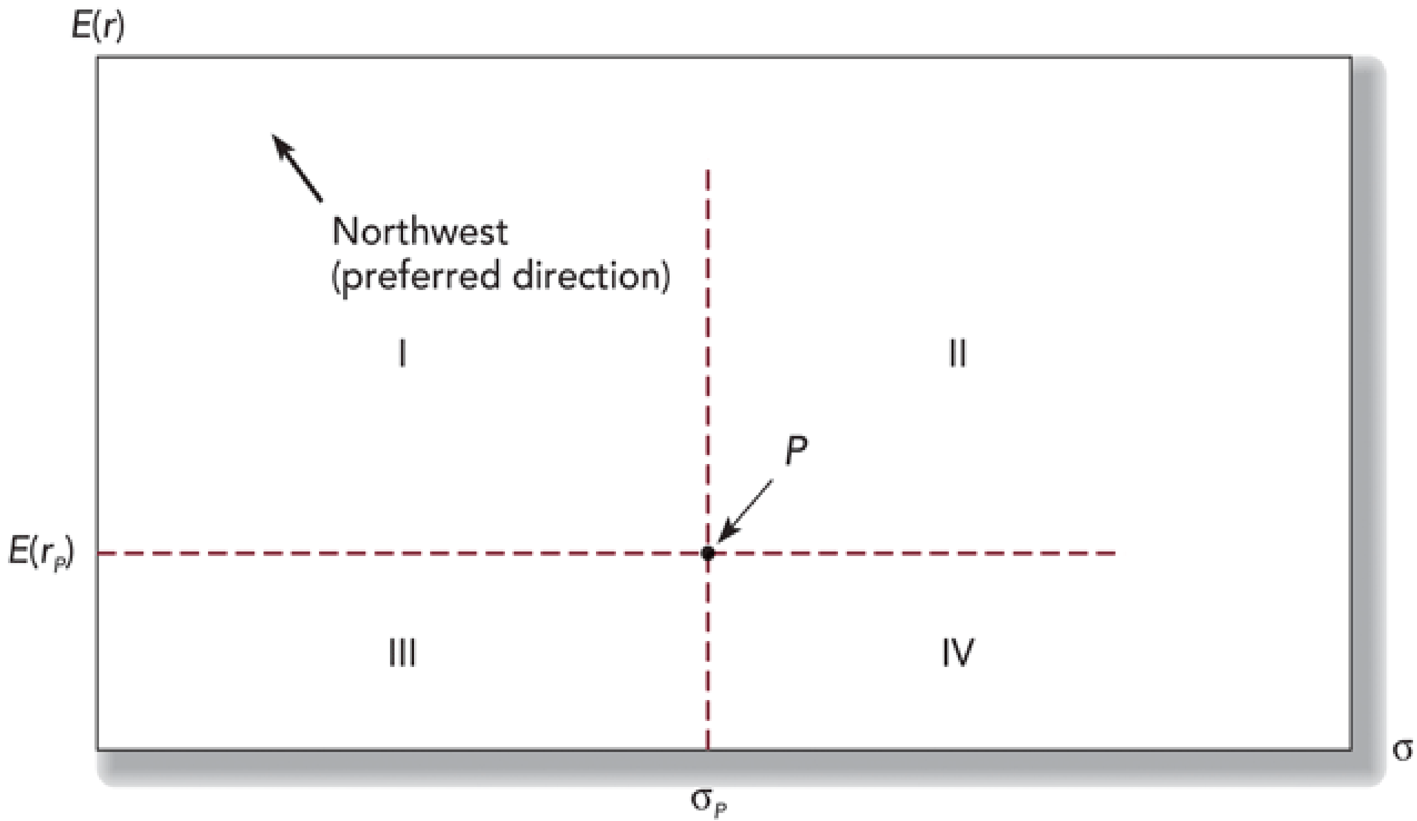
Three possible portfolios

	L	M	H
E(r)	0.07	0.09	0.13
σ(r)	0.05	0.10	0.20

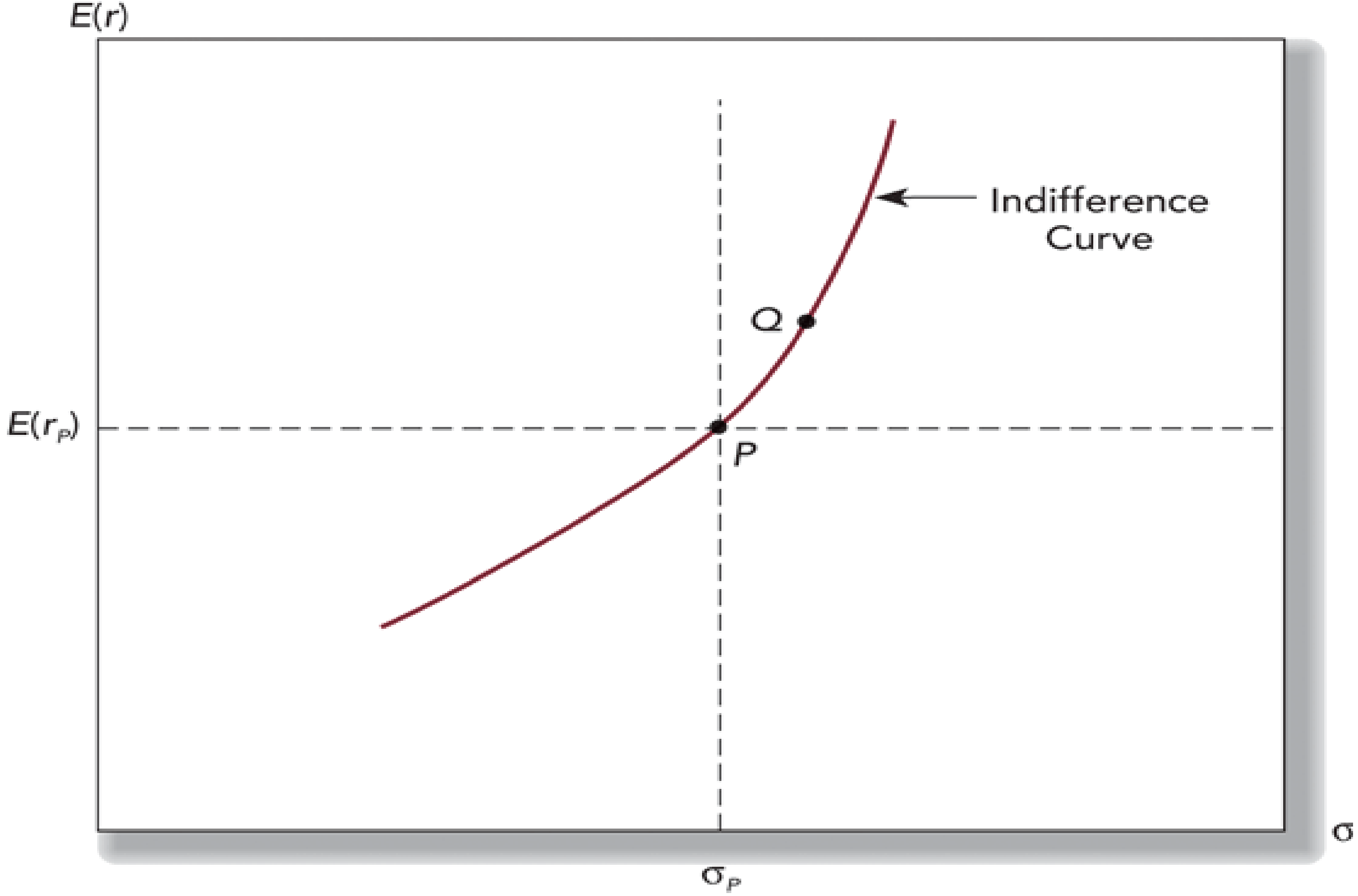
Utility of three possible portfolios

	L	M	H
E(r)	0.07	0.09	0.13
σ(r)	0.05	0.10	0.20
A=2	0.0675	0.08	0.09
A=5	0.06375	0.065	0.03
A=8	0.06	0.05	-0.03

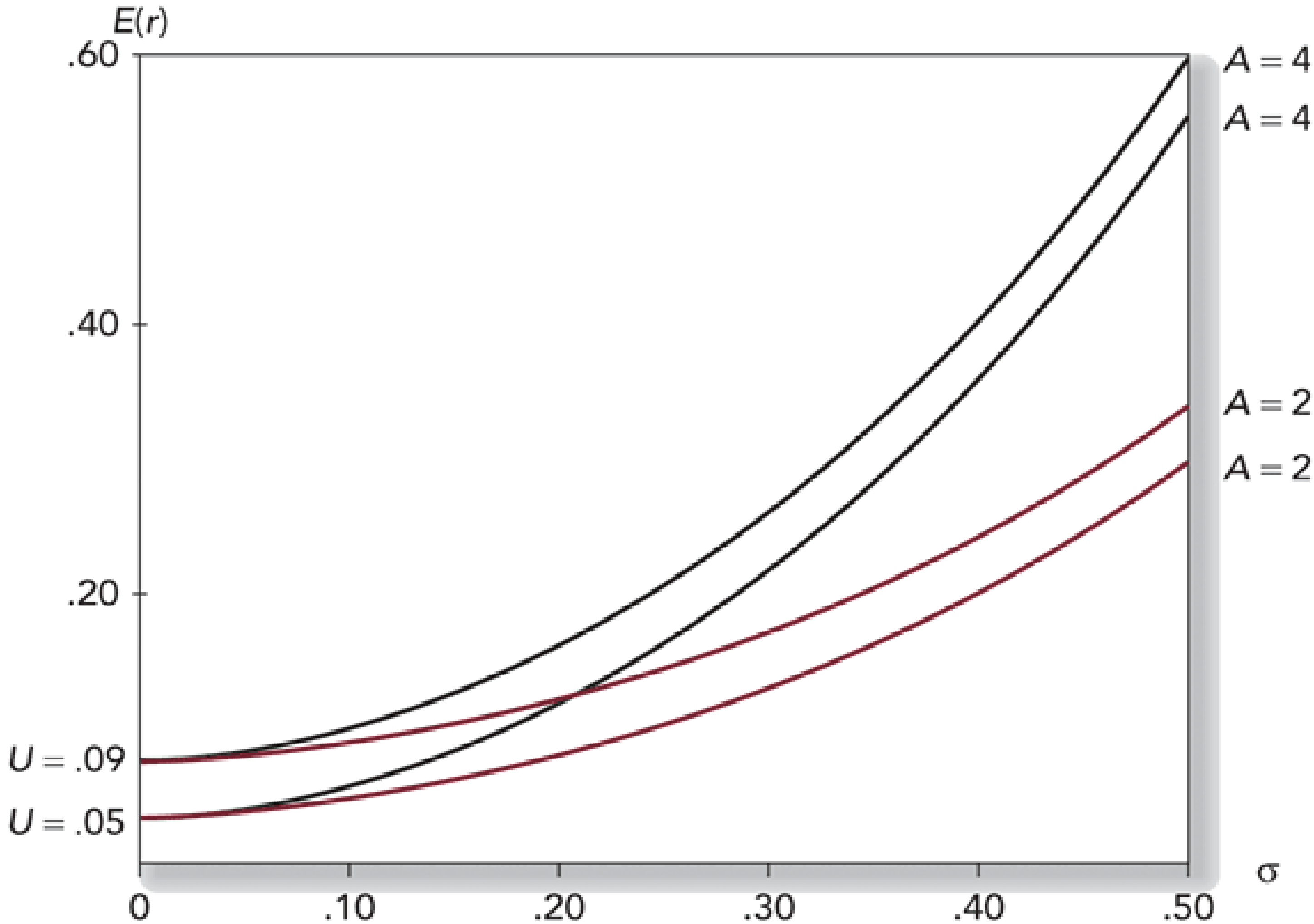
The Trade-off Between Risk and Returns of a Potential Investment Portfolio, *P*



The Indifference Curve



Indifference Curves with A = 2 and A = 4



Basic Results from Statistics

- Suppose X_1 and X_2 are random variables

$$E(k_1X_1 + k_2X_2) = k_1E(X_1) + k_2E(X_2)$$

$$Var(k_1X_1 + k_2X_2) =$$

$$k_1^2Var(X_1) + k_2^2Var(X_2) + 2k_1k_2Cov(X_1, X_2)$$

- If $X_{1,}$ X_2 ,… X_n are random variables

$$E(\Sigma k_jX_j) = \Sigma k_jE(X_j)$$

$$Var(\Sigma k_jX_j) = \Sigma_{i=1}^{n}\Sigma_{j=1}^{n}k_ik_jCov(X_i, X_j)$$

Mean, Variance and Covariance of Portfolios

- Suppose there are assets with returns r(1), r(2), ..r(n)
- Suppose I form a portfolio with weights w(1), w(2),…w(n)
- The properties of the portfolio are

$$r(p) = \Sigma_{i=1}^{n} w(i) r(i)$$

$$E(r(p)) = \Sigma_{i=1}^{n} w_i E(r(i))$$

$$Var(r(p)) = \Sigma_{i=1}^{n} \Sigma_{j=1}^{n} w(i) w(j) Cov(r(i), r(j))$$

Portfolios of One Risky Asset and a Risk-Free Asset

- It's possible to split investment funds between safe and risky assets.
- Risk free asset: proxy; T-bills
- Risky asset: stock (or a portfolio)

Properties of combination of risk-free and risky asset

- **r_c = combined portfolio putting weight y in the risky asset and 1-y on the risk-free asset**

- $E(r_c) = yE(r_p) + (1-y)\, r_f$

- $\sigma_c = |y|\, \sigma_p$

Example

- r_f = 7%, σ_f=0
- Er_p = 15%, σ_p=22%

- y=0.75
  - $E(r_c)$=0.75*0.15+0.25*0.07=0.13
  - σ_c=0.75*0.22=0.165

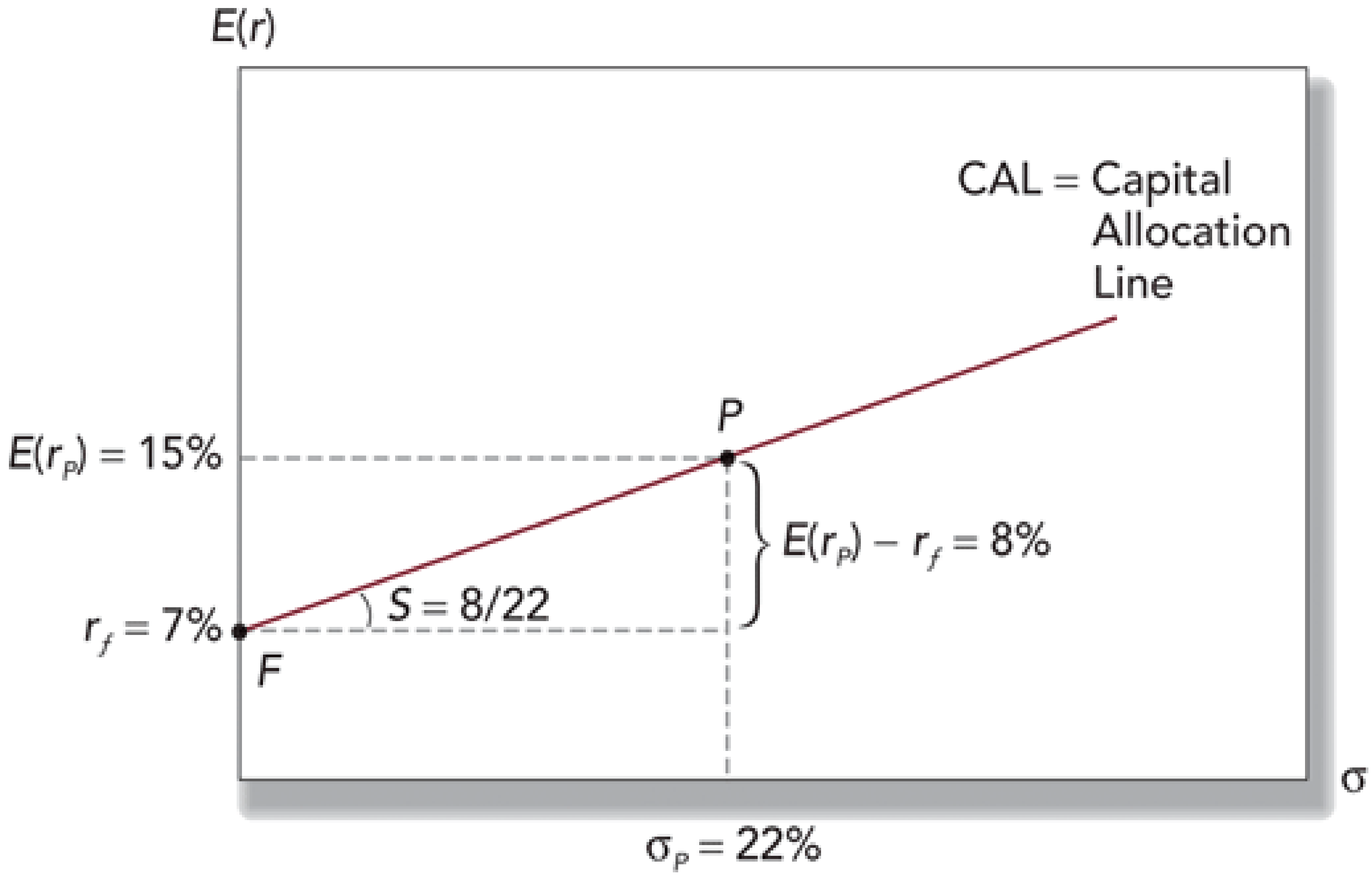
- y=0
  - $E(r_c)$=0.07
  - σ_c=0

Example

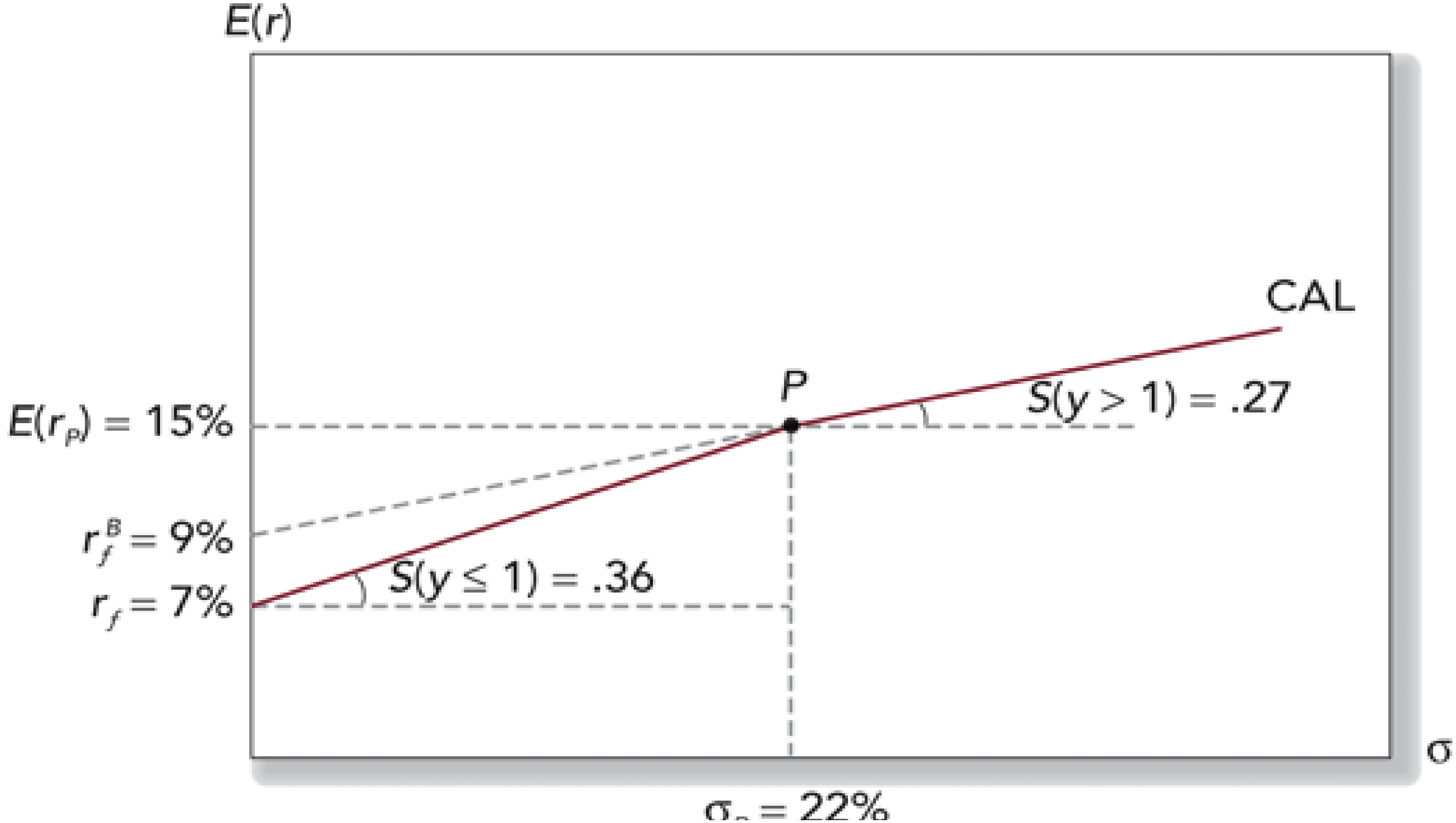
- r_f = 7%, σ_f=0
- Er_p = 15%, σ_p=22%

- y=1.5
  - $E(r_c)=1.5*0.15-0.5*0.07=0.19$
  - $\sigma_c=1.5*0.22=0.33$

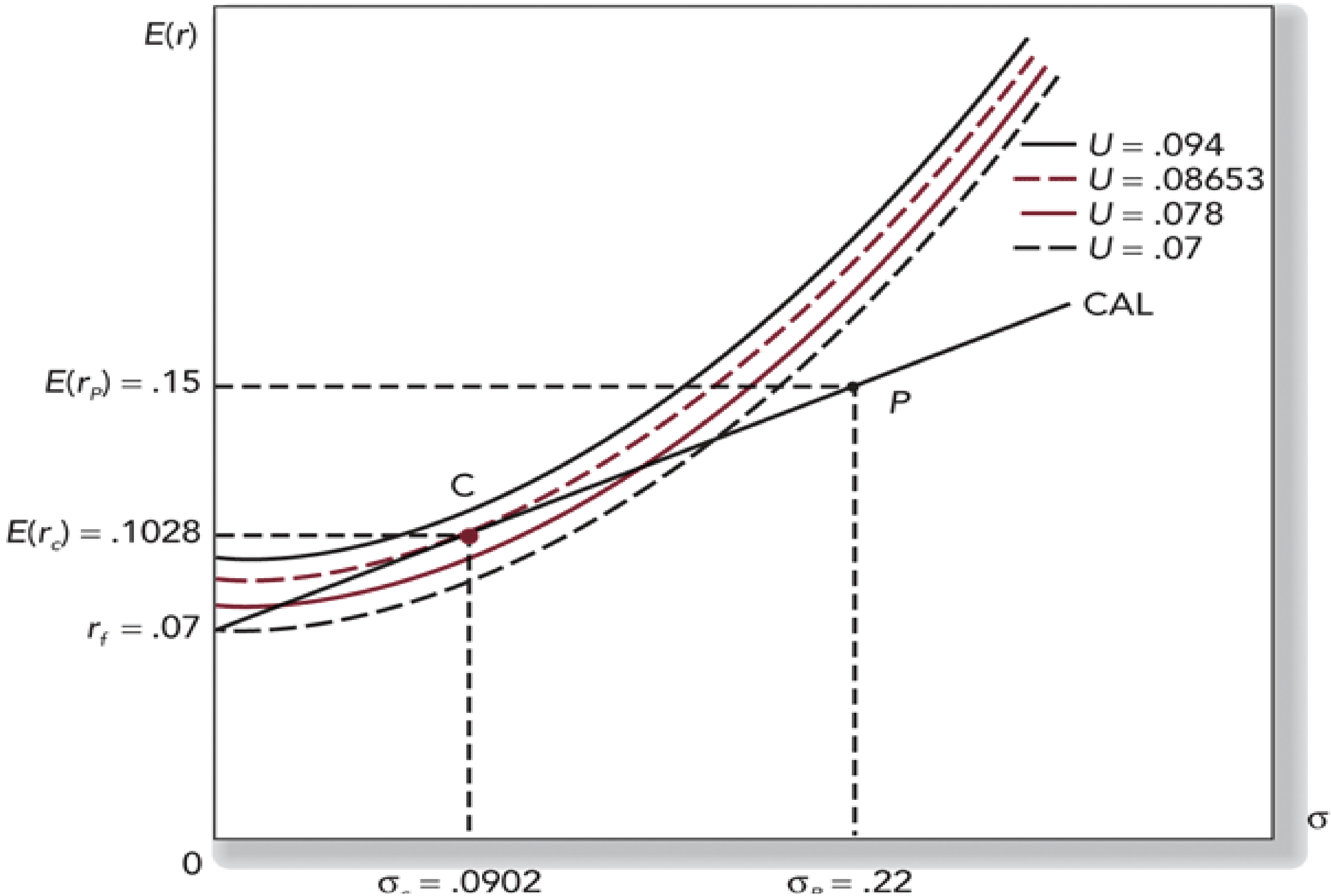
Capital Allocation Line



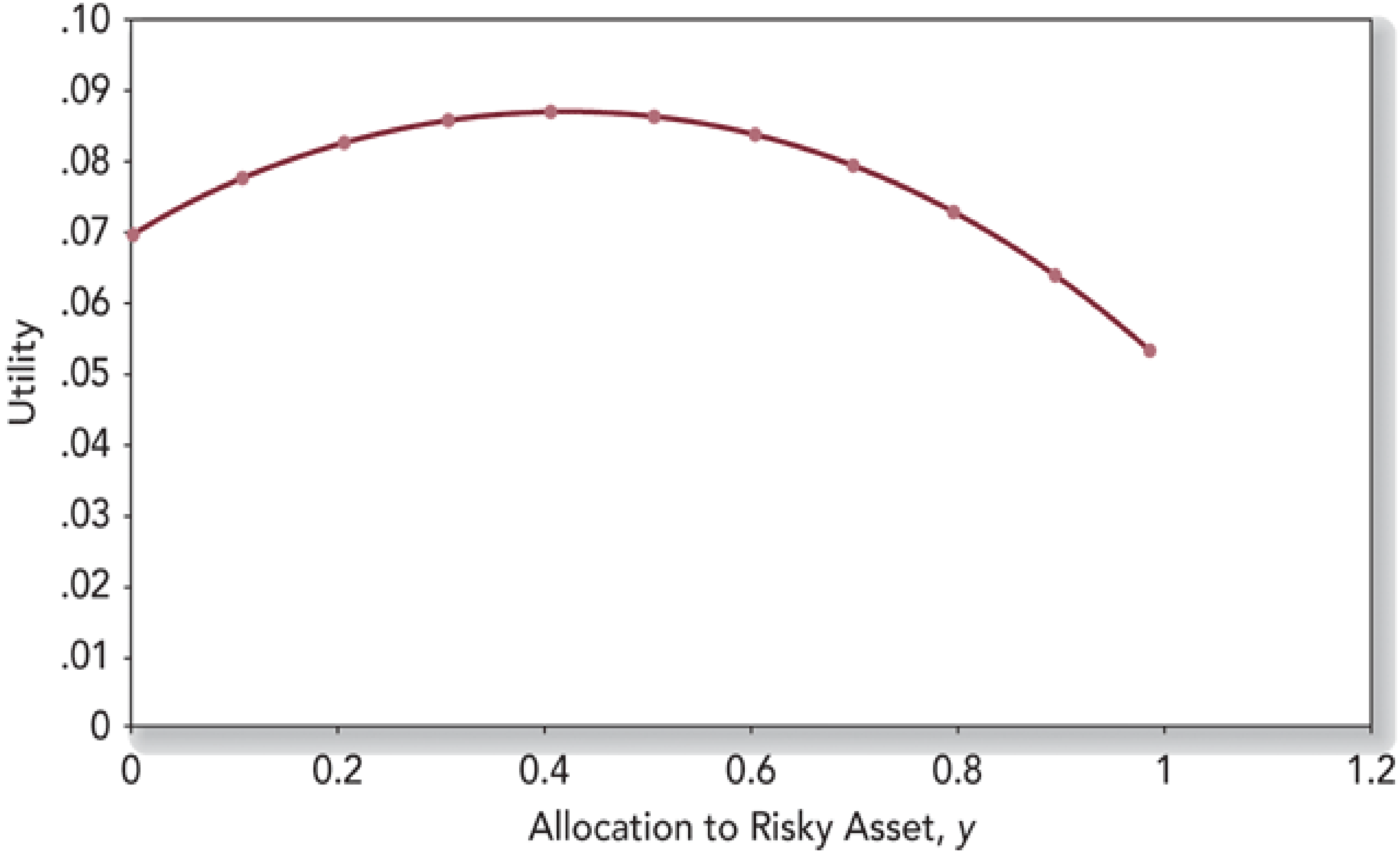
Capital Allocation Line with Differential Borrowing and Lending Rates



Optimal Portfolio Using Indifference Curves



Utility as a Function of Allocation to the Risky Asset, y



Risk Tolerance and Asset Allocation

- The investor must choose one optimal portfolio, y^*, from the set of feasible choices

$$\max E(r_c) - \frac{A\sigma_c^2}{2} = \max yE(r_p) + (1-y)r_f - \frac{Ay^2\sigma_p^2}{2}$$

$$\Rightarrow y^* = \frac{E(r_p) - r_f}{A\sigma_p^2}$$

Example

- $r_f = 7\%,\ \sigma_f = 0$
- $Er_p = 15\%,\ \sigma_p = 22\%$

- $A=4 \rightarrow y^* = (0.15-0.07)/(4*0.22^2) = 0.41$

An Optimal Portfolio of Risky Assets

- Before we considered choice between one risky asset and a risk-free asset

- But there are in fact many risky assets.

- Suppose we are now picking an optimal portfolio of risky assets (no risk-free asset)

Covariance

$$\mathrm{Cov}(r_D, r_E) = \rho_{DE}\sigma_D\sigma_E$$

$\rho_{D,E}$ = **Correlation coefficient of returns**

σ_D = **Standard deviation of returns for Security D**

σ_E = **Standard deviation of returns for Security E**

Correlation Coefficients: Possible Values

Range of values for correlation coefficient

$$+1.0 \geq \rho \geq -1.0$$

If $\rho = 1.0$, the securities would be perfectly positively correlated

If $\rho = -1.0$, the securities would be perfectly negatively correlated

Two assets (debt and equity) in a portfolio

- $r_P = y r_D + (1-y) r_E$

$$E(r_p) = yE(r_D) + (1-y)E(r_E)$$

$$Var(r_p) = y^2 Var(r_D) + (1-y)^2 Var(r_E) + 2y(1-y)Cov(r_D, r_E)$$

Two assets (debt and equity) in a portfolio

- Suppose that **ρ =–1**

$$\sigma_P^2 = y^2\sigma_D^2 + (1-y)^2\sigma_E^2 - 2y(1-y)\sigma_D\sigma_E$$
$$= \{y\sigma_D - (1-y)\sigma_E\}^2$$

- Now let $y = \dfrac{\sigma_E}{\sigma_E + \sigma_D}.$ Then $\sigma_P^2 = 0$

Two assets (debt and equity) in a portfolio

- Suppose that **ρ =+1**

$$\sigma_P^2 = y^2\sigma_D^2 + (1-y)^2\sigma_E^2 + 2y(1-y)\sigma_D\sigma_E$$
$$= \{y\sigma_D + (1-y)\sigma_E\}^2$$
$$\geq \min(\sigma_D, \sigma_E)^2$$

- No risk reduction possible.

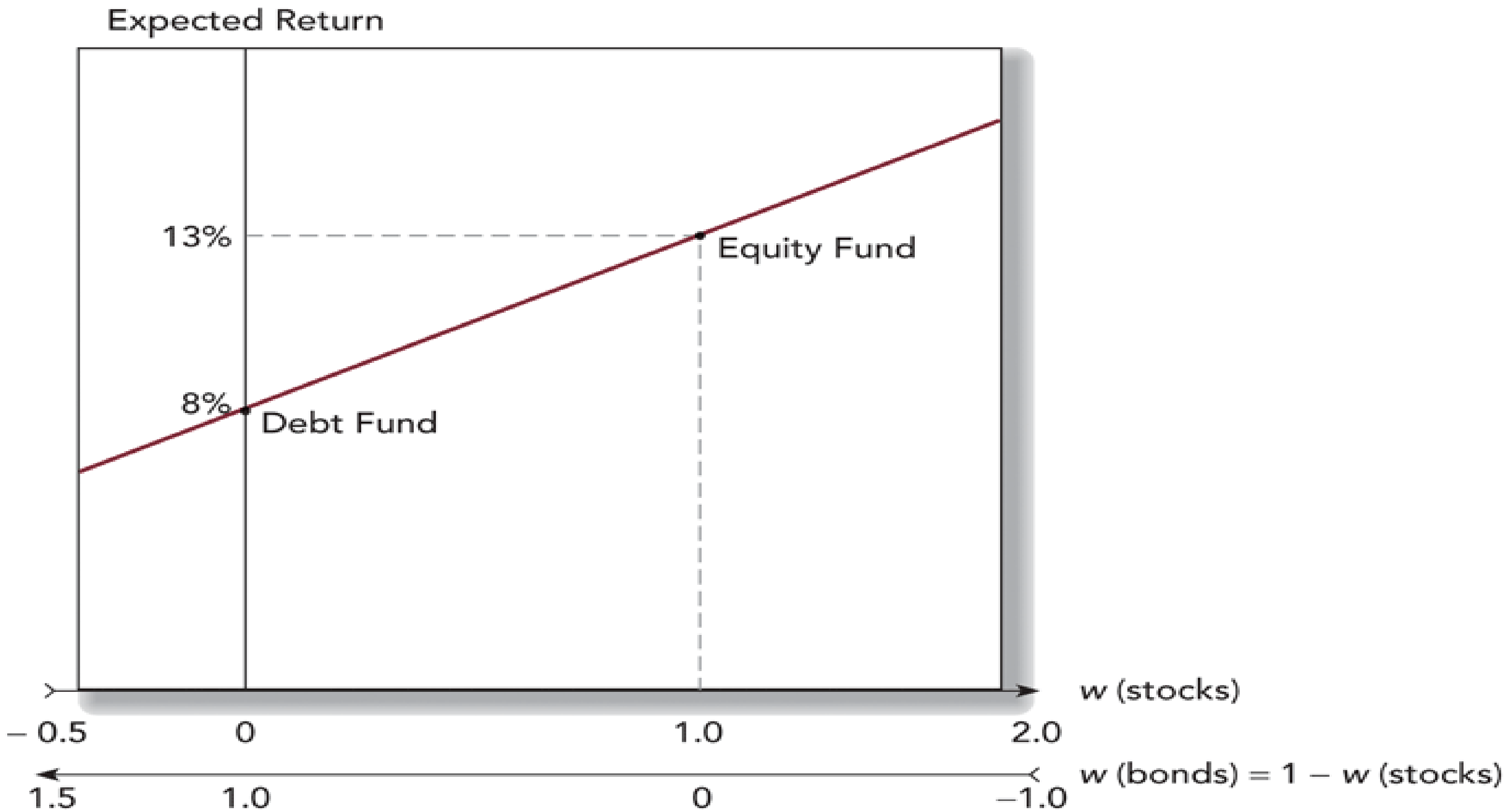
Correlation Effects

- The relationship depends on the correlation coefficient
- $-1.0 \leq \rho \leq +1.0$
- The smaller the correlation, the greater the risk reduction potential
- If $\rho = +1.0$, no risk reduction is possible

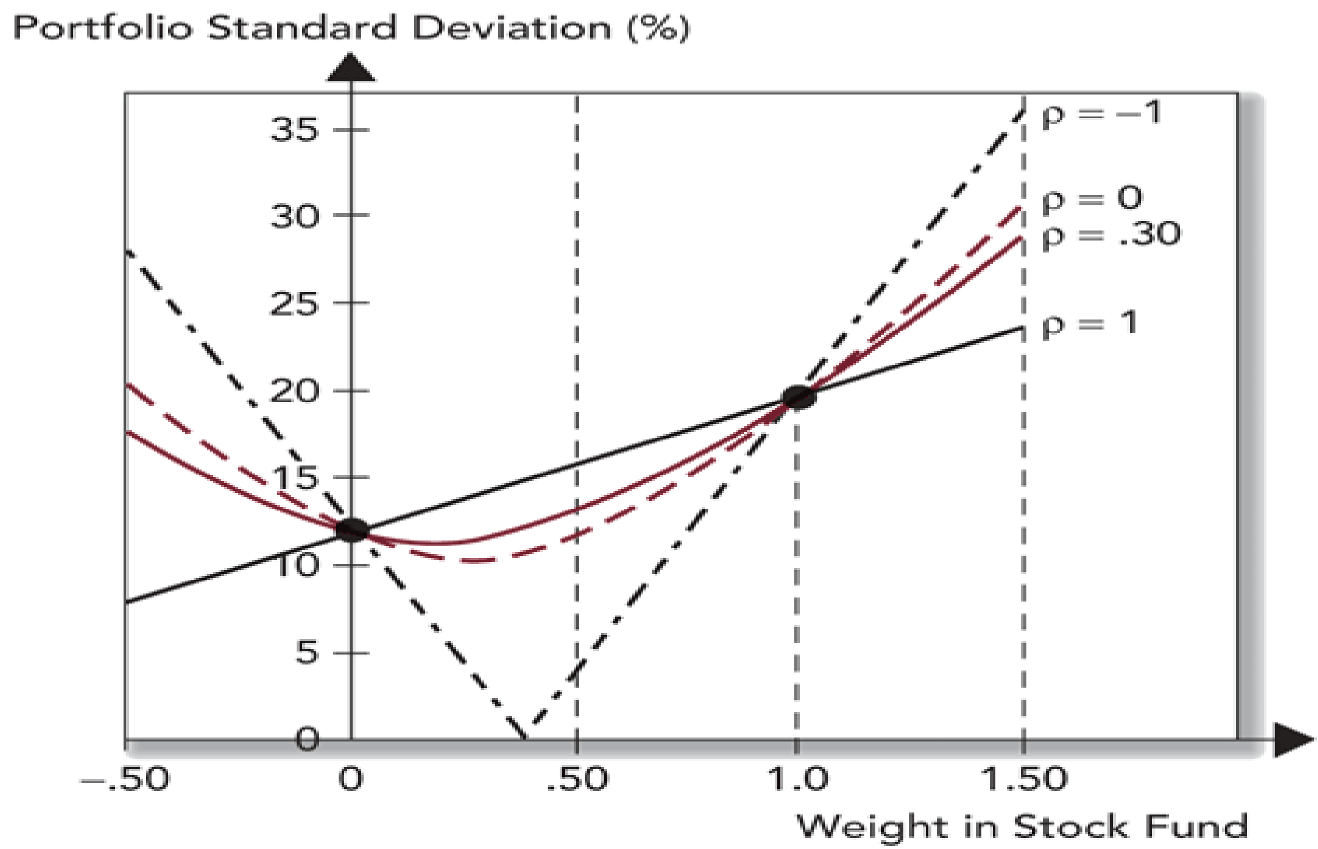
Example

	Debt	Equity
Expected Return	0.08	0.13
St Dev	0.12	0.20
Correlation	0.3	
Covariance	0.0072	

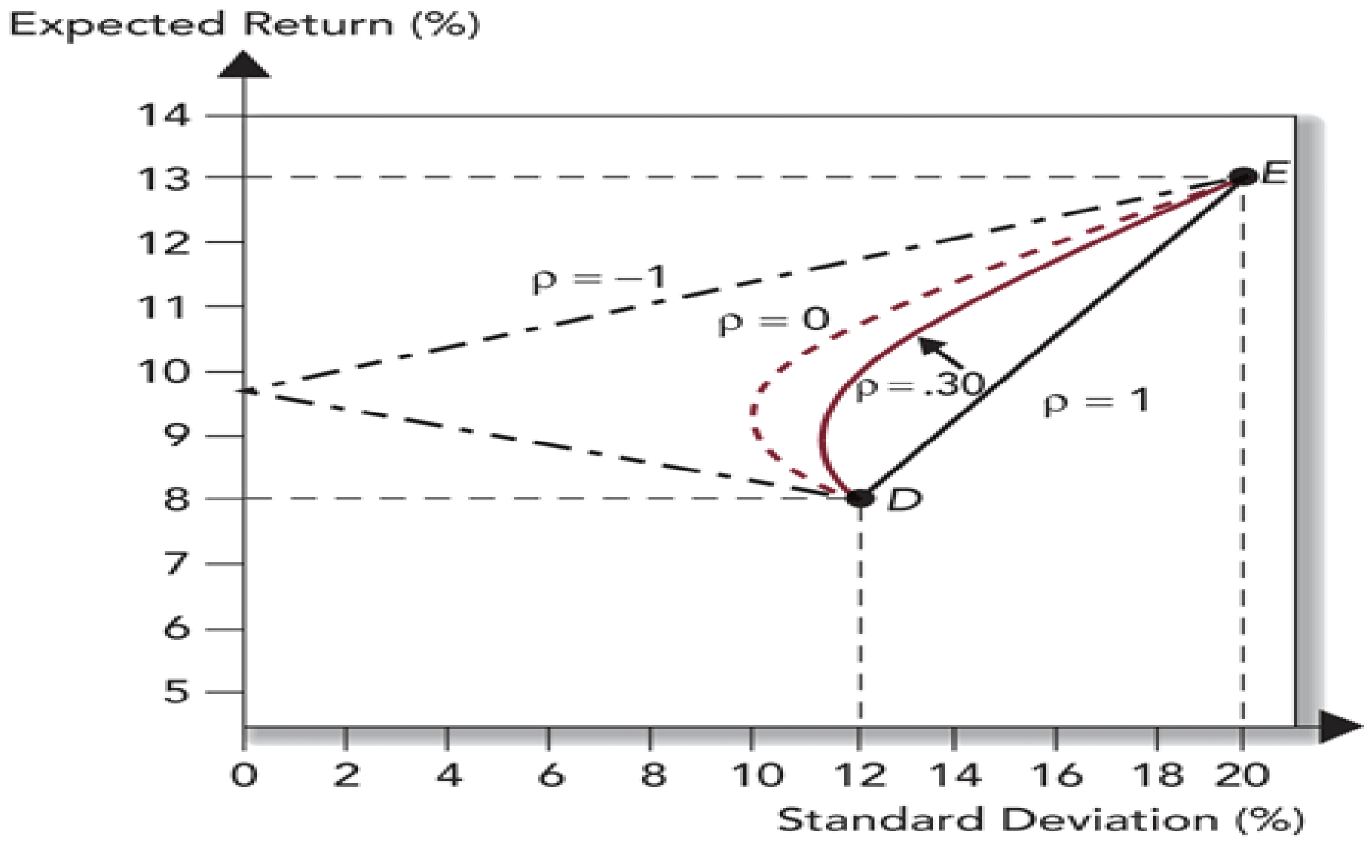
Portfolio Expected Return as a Function of Investment Proportions



Portfolio Standard Deviation as a Function of Investment Proportions



Portfolio Expected Return as a Function of Standard Deviation



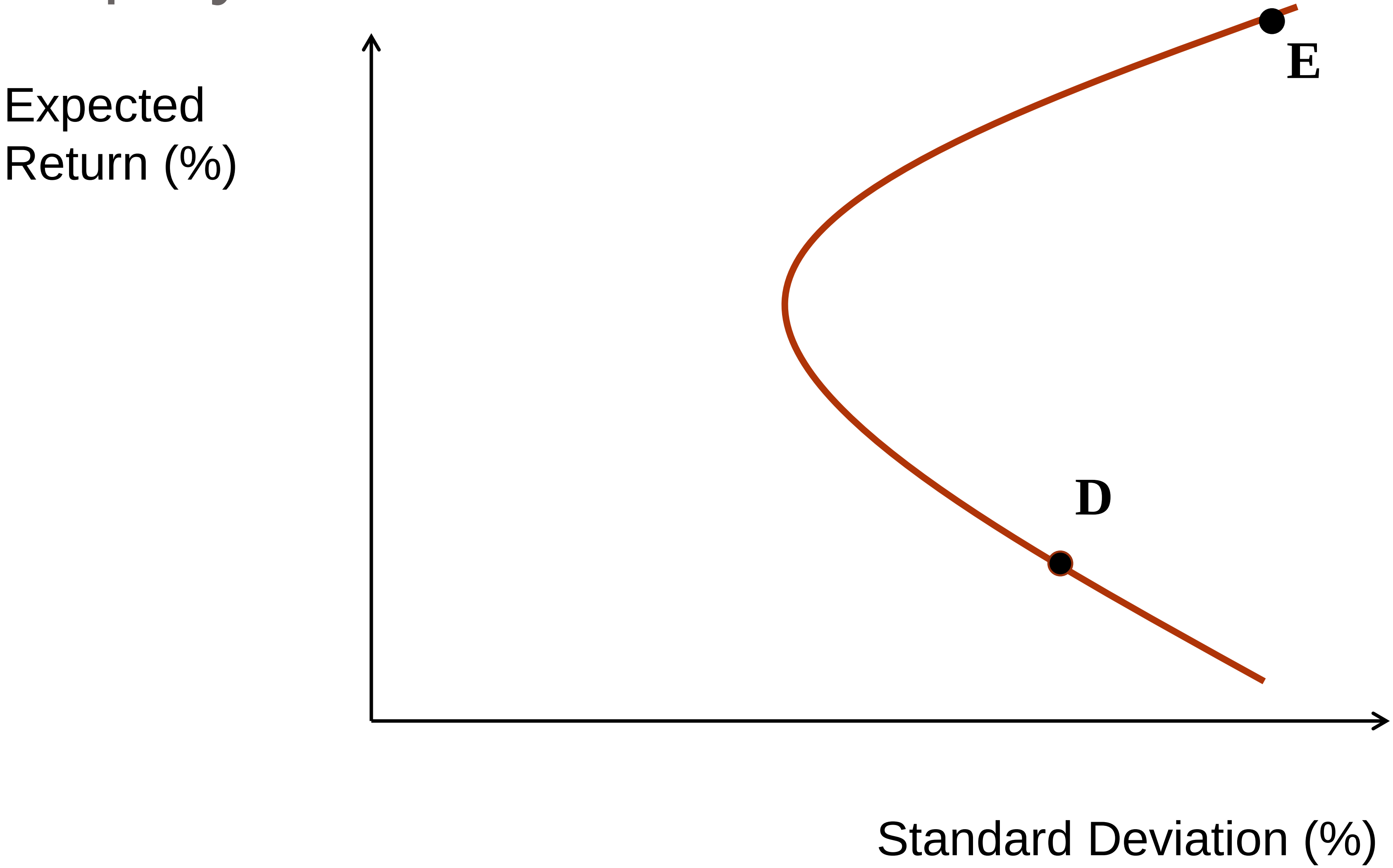
Formula for Minimum Variance Portfolio

$$w_D = \frac{\sigma_E^2 - Cov(R_D, R_E)}{\sigma_E^2 + \sigma_D^2 - 2Cov(R_D, R_E)}$$

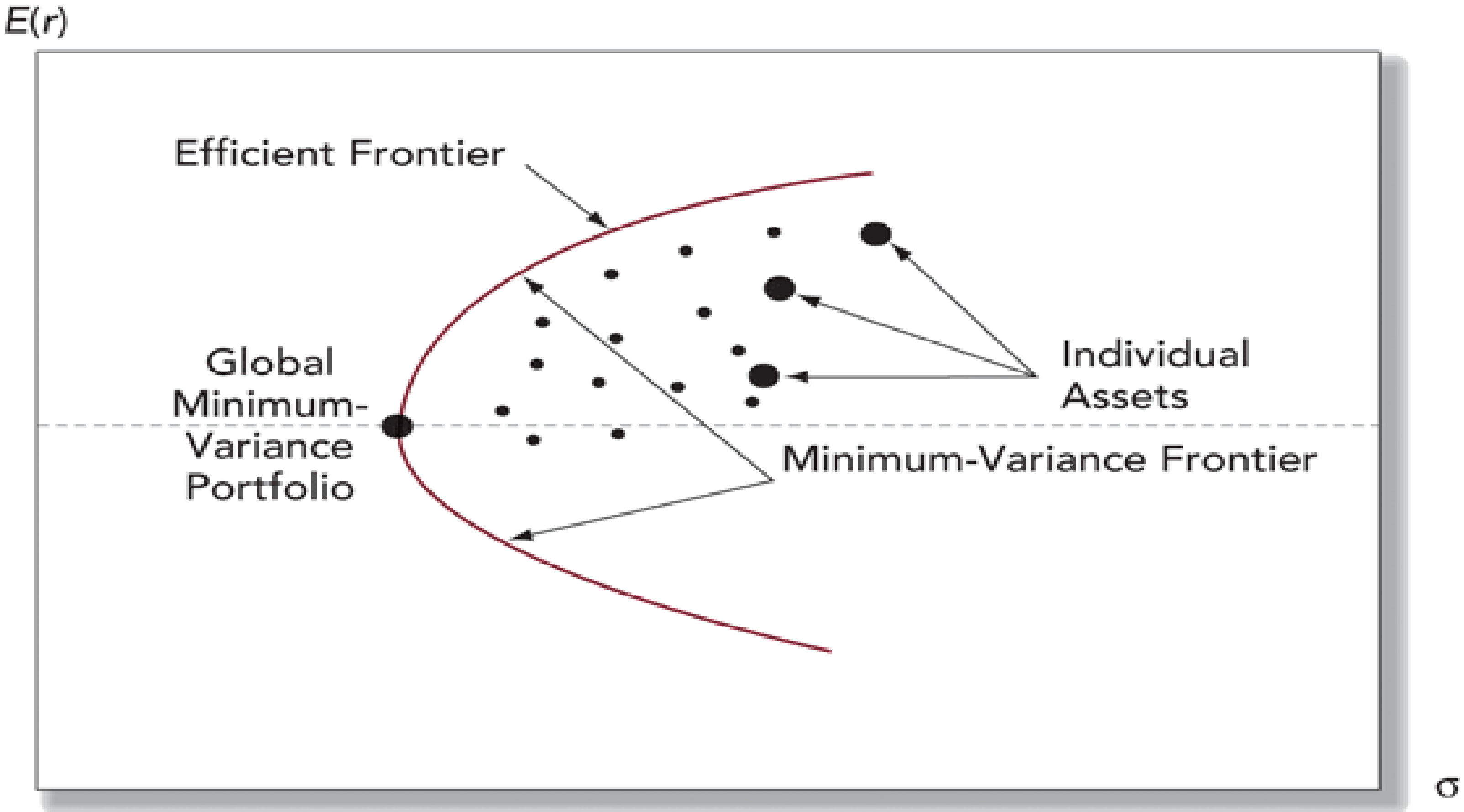
$$w_E = 1 - w_D$$

where R_D and R_E are the returns.

The Opportunity Set of the Debt and Equity Funds



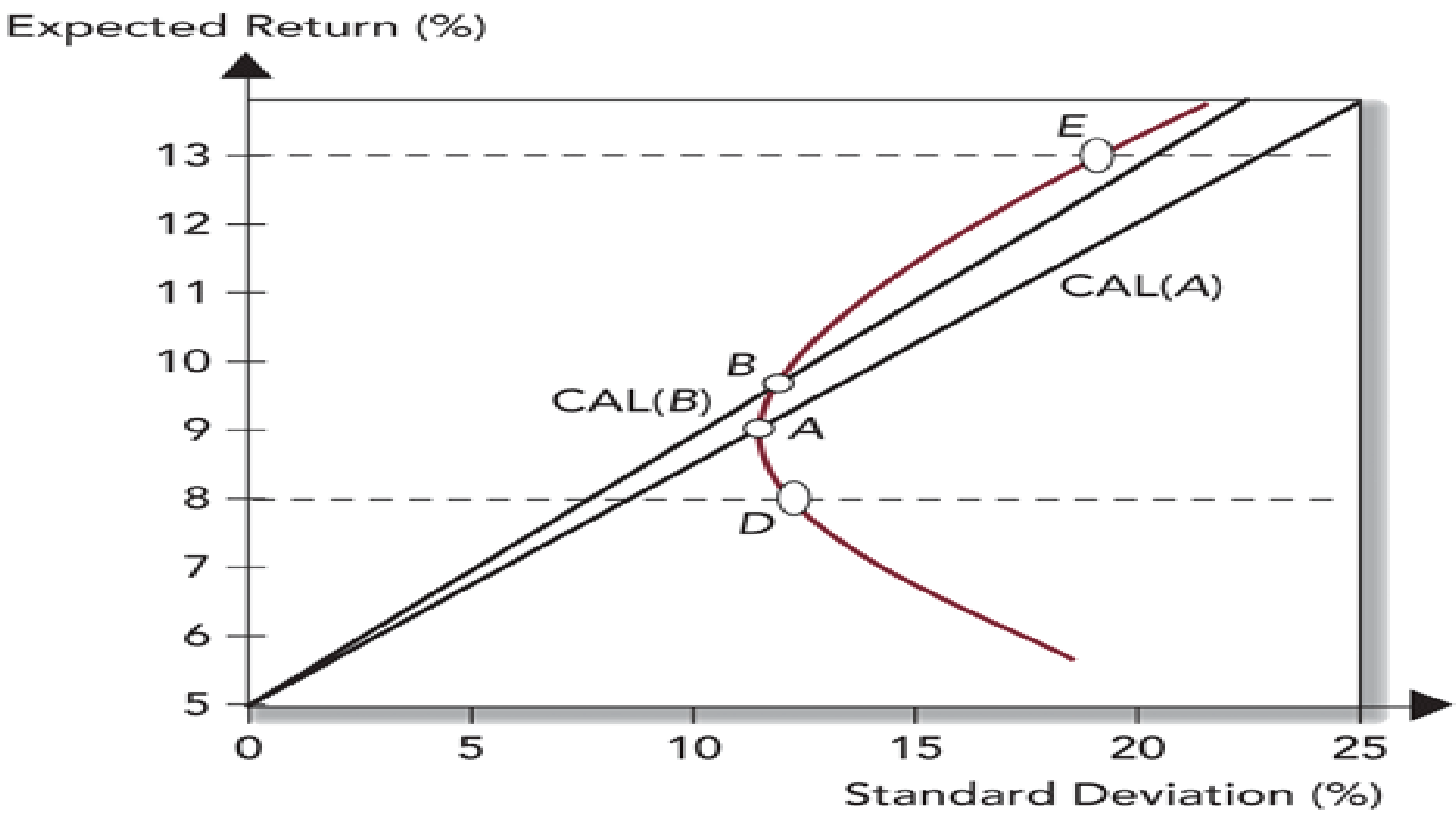
Minimum-Variance Frontier of Risky Assets



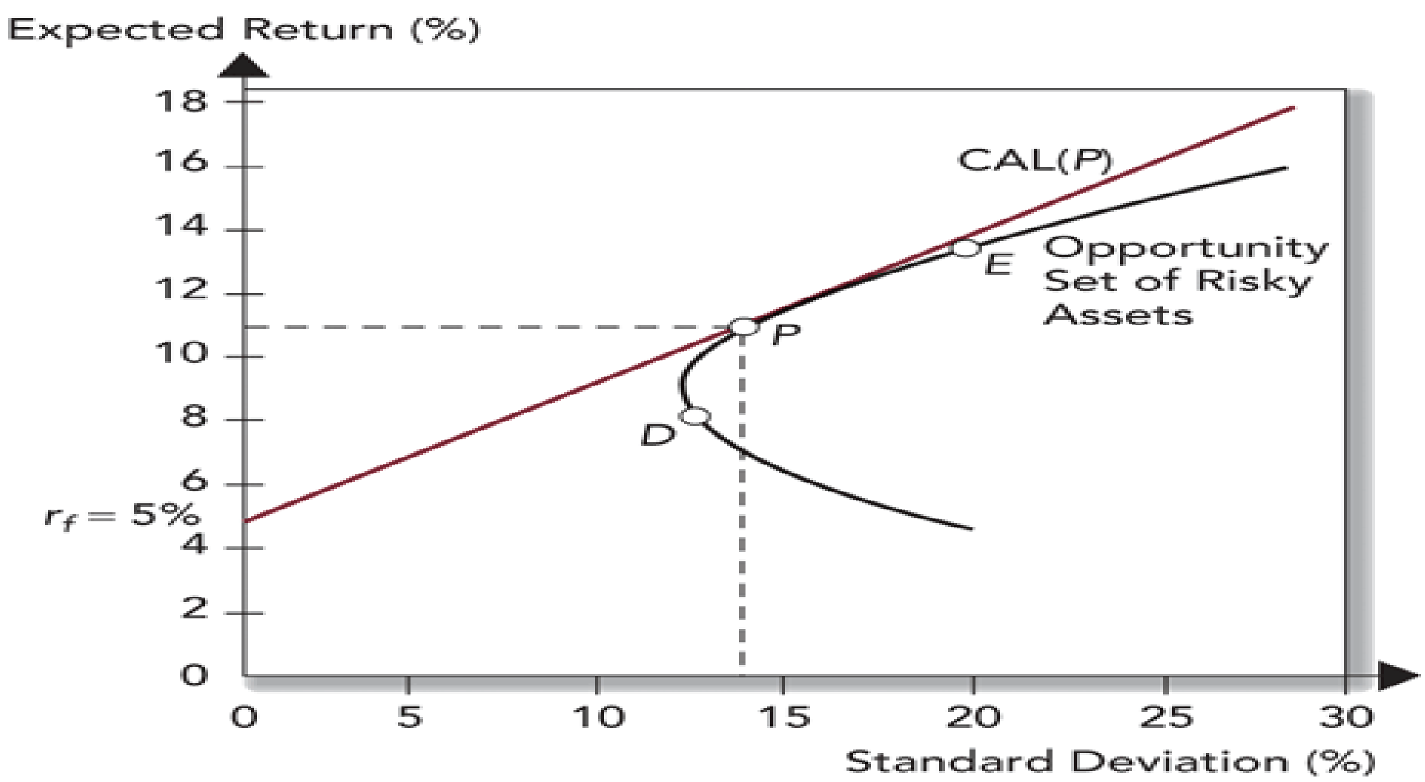
The Opportunity Set of the Debt and Equity Funds

- But we don’t just have the two risky assets.
- There’s also a risk-free asset
- Combination of the risk-free asset and any point on the opportunity set of the debt and equity funds is the capital allocation line

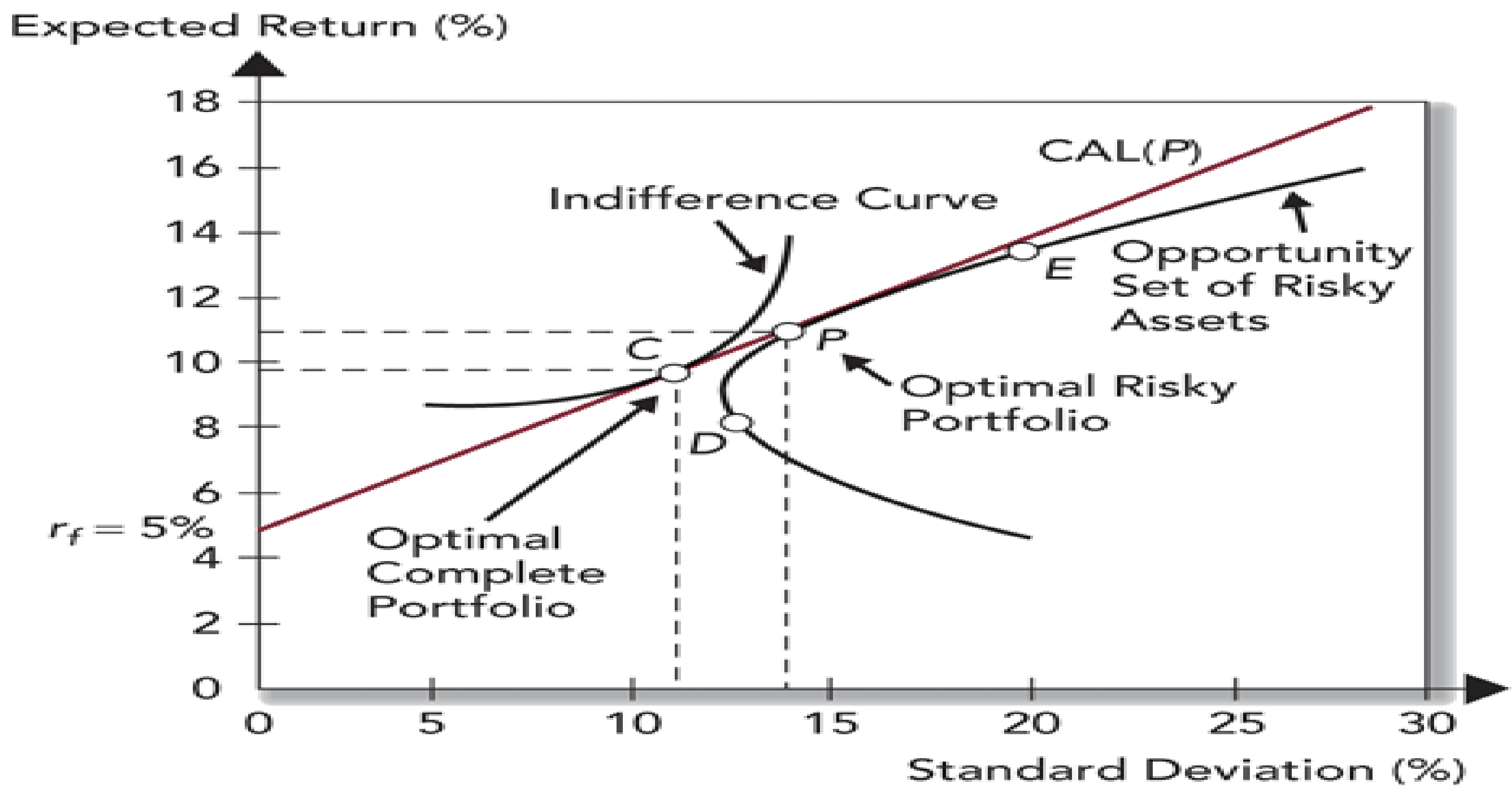
The Opportunity Set of the Debt and Equity Funds and Two Feasible CALs



The Opportunity Set of the Debt and Equity Funds with the Optimal CAL and the Optimal Risky Portfolio



Determination of the Optimal Overall Portfolio



The Sharpe Ratio

- Tangency portfolio maximizes the slope of the CAL for any possible portfolio, *p*
- The objective function is the slope:

$$S_p = \frac{E(r_p) - r_f}{\sigma_p}$$

Formula for Optimal Risky Portfolio

$$w_D = \frac{E(R_D)\sigma_E^2 - E(R_E)Cov(R_D, R_E)}{E(R_D)\sigma_E^2 + E(R_E)\sigma_D^2 - [E(R_D) + E(R_E)]Cov(R_D, R_E)}$$

$$w_E = 1 - w_D$$

where R_D and R_E are the excess returns over the riskfree rate

Example

	Debt	**Equity**
Expected Return	0.08	0.13
St Dev	0.12	0.20
Correlation	0.3	
Covariance	0.0072	

T-Bill yield: 5 percent

Optimal Portfolio

$$w_D = \frac{0.03 * 0.04 - 0.08 * 0.0072}{0.03 * 0.04 + 0.08 * 0.0144 - (0.03 + 0.08) * 0.0072} = 0.4$$

$$w_E = 0.6$$

Example (continued)

$$E(r) = (0.4 * 0.08) + (0.6 * 0.13) = 11\%$$

$$\sigma^2(r) = (0.4^2 * 0.0144) + (0.6^2 * 0.04) + (2 * 0.4 * 0.6 * 0.0072)$$

$$= 0.020164$$

$$\sigma(r) = 14.2\%$$

CAL of optimal portfolio has slope of

$$\frac{11 - 5}{14.2} = 0.42$$

Optimal Complete Portfolio

- Consider investor with utility function

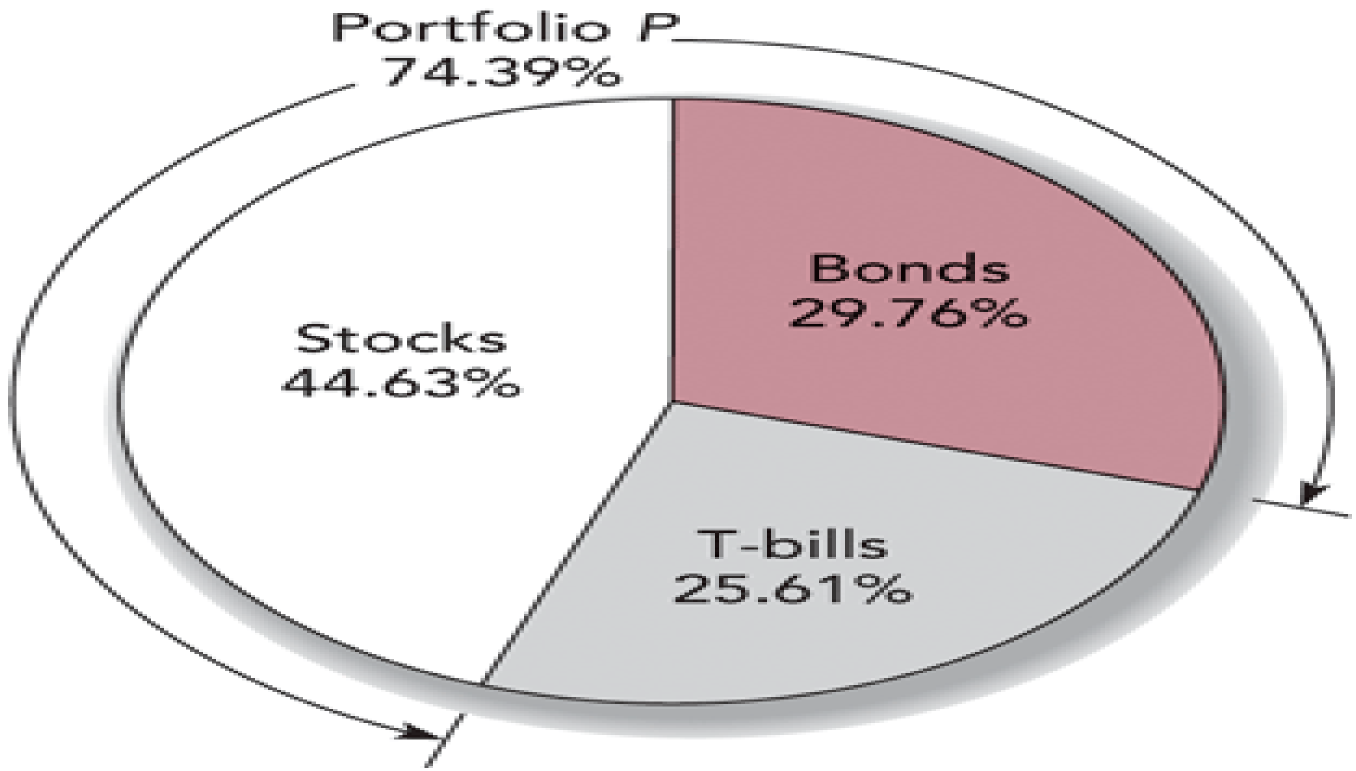
$$U = E(r) - \frac{A}{2}\sigma^2$$

- Position in portfolio will be

$$y = \frac{E(r_p) - r_f}{A\sigma_p^2}$$

- For example, if A=4, $y = \frac{0.11 - 0.05}{4 * 0.142^2} = 0.7439$

Optimal Complete Portfolio in Example



Markowitz Portfolio Selection Model

- Security Selection
  - First step is to determine the risk-return opportunities available
  - All risky portfolios that lie on the minimum-variance frontier from the global minimum-variance portfolio and upward provide the best risk-return combinations

Capital Allocation and the Separation Property

- **Separation property**: The property that portfolio choice problem is separated into two independent parts:
  - (1) determination of the optimal risky portfolio, and
  - (2) the personal choice of the best mix of the risky portfolio and risk-free asset.

- Implication of the separation property: the optimal risky portfolio P is the same for all clients of a fund manager.

The Power of Diversification

- We have $\sigma_p^2 = \Sigma_{i=1}^{n} \Sigma_{j=1}^{n} w_i w_j Cov(r_i, r_j)$

- Suppose that all securities in the portfolio have the same weight, have variance $\bar{\sigma}^2$ and covariance Cov

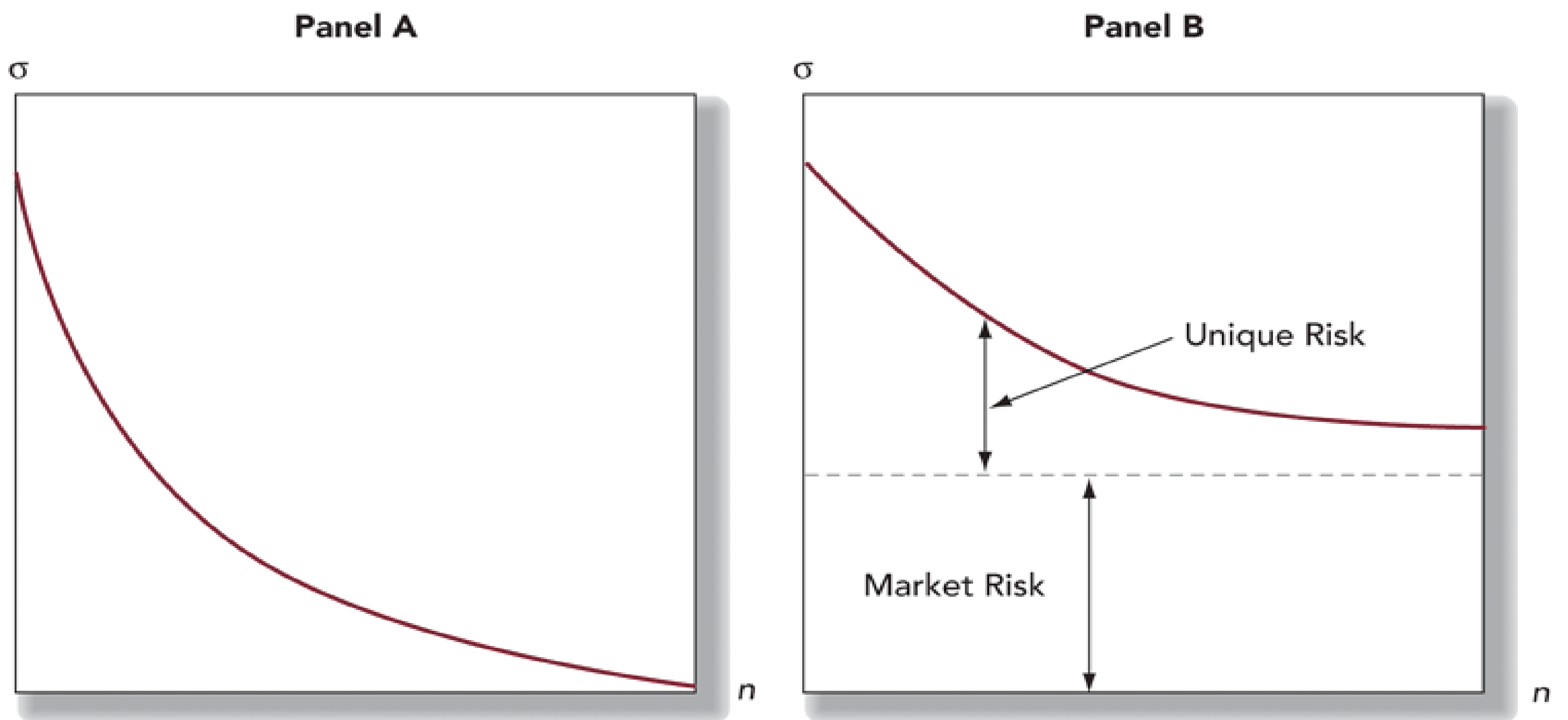
- We can then express portfolio variance as:

$$\sigma_p^2 = \frac{1}{n}\bar{\sigma}^2 + \frac{n-1}{n} Cov$$

Risk Reduction of Equally Weighted Portfolios

Number of Stocks	ρ=0	ρ=0.4
1	0.5000	0.5000
2	0.3536	0.4183
10	0.1581	0.3391
100	0.0500	0.3186
Infinite	0.0000	0.3162

Portfolio Risk as a Function of the Number of Stocks in the Portfolio



$$\text{Market risk} = \lim_{n\to\infty} \sigma_P^2 = Cov$$

An Example

- Suppose there are many stocks
  - All have mean 15%
  - Standard deviation 60%
  - Correlation 0.5

- 1. What is the expected return and standard deviation of a portfolio of 25 stocks?

- 2. How many stocks are needed to get the standard deviation down to 43%

An Example

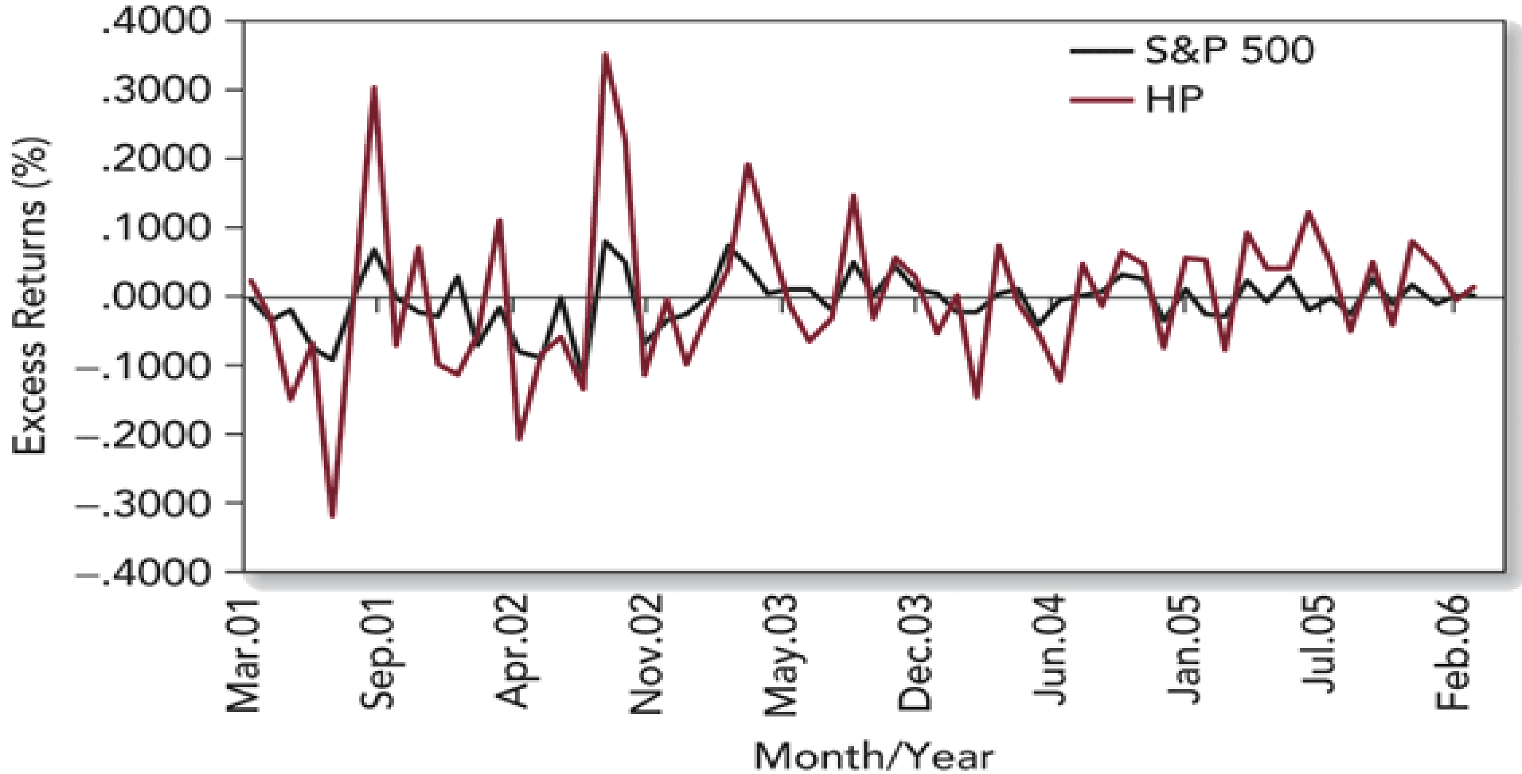
- 3. What is the systematic (market) risk in this universe?

- 4. If T bills are available and yield 10% what is the slope of the CAL?

Where next?

- Analysis using optimal portfolio choice requires a lot of parameters to be estimated
- Hard to use in practice
- So there are some models that are better at handling many assets
  - **Single Index Model**
  - CAPM
  - APT

Excess Returns on HP and S&P 500 April 2001 – March 2006



Single-Index Model

$$R_i(t) = \alpha_i + \beta_i R_M(t) + e_i(t)$$

ß$_i$ = index of a securities' particular return to the market

The alphas and betas of stocks

- Alphas is a measure of which stocks are under and overpriced

- Beta is a measure of market sensitivity
  - Which stocks have high beta?
  - Which stocks have low beta?

Single Index Model Decomposition

$$R_i(t) = \alpha_i + \beta_i R_m(t) + e_i(t)$$

- α_i is stock market mispricing
- $\beta_i R_M(t)$ is component of return due to **systematic risk**
- $e_i(t)$ is component of return due to **idiosyncratic risk** (or firm-specific risk)

How to estimate betas

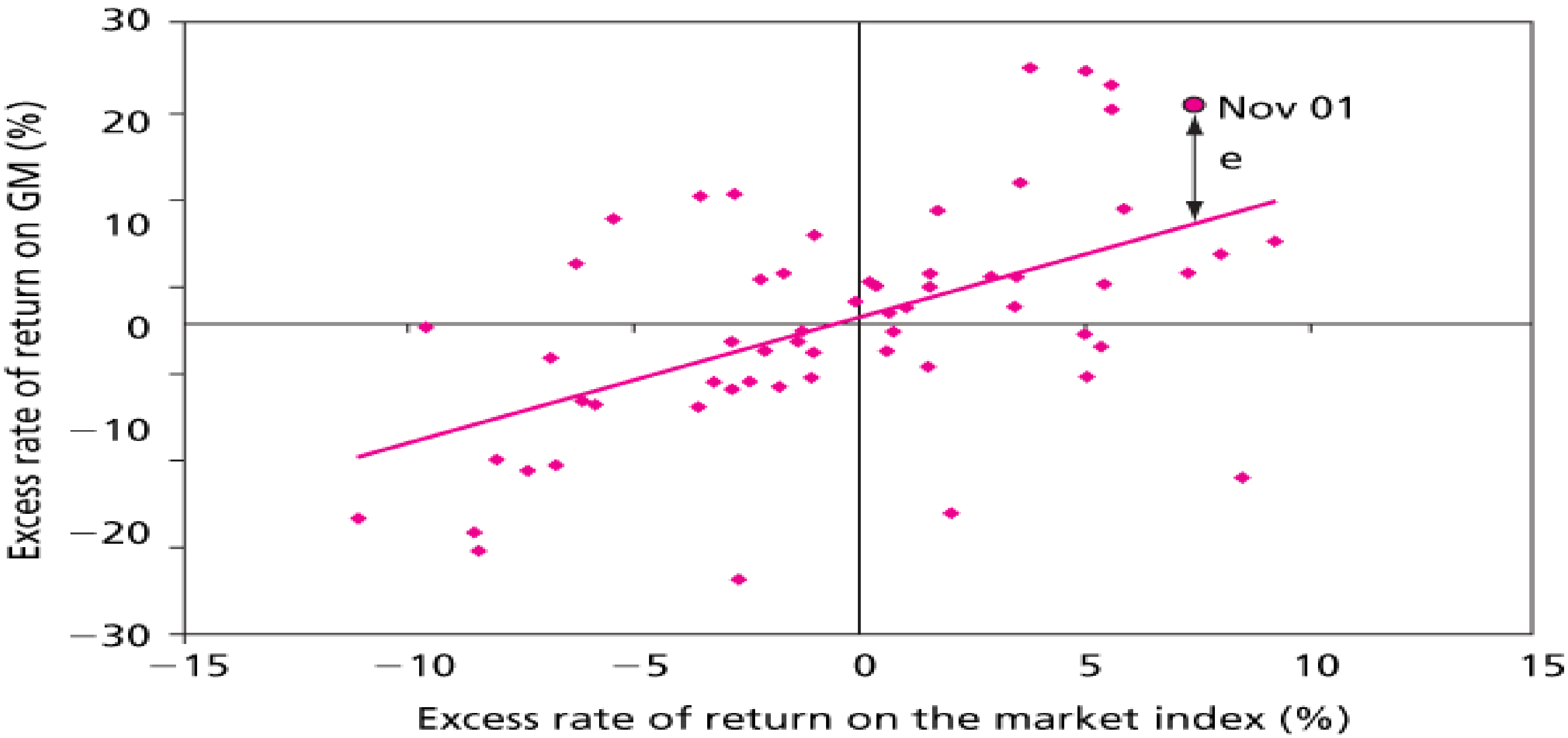
- Compute the excess returns of the stock
- Compute the excess returns of the market portfolio (proxied by S&P 500 Index)
- Regress excess returns of the stock on the excess returns of the S&P 500 index
- Slope coefficient is beta
- Also gives alpha and error estimates

Single-Index Model Input List

- Risk premium on the S&P 500 portfolio
- Estimate of the SD of the S&P 500 portfolio
- *n* sets of estimates of
  - Alpha values
  - Beta coefficient
  - Stock residual variances
- Fewer inputs than with a general covariance matrix

Security Characteristic Line

- Plots excess returns of a single asset against excess market returns for different time periods



Portfolios With the Single-Index Model

- For a portfolio $R_P(t) = \alpha_P + \beta_P R_M(t) + e_P(t)$
- Alpha and beta of a portfolio:

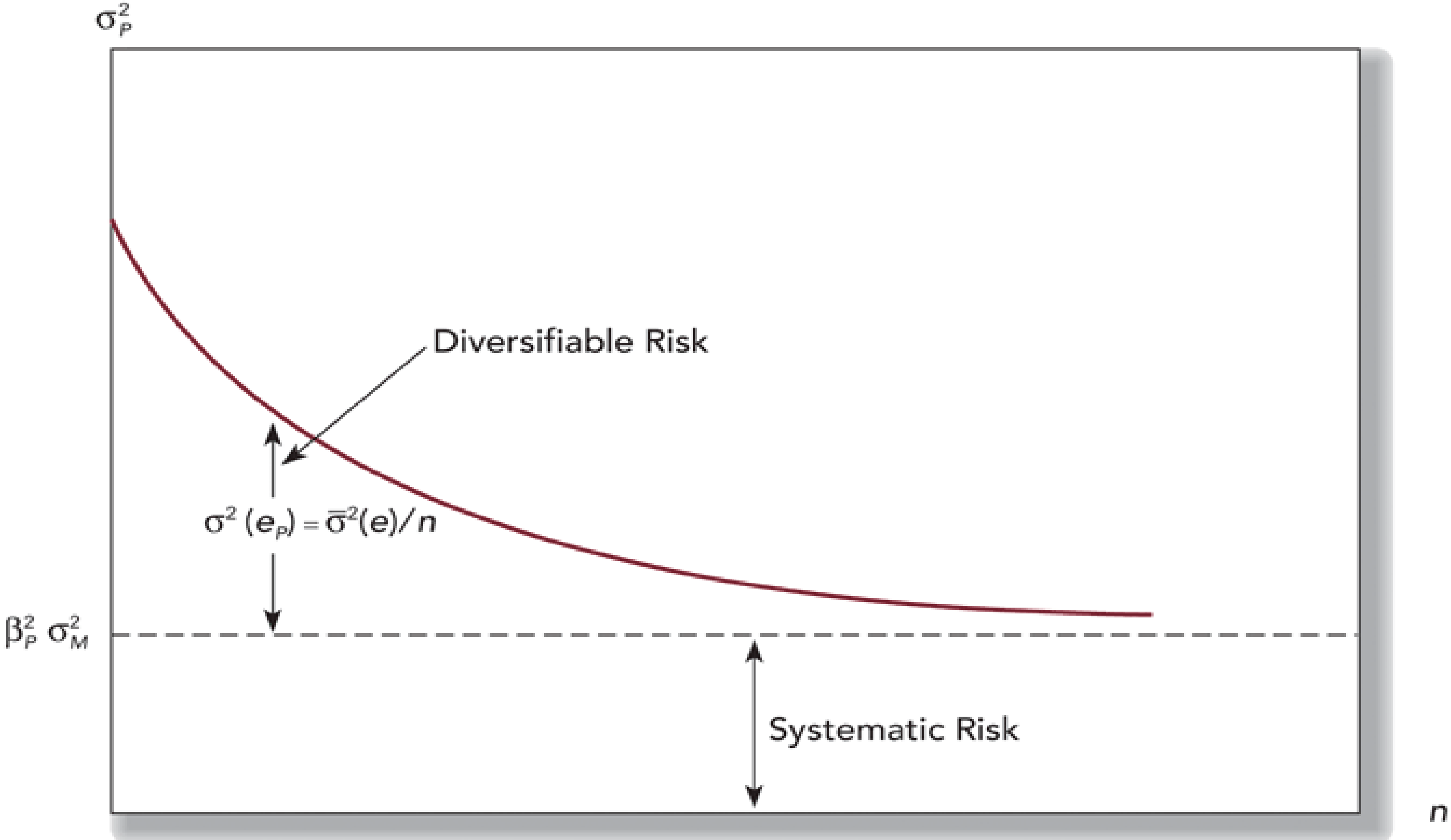
$$\alpha_p = \sum_{i=1}^{n} x_i \alpha_i \text{ and } \beta_p = \sum_{i=1}^{n} x_i \beta_i$$

- Variance of a portfolio:

$$\sigma_p^2 = \beta_p^2 \sigma_m^2 + \sigma_{ep}^2$$

- When *n* gets large, σ_{ep}^2 becomes negligible

The Variance of an Equally Weighted Portfolio with Risk Coefficient β_p in the Single-Factor Economy



Optimal Risky Portfolio of the Single-Index Model

- Mean, variance and covariances of returns

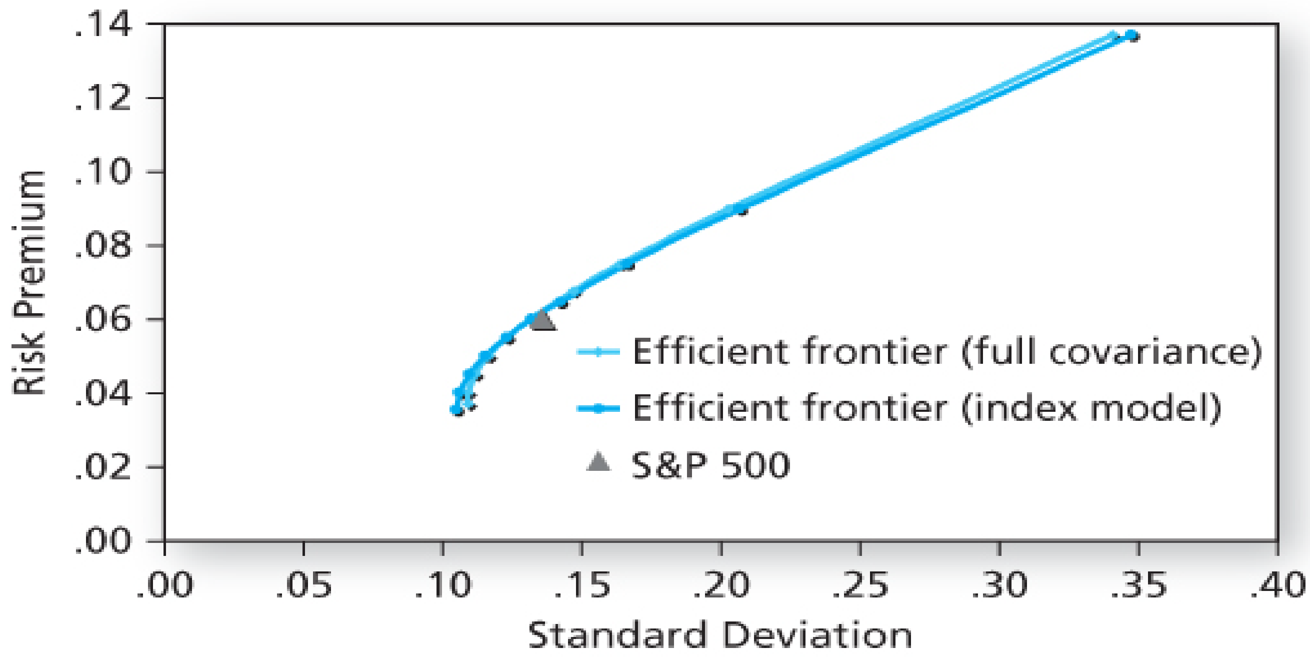
$$E(R_1) = \alpha_1 + \beta_1 E(r_m)$$

$$Var(R_1) = \beta_1^2 \sigma_m^2 + \sigma_{e1}^2$$

$$Cov(R_1, R_2) = \beta_1 \beta_2 \sigma_m^2$$

- Can then work out efficient frontier as before.

Efficient Frontier with full covariance matrix and the single index model



Question

- Why do some assets have higher returns than others?

- Capital Asset Pricing Model provides an answer

Capital Asset Pricing Model (CAPM)

- It is the equilibrium model that underlies all modern financial theory

Assumptions

- Investors are price takers
- Single-period investment horizon
- Same expectations
- “Perfect” markets
  - No transactions costs or taxes
  - Short selling and borrowing/lending at risk-free rate are allowed
- Investors have preferences on the mean and variance of returns

Resulting Equilibrium Conditions

- For any stock (say stock i) the undiversifiable risk is

$$Cov(R_i - R_f, R_M - R_f)$$

- Equilibrium condition is that all assets should have the same risk-reward ratio defined as

$$\frac{E(R_i) - R_f}{Cov(R_i - R_f, R_M - R_f)} = \frac{E(R_m) - R_f}{Var(R_m - R_f)}$$

Resulting Equilibrium Conditions

- Can rewrite to say expected return is a function of
  - Beta
  - Market return
  - Risk-free return

The CAPM Pricing Equation

$$E(r_i) - r_f = \beta_i [E(r_m) - r_f]$$

where

$$\beta_i = Cov(r_i - r_f, r_m - r_f) / Var(r_m - r_f)$$

- This is also known as the security market line (SML), or the “Expected Return-Beta” relationship

CAPM Implications

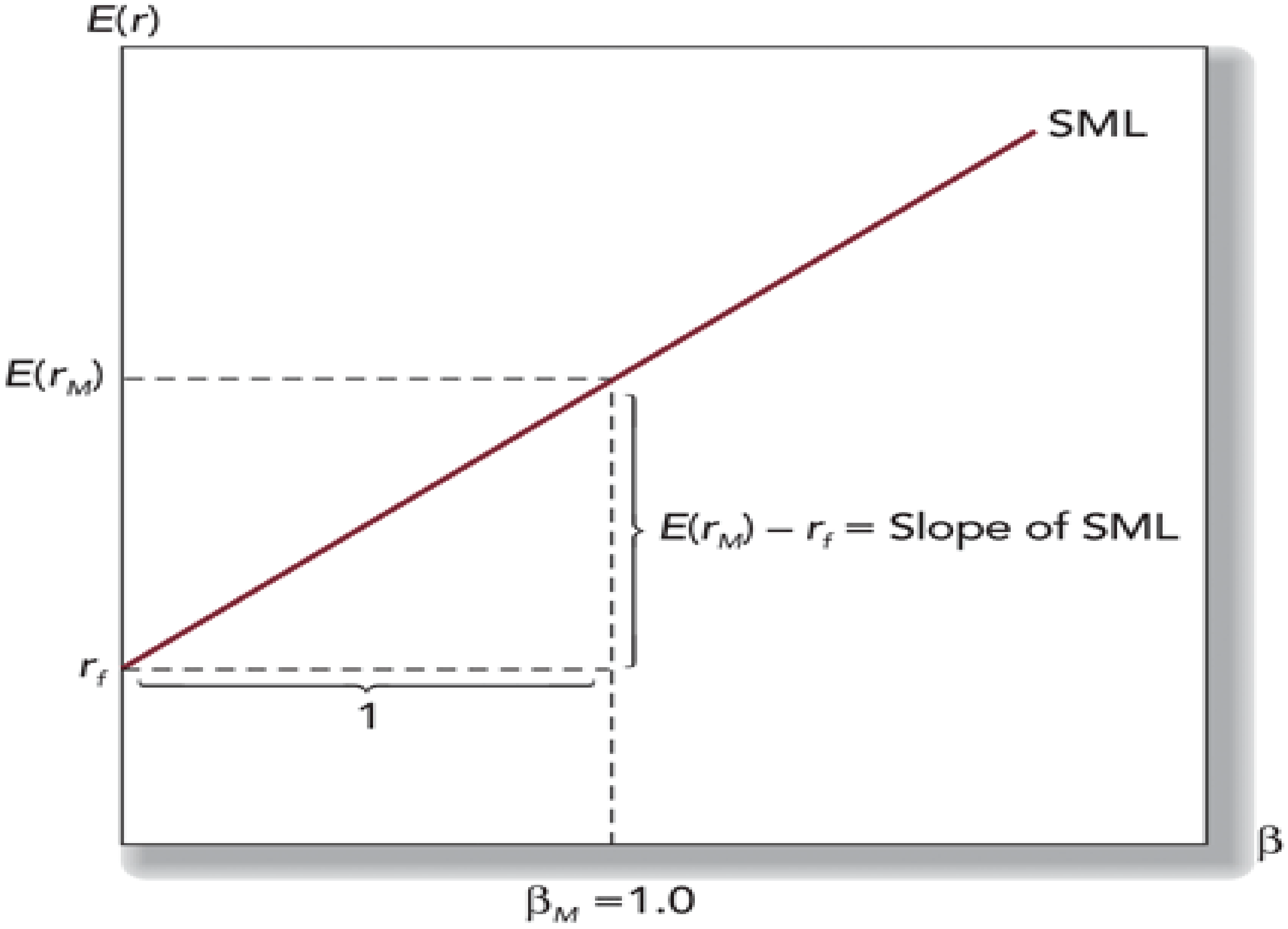
- If β_i=1, $E(r_i)=E(r_m)$
- If β_i>1, $E(r_i)>E(r_m)$
- If β_i<1, $E(r_i)<E(r_m)$
- If β_i=0, $E(r_i)=r_f$

Using the CAPM: An Example

- Suppose you have the following info:
  - Risk free rate: 3.5%
  - Expected market return: 8.5%
  - Beta of IBM is 0.75

- Q. What is the expected return on IBM stock?
- A. 0.035+0.75*[0.085-0.035]=7.25%

The Security Market Line



Expected Return-Beta Relationship

- CAPM holds for any portfolio because:

$$E(r_P) = \sum_k w_k E(r_k)$$

$$\beta_P = \sum_k w_k \beta_k$$

- This also holds for the market portfolio:

$$E(r_M) - r_f = \beta_M [E(r_M) - r_f]$$

$$\beta_M = 1$$

Different Agents

- CAPM does not assume that all agents are the same

- They can have different risk aversion

- This will affect only the mix of the market and riskfree asset that they hold.

Market Risk Premium

- The risk premium on the market portfolio will be proportional to its risk and the degree of risk aversion of the average investor:

$$E(r_M) - r_f = \overline{A}\sigma_M^2$$

where σ_M^2 is the variance of the market

CAPM: Variance Decomposition

- CAPM implies that variance of returns on an asset are

$$\beta^2 \sigma_m^2 + \sigma_e^2$$

CAPM Intuition: Systematic and Unsystematic Risk

- Unsystematic risk can be diversified and is irrelevant
- Systematic risk cannot be diversified and is relevant
  - Measured by beta
  - Beta determines the level of expected return
- The risk-to-reward ratio should be the same across assets

CAPM versus the Index model

- The index model

$$R_i(t) - R_f(t) = \alpha_i + \beta_i[R_m(t) - R_f(t)] + e_i(t)$$

- The CAPM index model beta coefficient turns out to be the same beta as that of the CAPM expected return-beta relationship

$$E(R_i(t)) - R_f(t) = \beta_i[E(R_m(t)) - R_f(t)]$$

- Indeed, if you take the index model, take expectations and let $\alpha_i = 0$ you get the CAPM

CAPM versus the Index model

- CAPM is an equilibrium model
  - Derived assuming investors maximize utility
  - Index model is not

- The CAPM implies no intercept

- Index model says nothing about expected market return

Exercise: Can the following be consistent with CAPM?

Portfolio	Expected Return	Standard Deviation	Beta
A	13.4%	40%	1.2
B	15.5%	50%	1.5
Market	12.0%	34%	1.0

Exercise: Can the following be consistent with CAPM?

Portfolio	Expected Return	Standard Deviation	Beta
A	6%	20%	0.7
B	10%	20%	1.0
C	12%	45%	1.5

Exercise: Can the following be consistent with CAPM?

Portfolio	Expected Return	Standard Deviation	Residual Variance
A	12%	30%	6%
Market	10%	20%	0%

Exercise: CAPM Example

Asset	Total Variance	Residual Variance
Stock A	30%	17.2%
Stock B	15%	7.8%
Market	5%	0%

- What is the beta of stock A and stock B?
- If the expected market return is 10% and the riskfree rate is 5%, what are the expected returns on stock A and stock B?

The CAPM and Reality

- Testing the CAPM
  - Proxies must be used for the market portfolio
  - And for the risk-free rate

Does Beta Explain the Cross-section of Returns?

- Early tests found strong evidence for an expected return-beta relationship
  - Black, Jensen and Scholes (1972)

- More recent results have been less positive.

Tests of the CAPM: The Fama MacBeth Procedure

$$E(r_i) = r_f + \beta_i[E(r_M) - r_f]$$

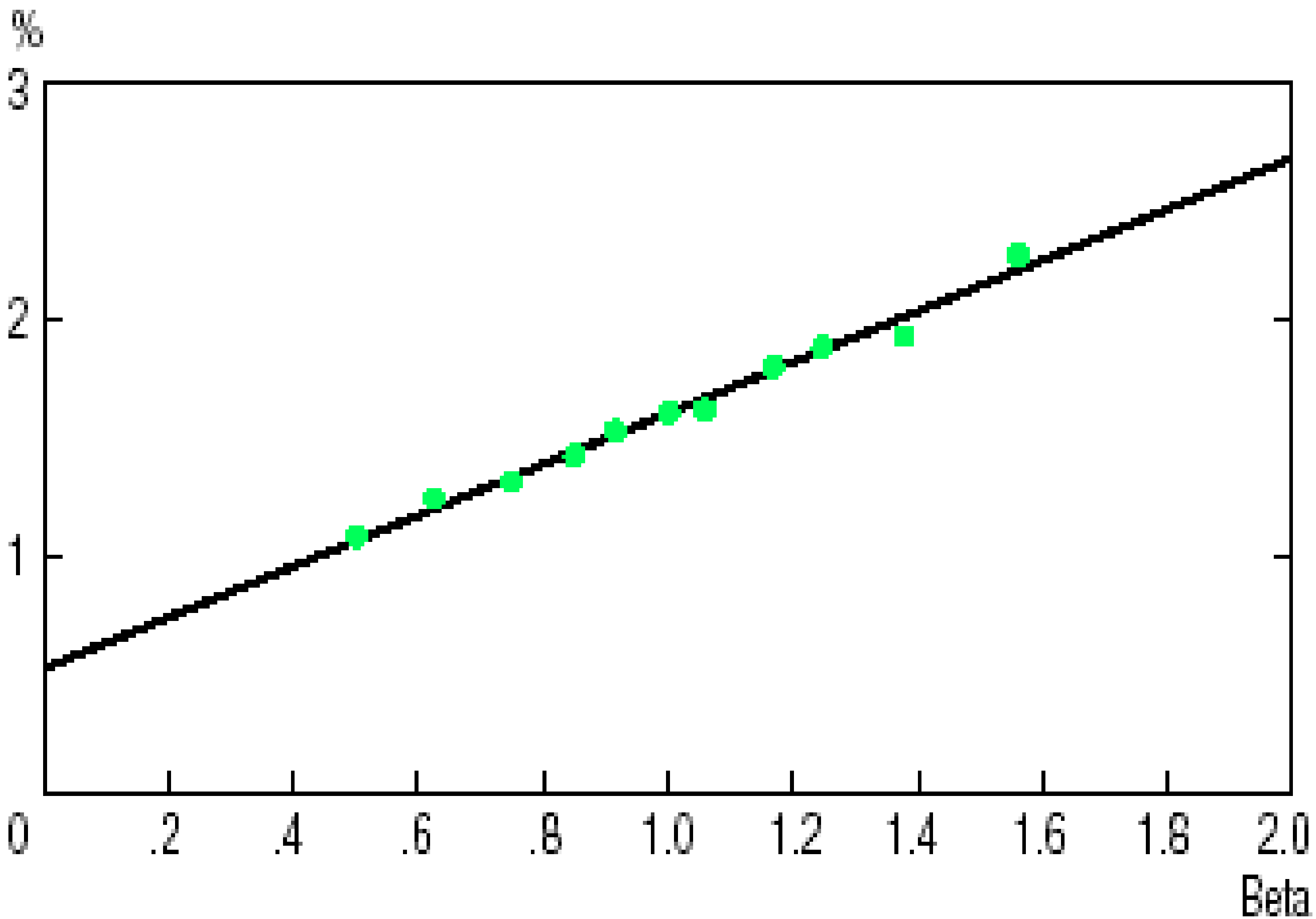
- First pass regression
  - Estimate the betas (and maybe variances of residuals)

- Second Pass: Using estimates from the first pass to determine if model is supported by the data

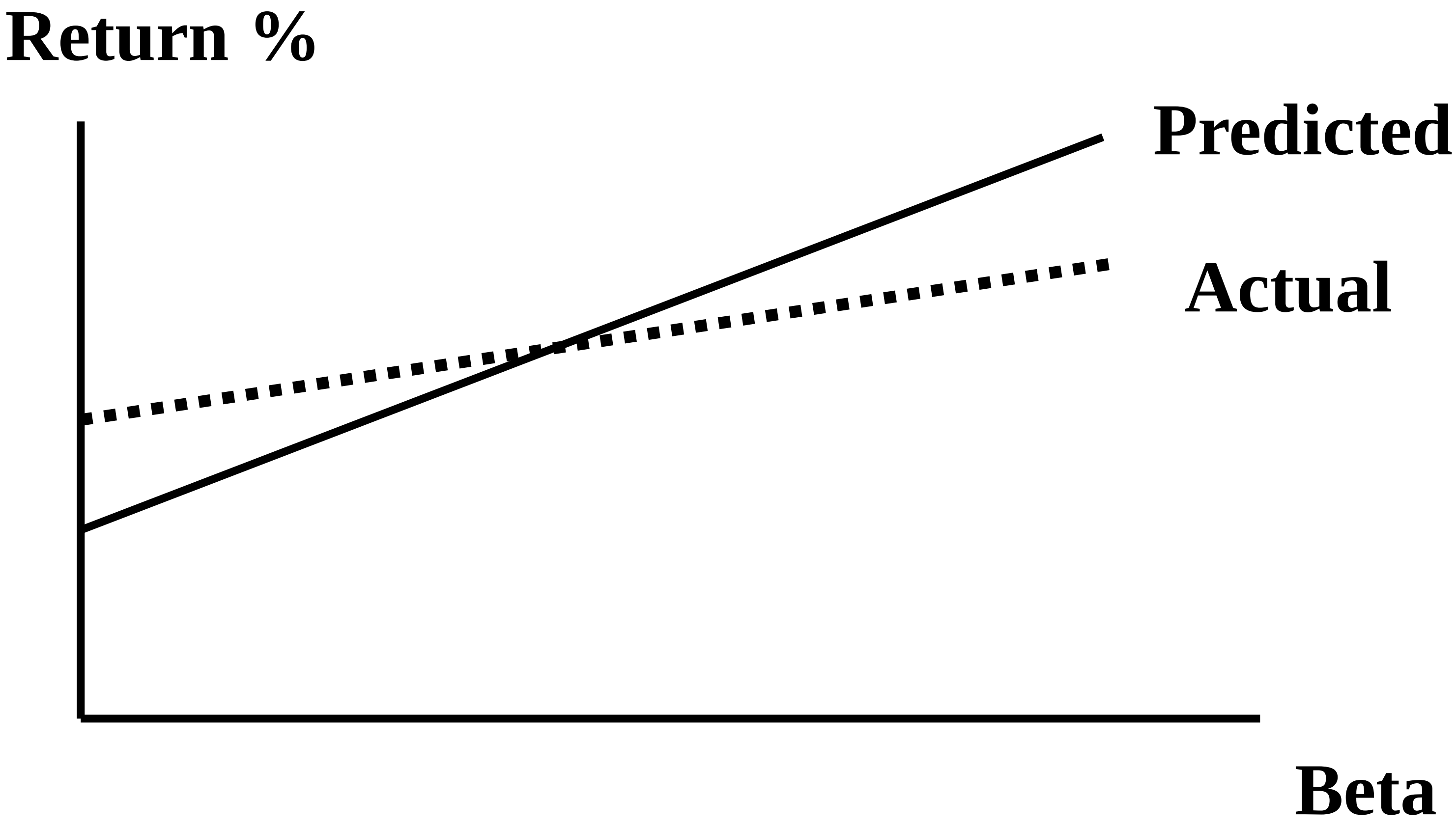
$$R_i = \gamma_0 + \gamma_1\beta_i + \varepsilon_i$$

$$R_i = \gamma_0 + \gamma_1\beta_i + \gamma_2 Var(e_{it}) + \varepsilon_i$$

Classic Test of the CAPM (Black, Jensen and Scholes, 1972)



Single Factor Test Results



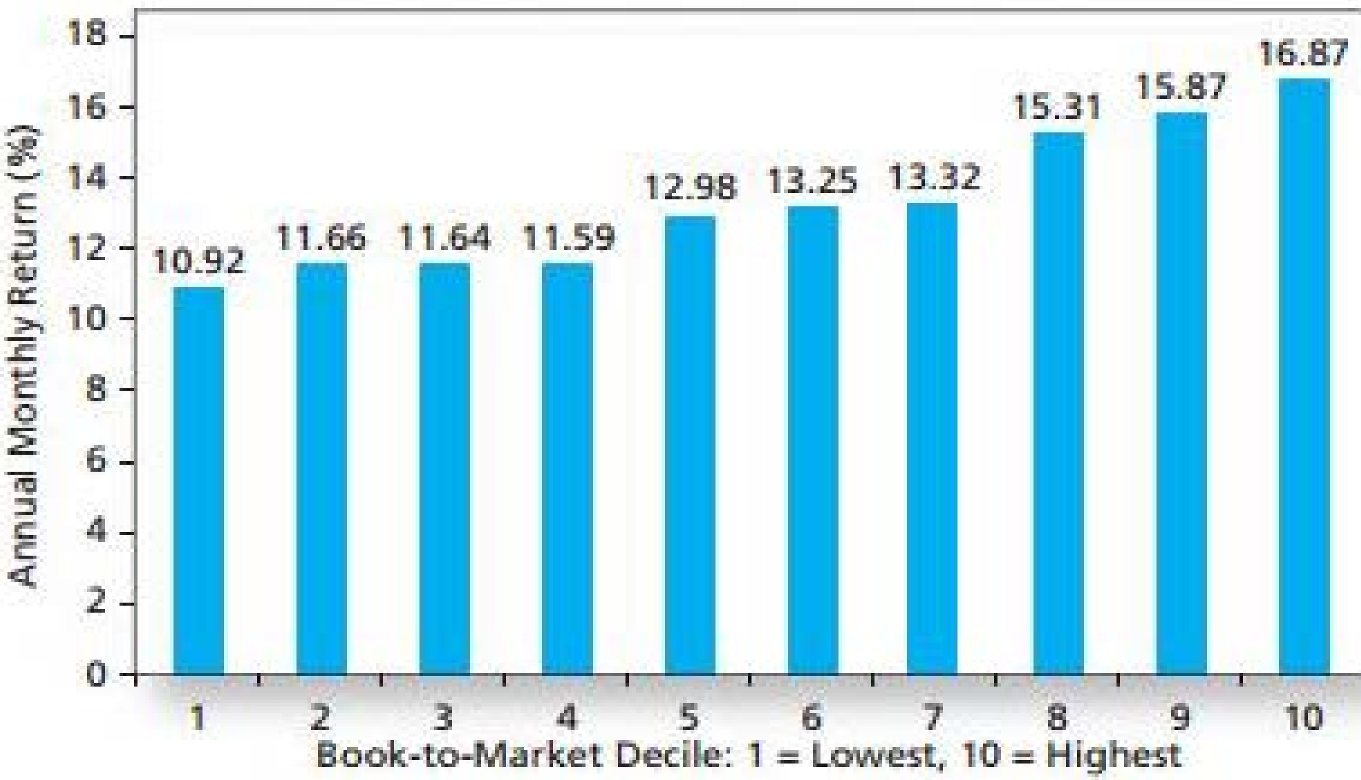
Does Beta Explain Everything?

- Does it explain anything?
- Fama and French (1992) results
  - Cross sectional regression

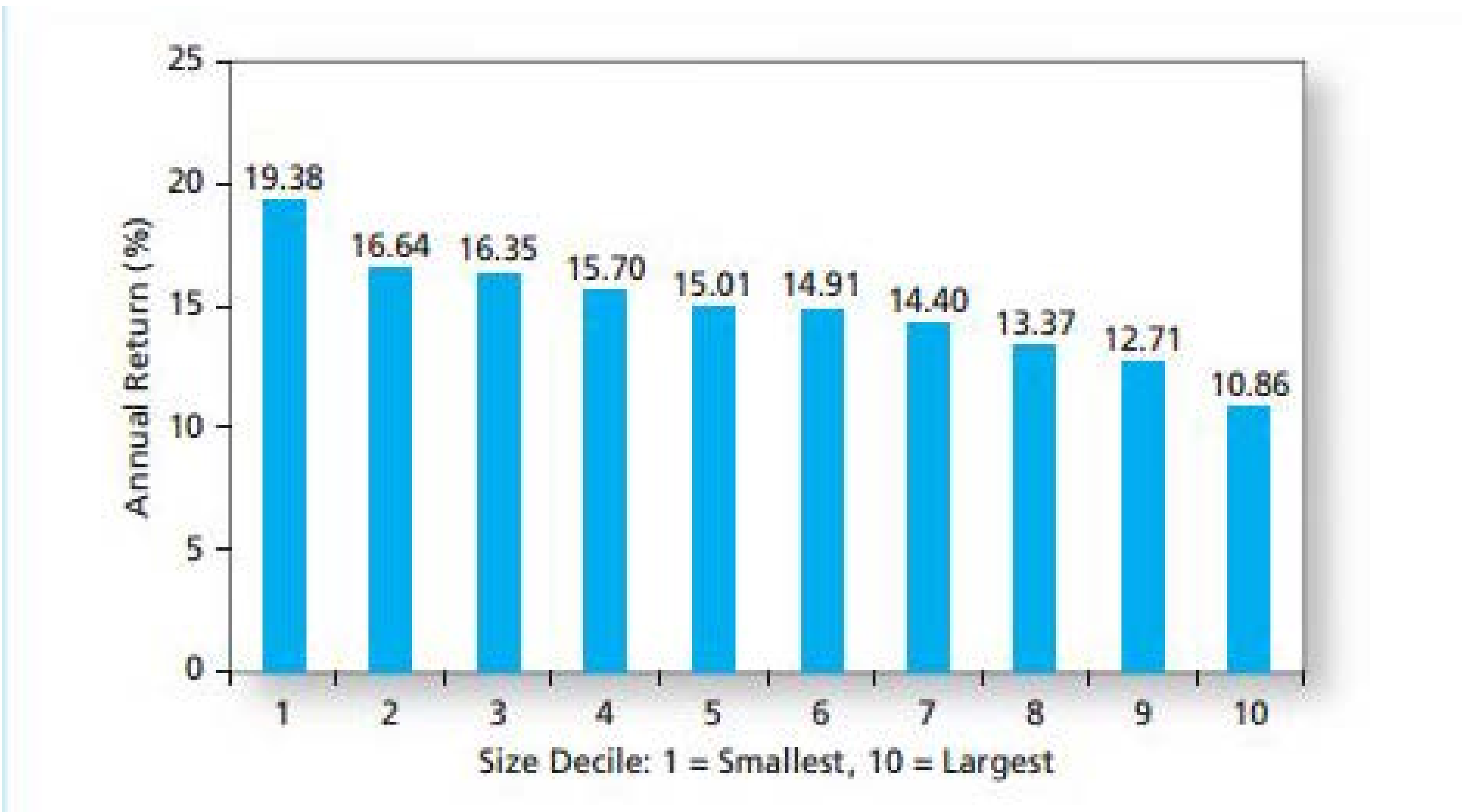
$$r_i = \gamma_0 + \gamma_1 (B/M)_i + \gamma_2 \log(ME_i) + \gamma_3 \beta_i$$

  - Book to market and size matter
  - Beta explains almost nothing!

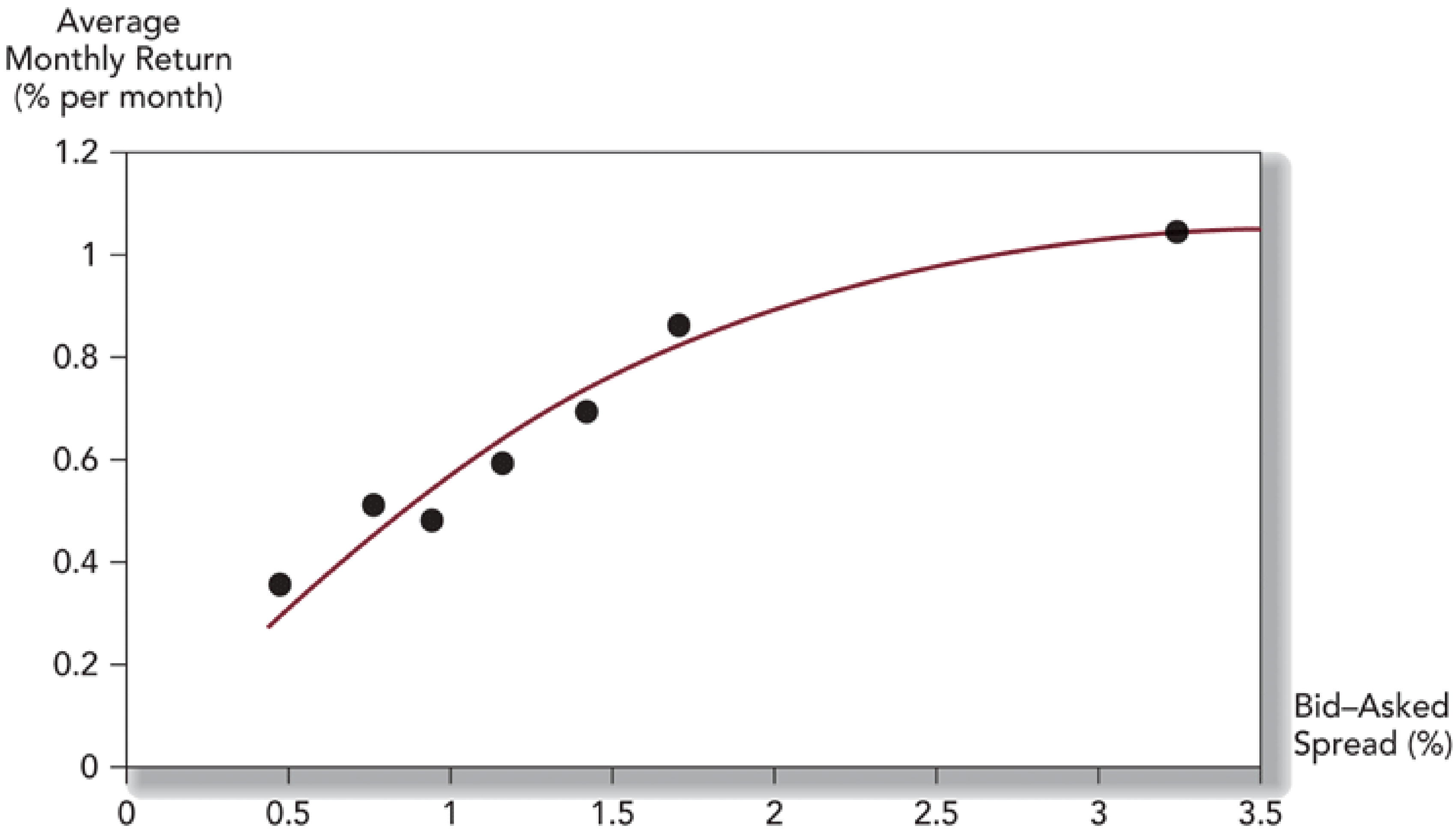
Average Return as a Function of Book-To-Market Ratio, 1926–2011



Average Annual Return for 10 Size-Based Portfolios, 1926 – 2011



The Relationship Between Illiquidity and Average Returns



The CAPM and Reality

- There are problems with the CAPM
- Other factors are important in explaining returns
  - Firm size effect
  - Ratio of book value to market value
  - Liquidity
- Still the benchmark asset pricing model

The CAPM without a risk-free asset

- Suppose there is no riskfree asset (e.g. due to inflation uncertainty)

$$E(R_i) = E(R_z) + \beta_i (E(R_m) - E(R_z))$$

where z is the return on any zero-beta portfolio

- This is called the "zero-beta" CAPM (Black (1972))

Factor Models

- Returns on a security come from two sources
  - Common factor
  - Firm specific events

- Possible common factors
  - Market excess return
  - Gross Domestic Product Growth
  - Interest Rates

Single Factor Model Equation

$$r_i = E(r_i) + \beta_i F + e_i$$

r_i = Return for security i

β_i = Factor sensitivity or factor loading or factor beta

Estimate by regression

F = **Surprise** in macro-economic factor (E(F)=0)

(F could be positive, negative or zero)

e_i = Firm specific events

APT & Well-Diversified Portfolios

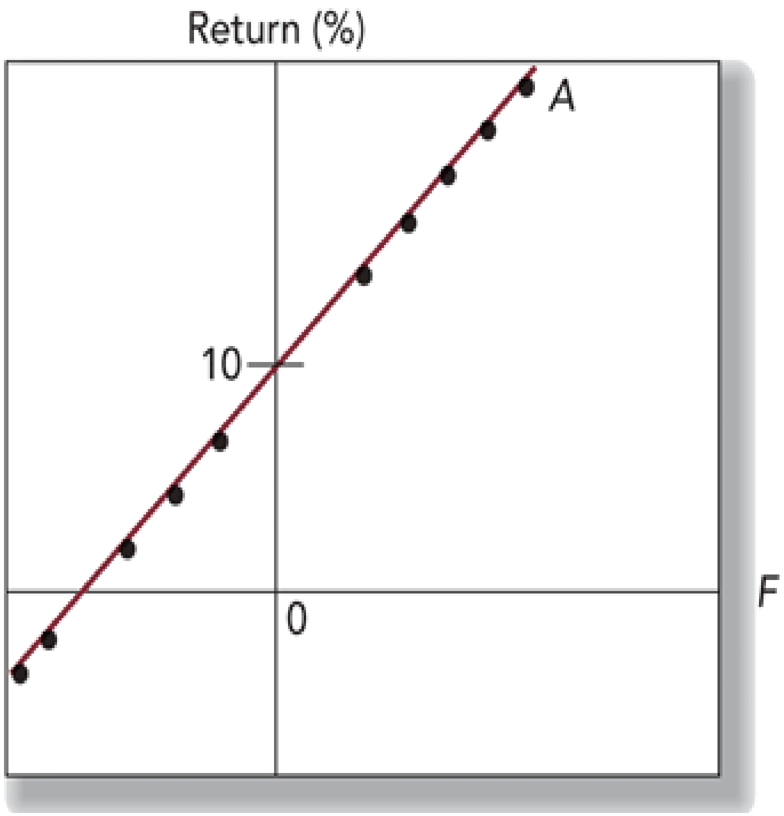
$r_P = E(r_P) + \beta_P F + e_P$

F = some factor

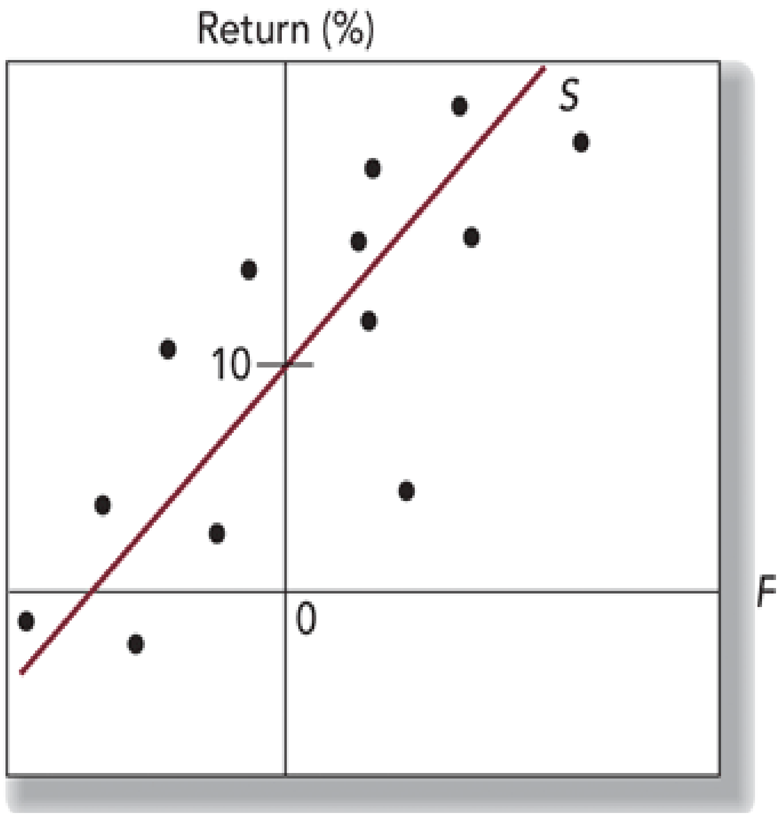
- For a well-diversified portfolio: e_P approaches zero

Returns as a Function of the Systematic Factor

Well Diversified Portfolios



Individual Stocks



Arbitrage Pricing Theory (APT)

Arbitrage - arises if an investor can construct a zero investment portfolio with a sure profit

- Since no investment is required, an investor can create large positions to secure large levels of profit
- In efficient markets, profitable arbitrage opportunities will quickly disappear

Pricing

- Implication of the factor structure for a well-diversified portfolio:

$$E(r_i) = r_f + \lambda \beta_i$$

- If not, there's an arbitrage
- Expected returns proportional to factor beta
- Intuition: only systematic risk should command higher expected returns

APT and CAPM

- Suppose that $F = r_m - E(r_m)$
- Then $r_i = E(r_i) + \beta_i[r_m - E(r_m)] + e_i$ and for any well-diversified portfolio

$$E(r_i) = r_f + \beta_i[E(r_m) - r_f]$$

where $\beta_i = Cov(r_i - r_f, r_m - r_f) / Var(r_m - r_f)$

- This is the CAPM, except that it applies only to well diversified portfolios

APT and CAPM Compared

- APT applies to well diversified portfolios and not necessarily to individual stocks
  - Possible for some individual stocks to be mispriced - not lie on the SML
- APT doesn't need investors to have mean-variance utility (which CAPM does)
- APT doesn't necessarily require us to measure market portfolio
- APT can have more than one factor.

Factor model

$$r_i = E(r_i) + \beta_i F + e_i$$

- Variance of returns is

$$\beta_i^2 Var(F) + Var(e_i)$$

Factor model: Example

- The risk-free rate is 4 percent and X and Y are two well-diversified portfolios:

Portfolio	Beta	Expected Return
X	1	10
Y	1/2	?

- Q. What is the expected return on Y?
- A. $10=4+\lambda$ and so $\lambda=6$. The expected return on Y is

$$4+\lambda*0.5=4+3=7$$

Factor model: An arbitrage

- Suppose instead that the expected return on Y were 9%

Portfolio	Beta	Expected Return
X	1	10
Y	1/2	9

- Q. What can an investor do?
- 1. Invest $100 in Y.
  - Payoff: $100*[1+0.09+0.5F]= 109+50F
- 2. Invest -$50 in the riskfree asset:
  - Payoff: -50*1.04=-52
- 3. Invest -$50 in X.
  - Payoff: -50*[1+0.10+F]= -55-50F
- Total payoff: $2: This is an arbitrage.

Factor model: creating an arbitrage

- General rule
  - Go long the stock with higher return
  - Go short the stock with lower return
  - Portfolio weights are ratios of the betas
  - Invest whatever is left in risk-free asset

Multifactor Models

- Use more than one factor
  - Examples include gross domestic product, expected inflation, interest rates etc.
  - Estimate a beta or "factor loading" for each factor using multiple regression.

Multifactor Model Equation

$$r_i = E(r_i) + \beta_{i1}F_1 + \beta_{i2}F_2 + e_i$$

r_i = Return for security *i*

β_{i1} = Factor sensitivity for first factor (e.g. GDP)

β_{i2} = Factor sensitivity for second factor (e.g. interest rate)

e_i = Firm specific events

Pricing with Multiple Factors

$$E(r_i) = r_f + \beta_{1i}\lambda_1 + \beta_{2i}\lambda_2$$

e.g. $$E(r_i) = r_f + \beta_{i,GDP}\lambda_{GDP} + \beta_{i,IR}\lambda_{IR}$$

$\beta_{i,GDP}$ = Factor sensitivity for GDP

λ_{GDP} = Risk premium for GDP

$\beta_{i,IR}$ = Factor sensitivity for Interest Rate

λ_{IR} = Risk premium for Interest Rate

APT Example

- There are 3 factors
- The betas are 1.1, 0.5 and 2
- The lambdas are 10%, 10% and 1%
- The riskfree rate is 5%
- Q: What is the expected return on stock i?
- A: 0.05+(1.1*0.1)+(0.5*0.1)+(2*0.01)=23%

APT Example 2

- Consider an APT model for a stock

Factor	Factor Beta	Factor Risk Premium
Inflation	1.2	6%
IP Growth	0.5	8%
Oil Prices	0.3	3%

- Q If T Bills yield 6 percent, what is the expected return on this stock?
- A: 0.06+(1.2*0.06)+(0.5*0.08)+(0.3*0.03)=18.1%

APT Example 2 (ctd.)

- Here are the actual and expected values for the factors a stock

Factor	Expected	Actual
Inflation	5%	4%
IP Growth	3%	6%
Oil Prices	2%	0%

- Q What is the revised expectation of the stock return once the factors are known?
- A: 0.181+1.2*(-0.01)+0.5*0.03+0.3*(-0.02)=17.8%

What Factors?

- Fama-French Three Factor Model
- Factors that are important to performance of the general economy (Chen, Roll and Ross)

Fama French Three Factor Model

- Factors seem to predict average returns well

$$r_{it} = \alpha_i + \beta_{iM} r_{Mt} + \beta_{iSMB} SMB_t + \beta_{iHML} HML_t$$

- where:
  - SMB = Small Minus Big, i.e., the return of a portfolio of small stocks in excess of the return on a portfolio of large stocks
  - HML = High Minus Low, i.e., the return of a portfolio of stocks with a high book to-market ratio in excess of the return on a portfolio of stocks with a low book-to-market ratio

Empirical Methodology

- Method: Two -stage regression
  - Stage 1: Estimate the betas
  - Stage 2: Run a cross-sectional regression

Fama French Second Stage Estimates

Variable	Coefficient	T-stat
Market	-0.21	-1.25
SMB	0.25	8.38
HML	0.35	10.22

Stock Prices as a Random Walk

- Kendall (1953) found that log stock prices were approximately a random walk

$$p_t = p_{t-1} + \varepsilon_t$$

- Erratic market behavior, or
- A well functioning market (where prices reflect all available information) ?

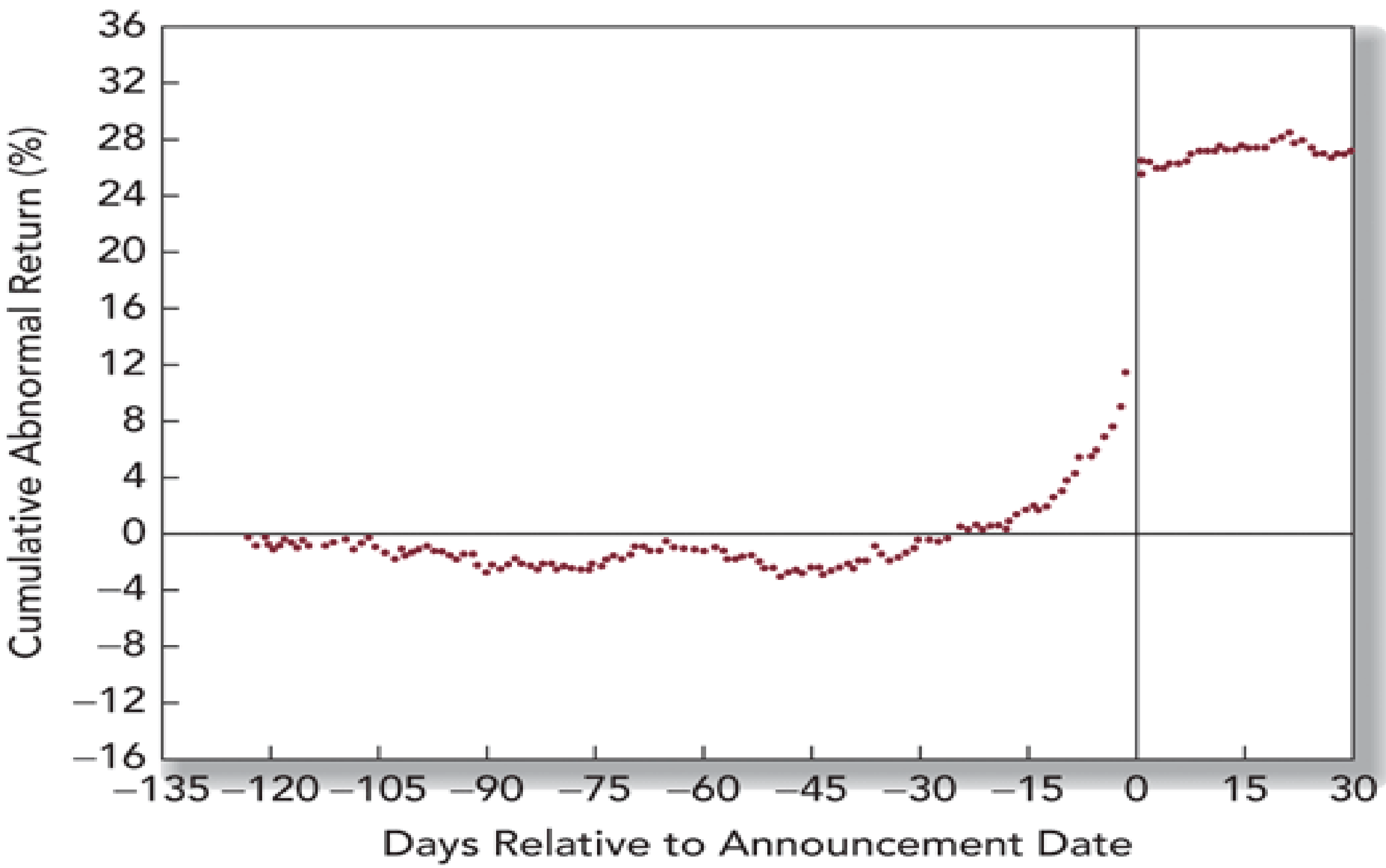
Efficient Market Hypothesis (EMH)

- EMH says stock prices already reflect all available information
- A forecast about favorable future performance leads to favorable current performance, as market participants rush to trade on new information.

Versions of the EMH

- Weak (Past trading data)
- Semi-strong (All public info)
- Strong (All info)

Cumulative Abnormal Returns Before Takeover Attempts: Target Companies



How Tests Are Structured

- Returns are adjusted to determine if they are abnormal
  - Market model approach:

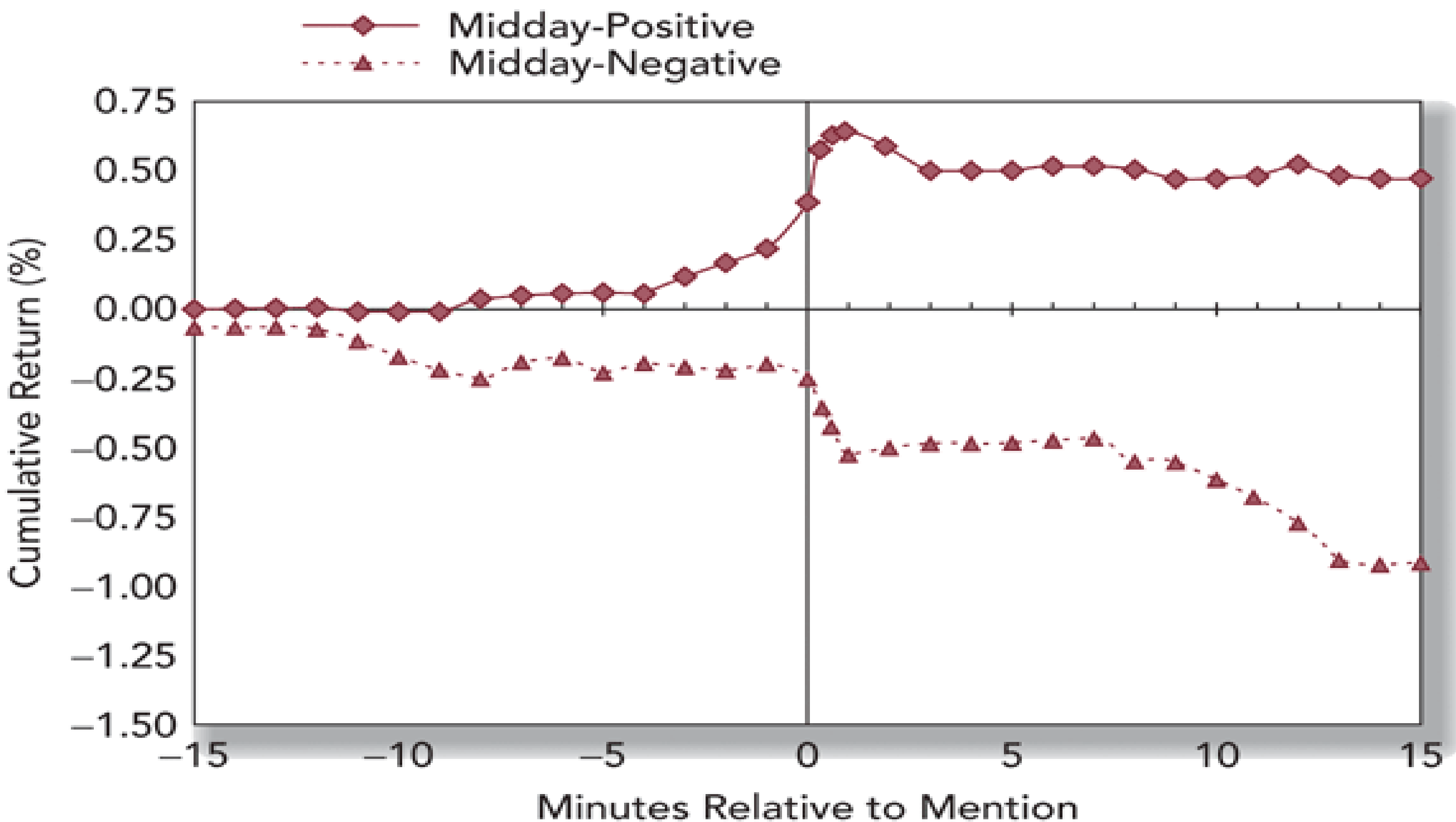
a. Expected Return:

$$r_t = \alpha + \beta r_{Mt} + e_t$$

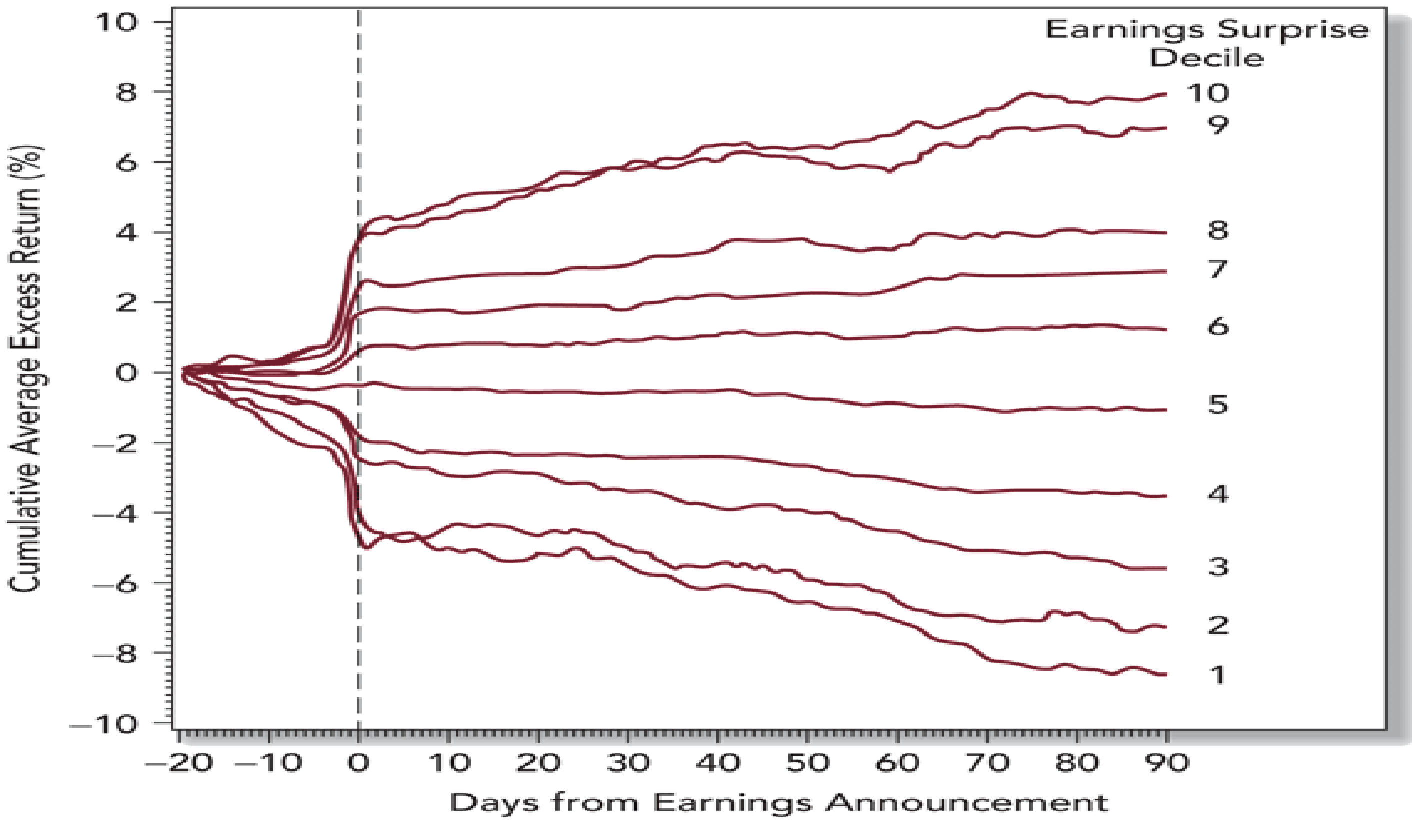
b. Abnormal Return:

$$e_t = r_t - (\alpha + \beta r_{Mt})$$

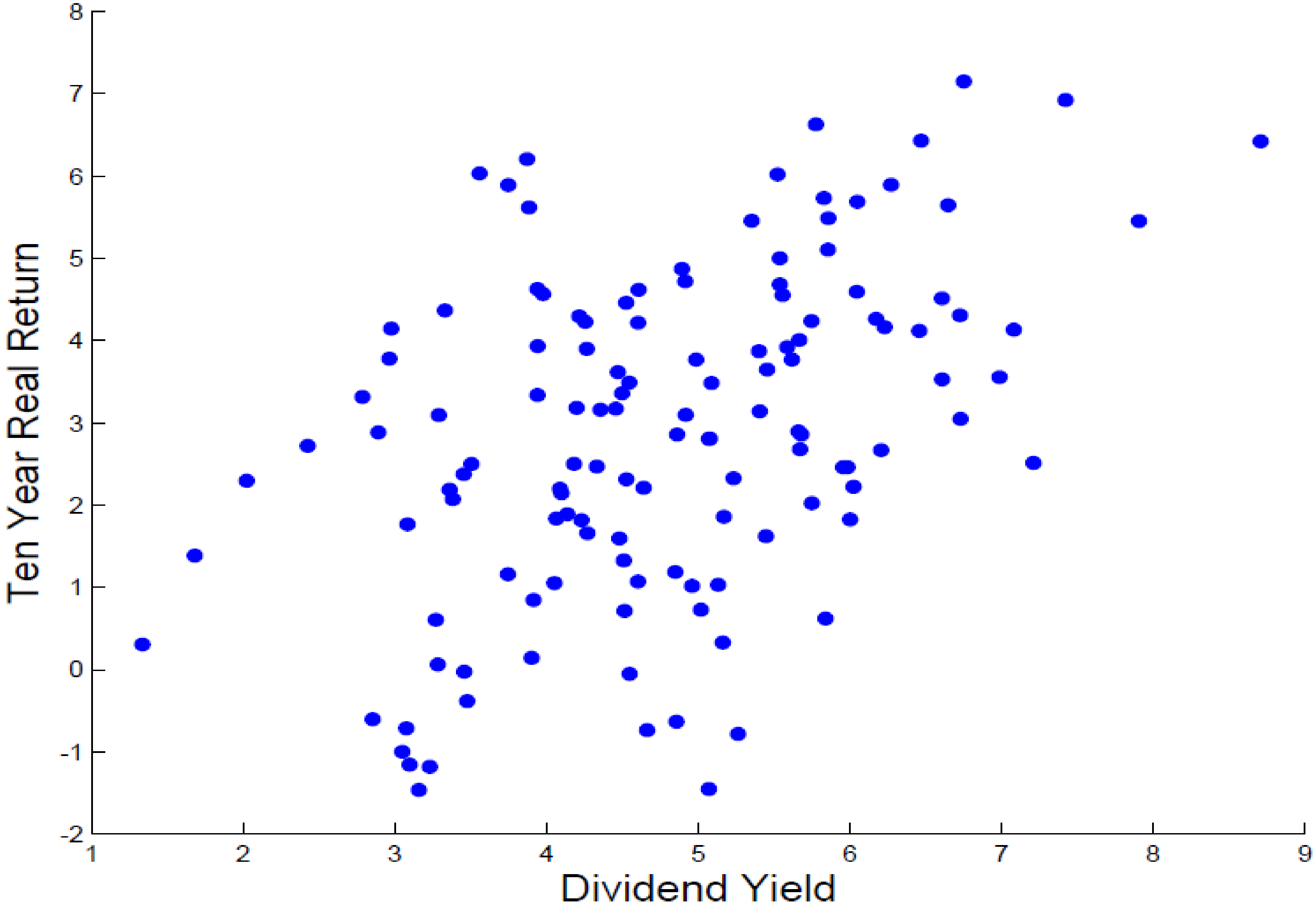
Stock Price Reaction to CNBC Reports



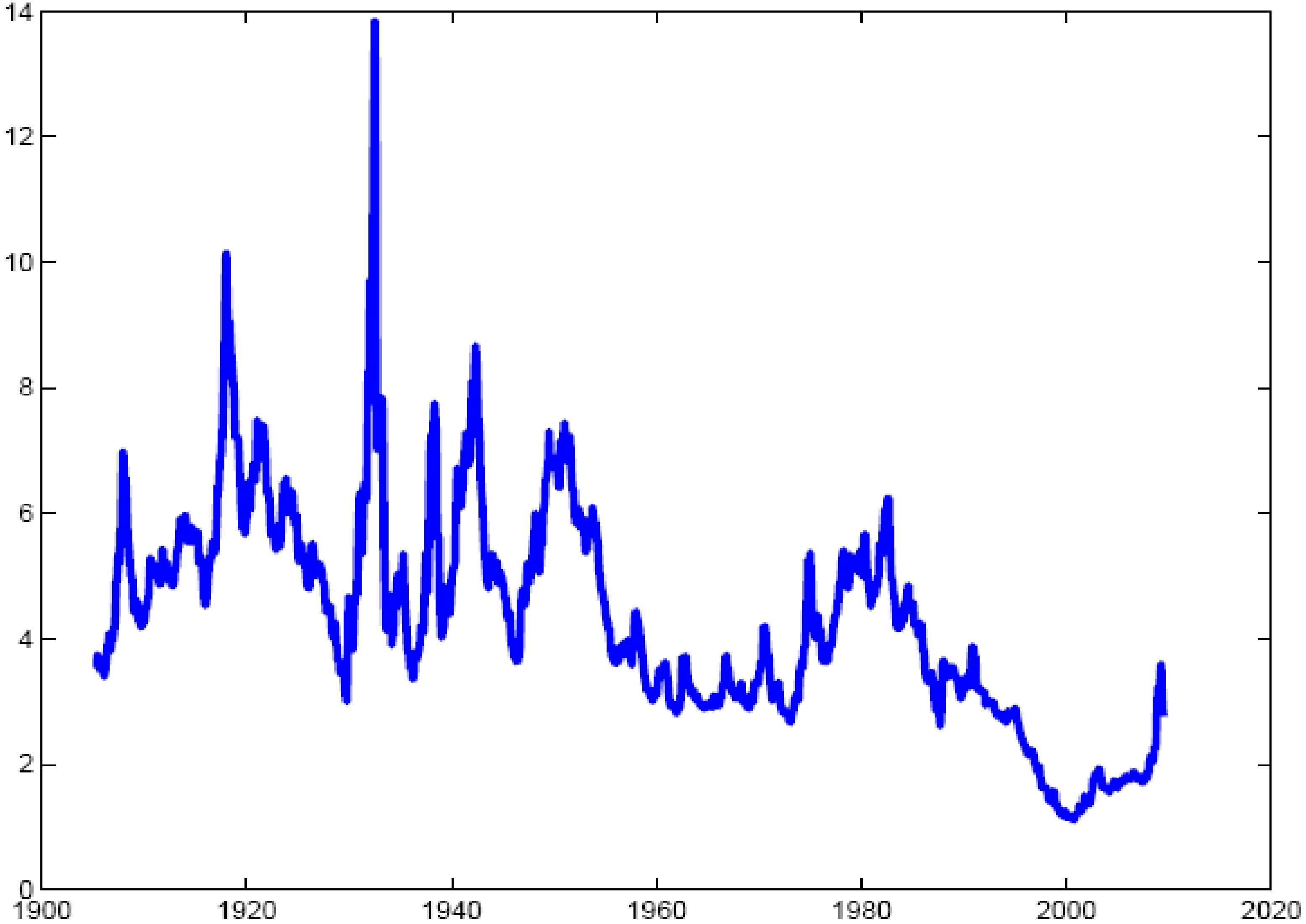
Cumulative Abnormal Returns in Response to Earnings Announcements



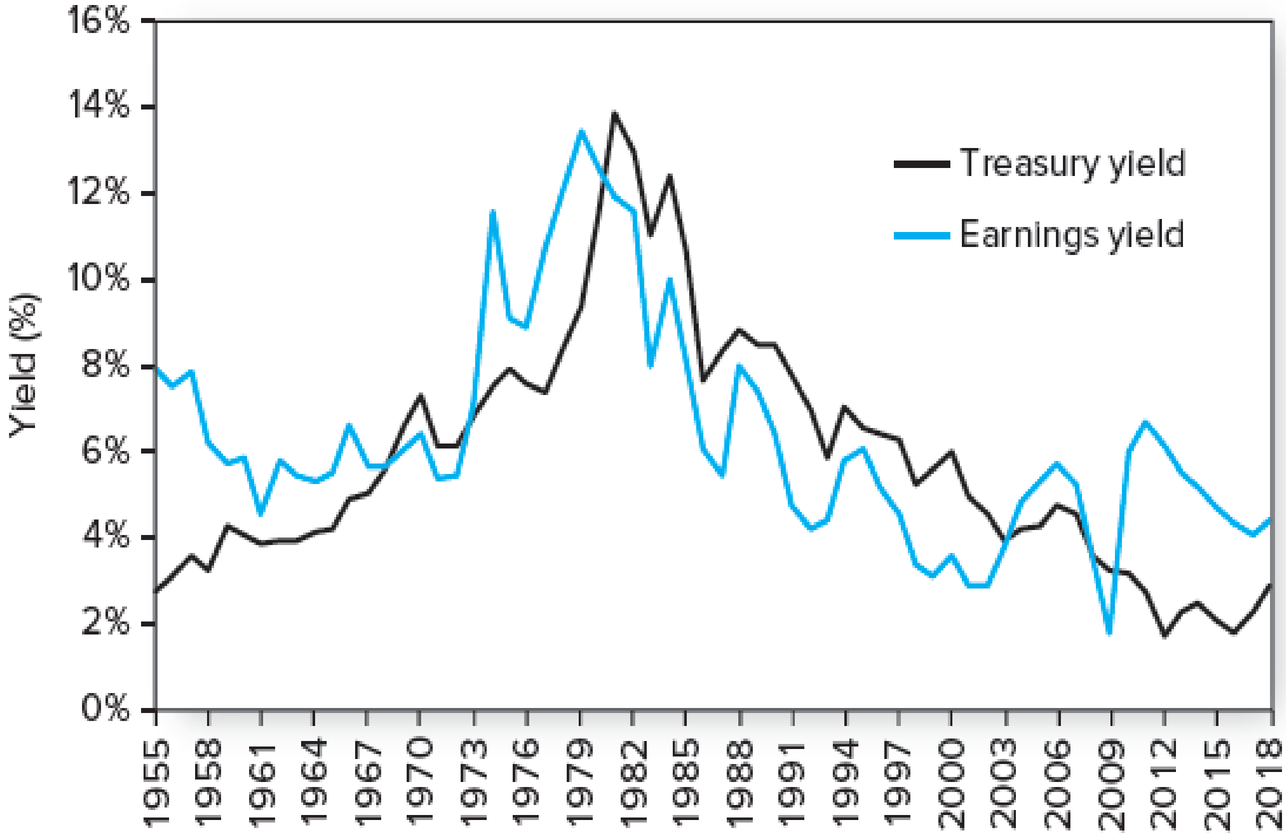
Dividend yield and stock returns



Dividend yields since 1900



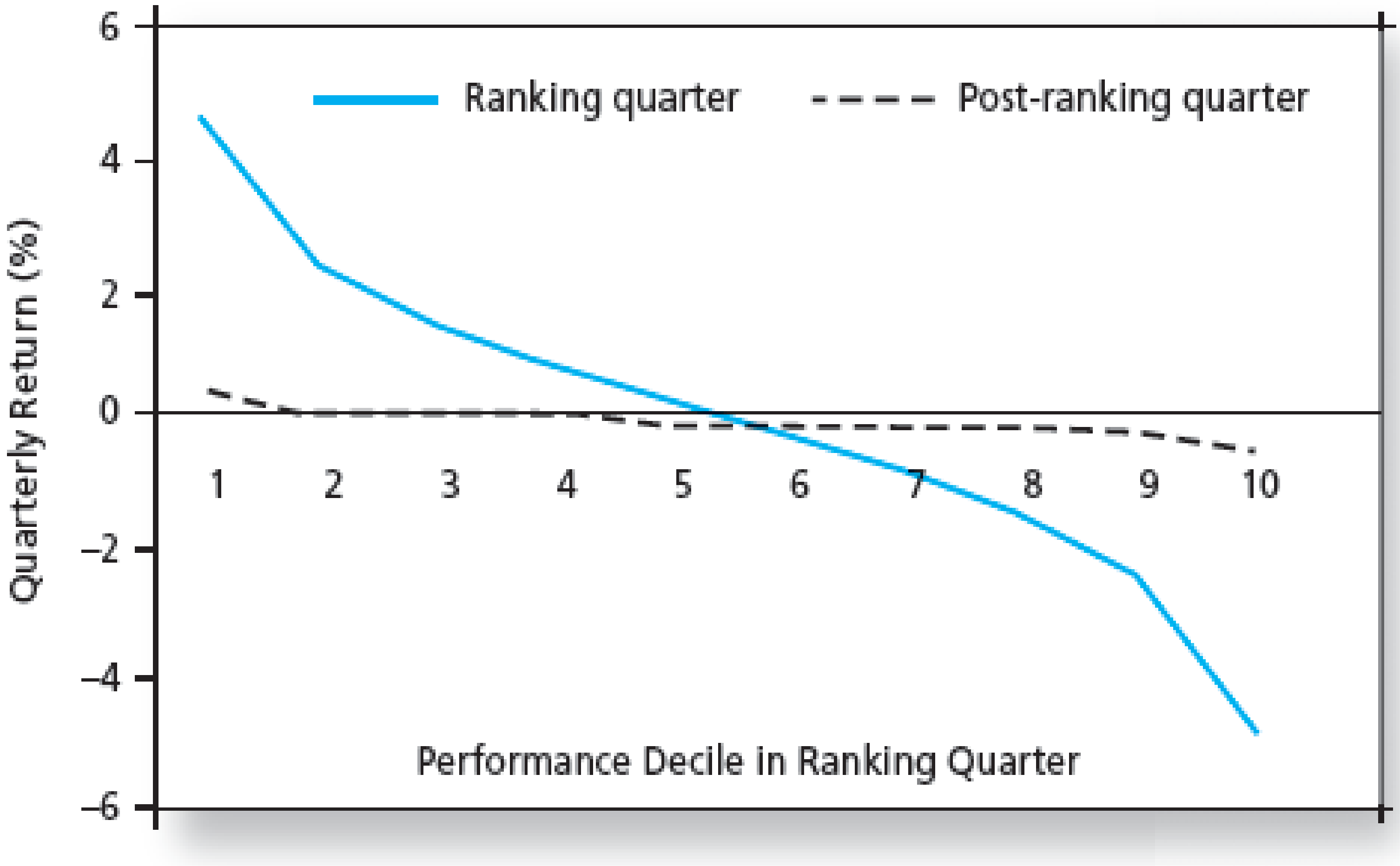
Earnings yield and Treasury yield



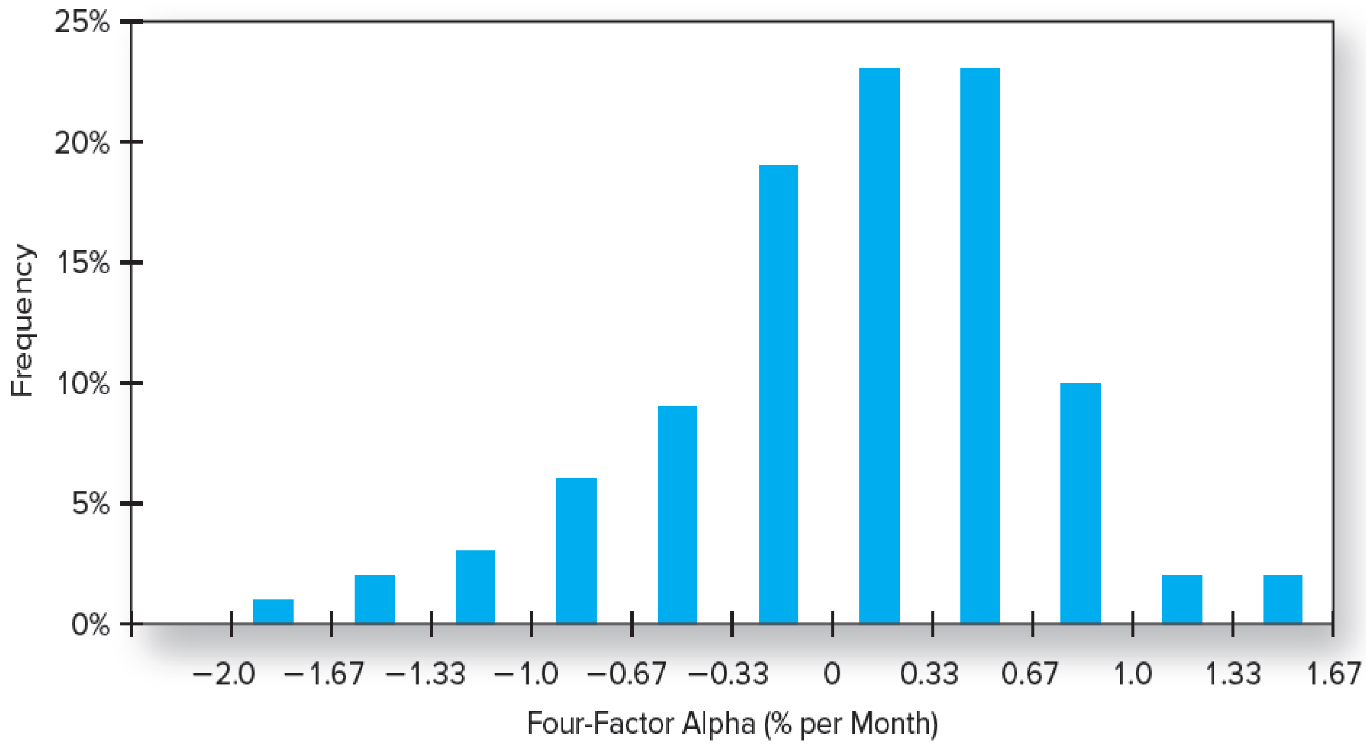
Mutual Fund Performance

- Some evidence of persistent positive and negative performance (“hot hands”)
- Mutual fund fees

Mutual funds in ranking & post ranking quarter



Estimates of Individual Mutual Fund Alphas



Hedge Funds

- Non-traditional mutual fund with 4 key characteristics
  - Attempts to earn returns in rising or falling markets
  - Subject to lighter regulation than mutual funds
  - Not open to the general public
  - Charges higher fees (“2 and 20” is typical)

Hedge Funds vs. Mutual Funds

Hedge Fund

- Transparency: Limited Liability Partnerships that provide only minimal disclosure of strategy and portfolio composition
- No more than 100 “sophisticated”, wealthy investors

Mutual Fund

- Transparency: Regulations require public disclosure of strategy and portfolio composition
- Number of investors is not limited

Hedge Funds vs. Mutual Funds

Hedge Fund

- Investment strategy: Very flexible, funds can act opportunistically and make a wide range of investments
- Often use shorting, leverage, options
- Liquidity: Often have lock-up periods, require advance redemption notices

Mutual Fund

- Investment strategy: Predictable, stable strategies, stated in prospectus
- Limited use of shorting, leverage, options
- Liquidity: Can often move more easily into and out of a mutual fund

Hedge Funds vs. Mutual Funds

Hedge Fund

- Compensation structure: Typically charge a management fee of 1-2% of assets and an incentive fee of 20% of profits

Mutual Fund

- Compensation structure: Fees are usually a fixed percentage of assets, typically 0.5% to 1.5%

Hedge Fund Strategies

- Directional
- Non-directional
  - Exploit temporary misalignments in relative valuation across sectors
  - Buy one type of security and sell another
  - Strives to be market neutral

Statistical Arbitrage

- Uses quantitative systems that seek out many temporary and modest misalignments in prices
- Involves trading in hundreds of securities a day with short holding periods
- Pairs trading: Pair up similar companies whose returns are highly correlated but where one is priced more aggressively

Weak or Semistrong Tests: Anomalies

- Momentum
- Long-term reversals
- Size and book-to-market effects
- January effect
- Post-Earnings Announcement Price Drift
- Persistence in mutual fund performance
- Relations between dividend yields & future returns

Are Markets Efficient?

- Magnitude Issue
  - Difficulty in detecting a small gain in performance
- Selection Bias Issue
  - Results of tests of market efficiency are only reported if there is evidence against efficiency
- Lucky Event Issue
  - Some method will appear to work well ex post by chance alone

Equity Premium Puzzle

- The average equity premium is about 7%
- The volatility (standard deviation) is about 16%
- Why?
  - Investors very risk averse
  - Irrational fear of stocks
  - The history in the U.S. in the last 100 years was a "fluke"
  - Survivor bias

Behavioral Finance

- Investors Do Not Always Process Information Correctly
- Investors Often Make Inconsistent or Systematically Suboptimal Decisions
- Asset Price Bubbles

Information Processing Critique

- Forecasting Errors
  - Too much weight on recent experience
  - Example: Malmendier and Nagel (2011) find that stock market participation depends on returns experienced in an investor’s lifetime.
- Overconfidence
  - 98% confidence intervals include actual outcome 60% of the time (Alpert and Raiffa (1982))

Behavioral Biases

- Prospect Theory
  - Kahneman and Tversky
  - Value function …. Loss aversion
  - Weighting function
- Ambiguity Aversion

Loss aversion

- People are more motivated by avoiding a loss than acquiring a similar gain.
  - Once I own something, not having it becomes more painful, because it is a loss.
  - If I don’t yet own it, then acquiring it is less important, because it is a gain.

Loss Aversion

- Coval and Shumway (2005) investigate morning and afternoon trades of 426 traders of CBOT
  - Assume significantly more risk in the afternoon trading following morning losses than gains

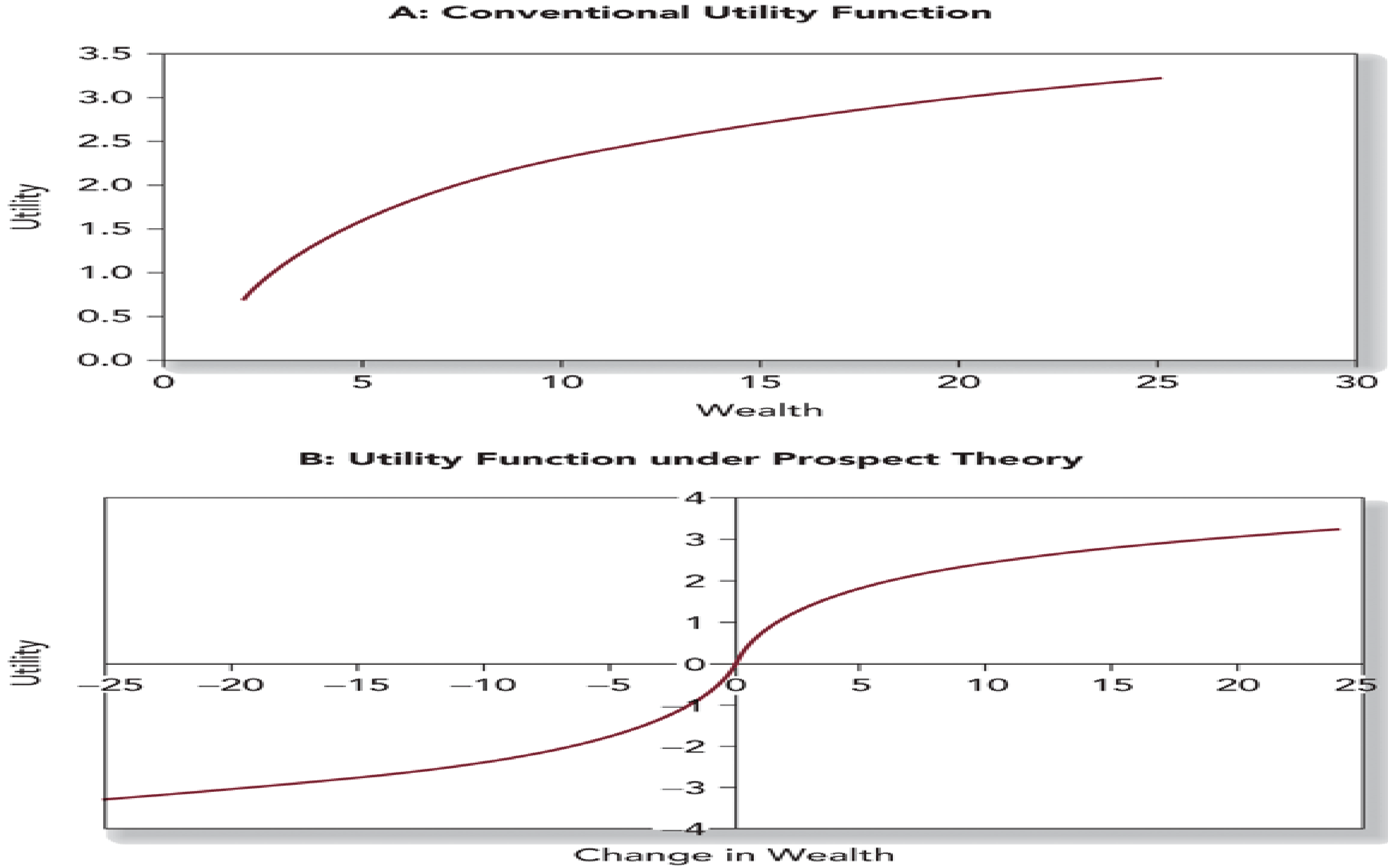
Loss Aversion

- The *disposition effect* — the tendency among investors to sell stock market winners too soon and hold on to losers too long may be explained by loss aversion.

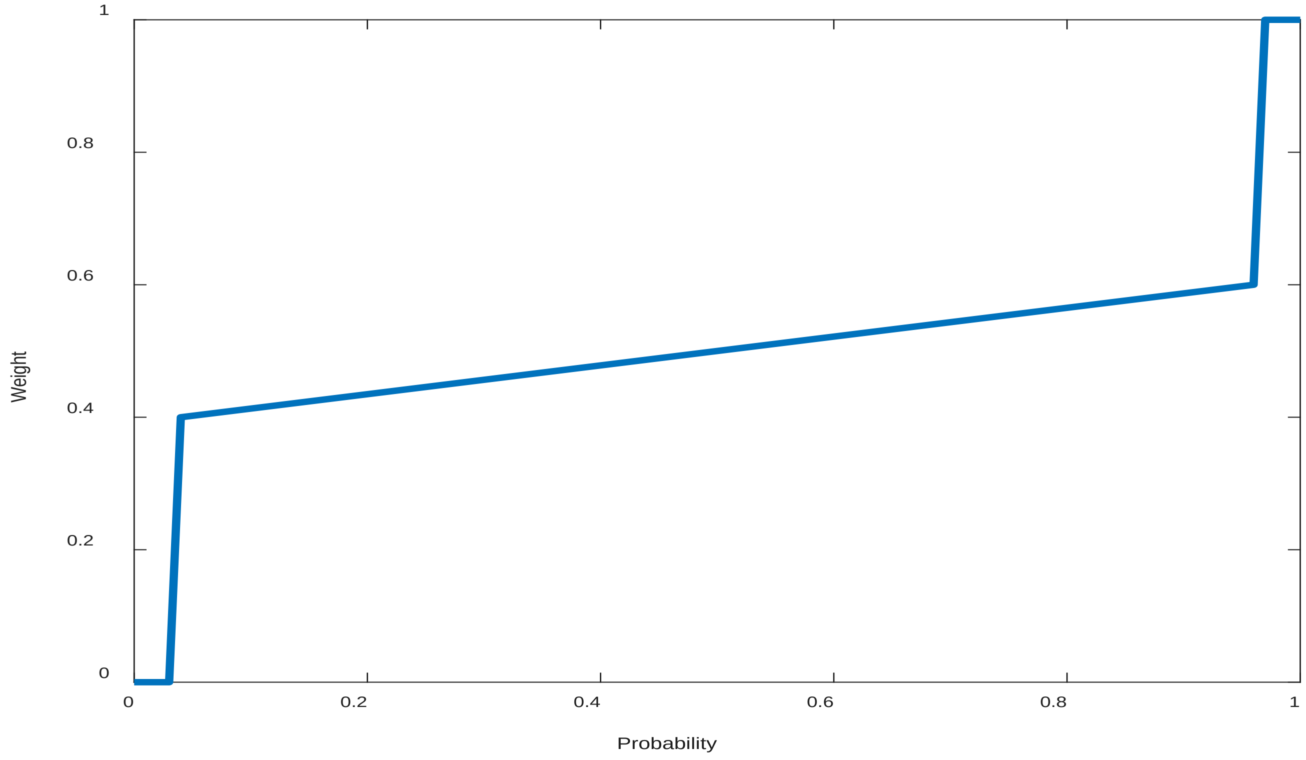
Loss Aversion

- Kahneman and Tversky considered the following choices:
  - A: Gain $24,000
  - B: Gain $100,000 wp 0.25 and nothing otherwise
  - C: Lose $76,000
  - D: Lose $100,000 wp 0.75 and nothing otherwise
- Most people choose A over B, but choose D over C
- Risk-averse about gains but risk-seeking over losses

Prospect Theory: Value Function



Prospect Theory: Weighting Function



Ambiguity Aversion

- You are to draw a ball at random from a bag containing 100 balls. You win a prize if the ball drawn is red. One bag contains 50/50 blue/red balls. The distribution of balls in the other bag is unknown. Which bag would you prefer to draw the ball from?

Anchoring

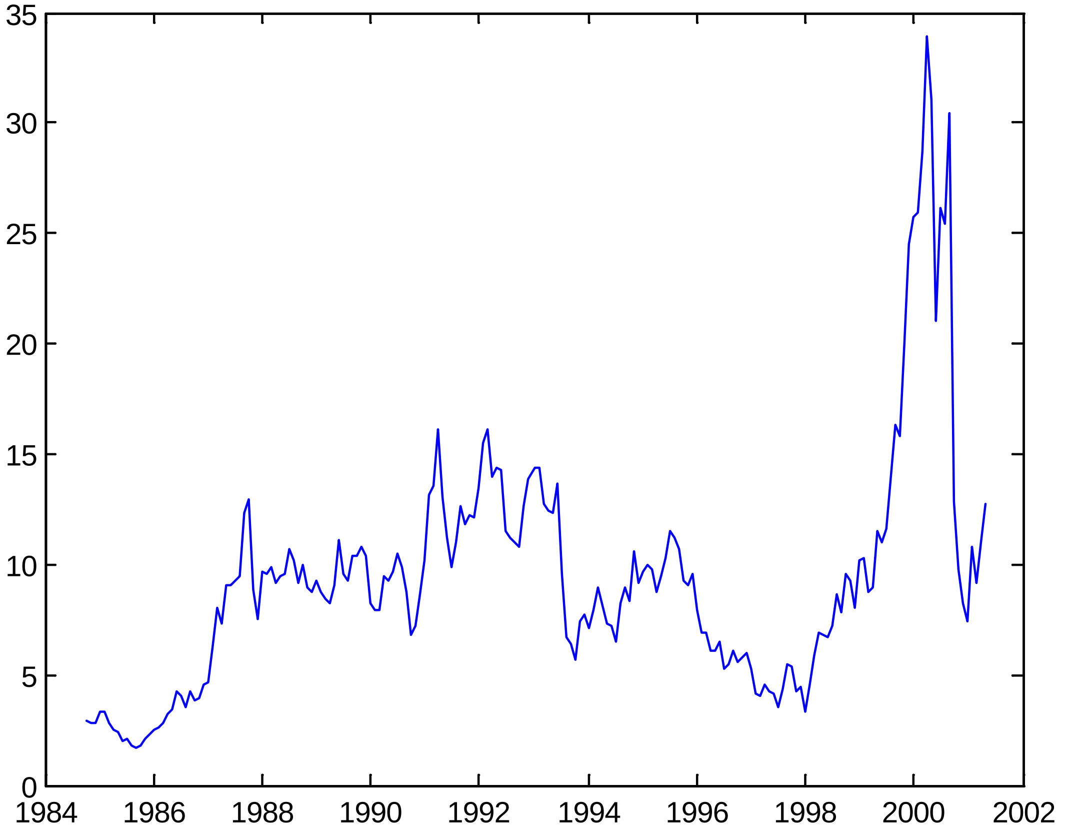
- Anchoring is a behavioral bias
- Experiment: Spin a wheel that has numbers from 1-100
- Then ask respondents a question with an answer from 1-100
- The answer people give will be related to the number that was shown on the wheel
- Investors will look for patterns in asset prices and expect them to repeat themselves

Asset Price Bubbles

- A bubble is an increase in asset prices justified by future price appreciation alone.

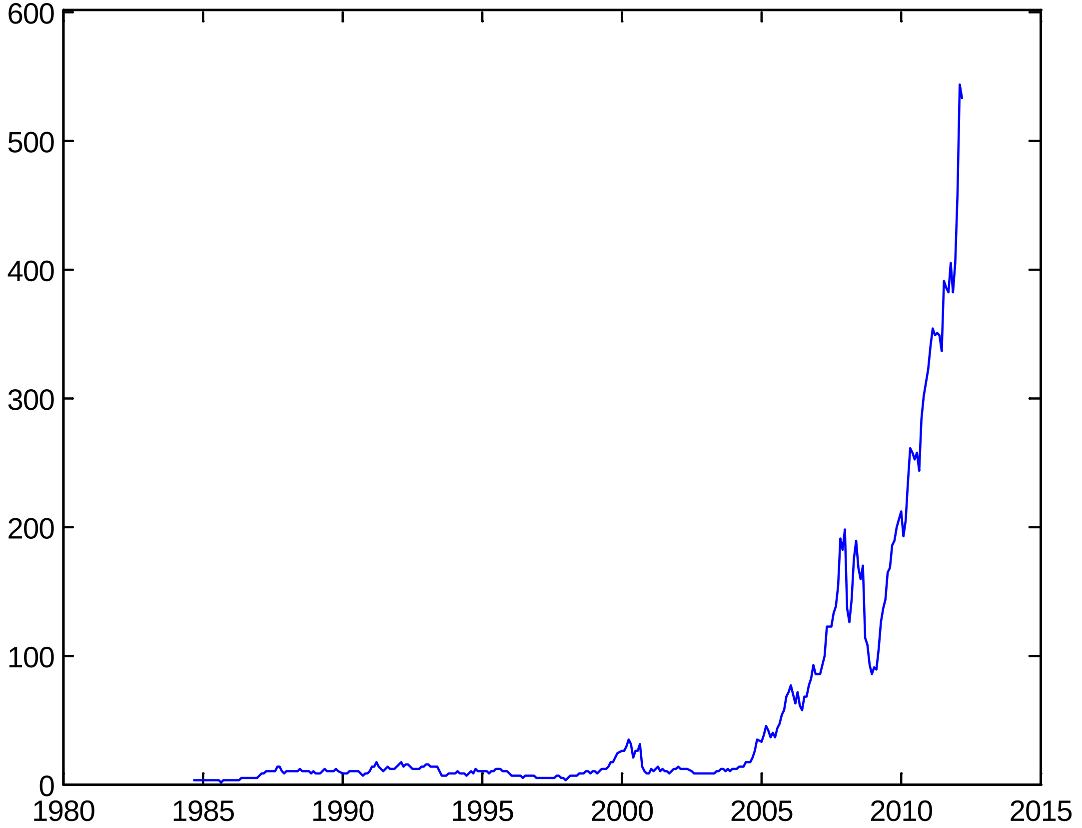
- Bubbles exist in tulip bulbs, stocks, houses etc.

A bubble



35
30
25
20
15
10
5
0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002

Or not


600
500
400
300
200
100
0
1980
1985
1990
1995
2000
2005
2010
2015

Bubbles in experimental economics

- Vernon Smith did experiments studying asset bubbles
- Considered assets which pay $1 in each of 12 rounds
- Had subjects trading these assets
- Generated bubbles, even with options traders as subjects

Origin of bubbles

- Bubbles can come about from learning based on just the recent past
- Can cause a “leverage cycle”
- Genuinely good idea comes along
- Investors see good returns and no volatility and pile in expecting this to continue
- Leads to a bubble
- Hyman Minsky was an economist with more following on Wall Street than in academia who worked on idea

Ideas of leverage cycle

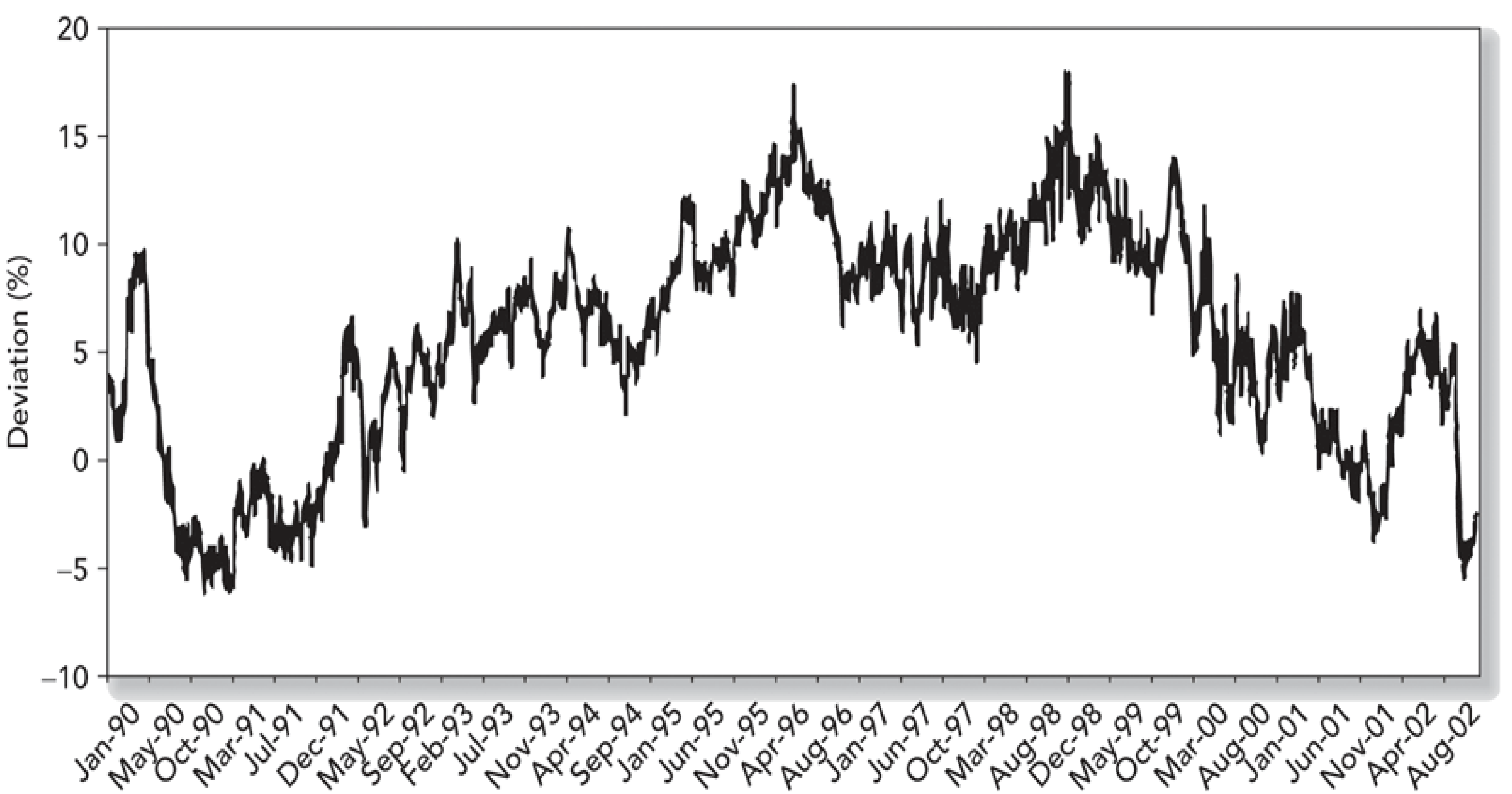
Limits to Arbitrage

- Fundamental Risk
  - Things may get worse before they get better
- Implementation Costs
  - Costly to implement strategy
- Model Risk
  - Maybe it wasn't really an arbitrage

Limits to Arbitrage

- Siamese Twin Companies
- Equity Carve-outs
- Closed-End Funds
- Index Inclusions

Pricing of Royal Dutch Relative to Shell (Deviation from Parity)



3Com and Palm

- In March 2000 3Com announced that at the end of the year it would give their shareholders 1.5 shares in Palm for each 3Com share they owned.

- Afterwards:
  - Price of Palm: $95.06
  - Price of 3 Com: $81.11
  - Value of “Non-Palm” 3 Com: -$61

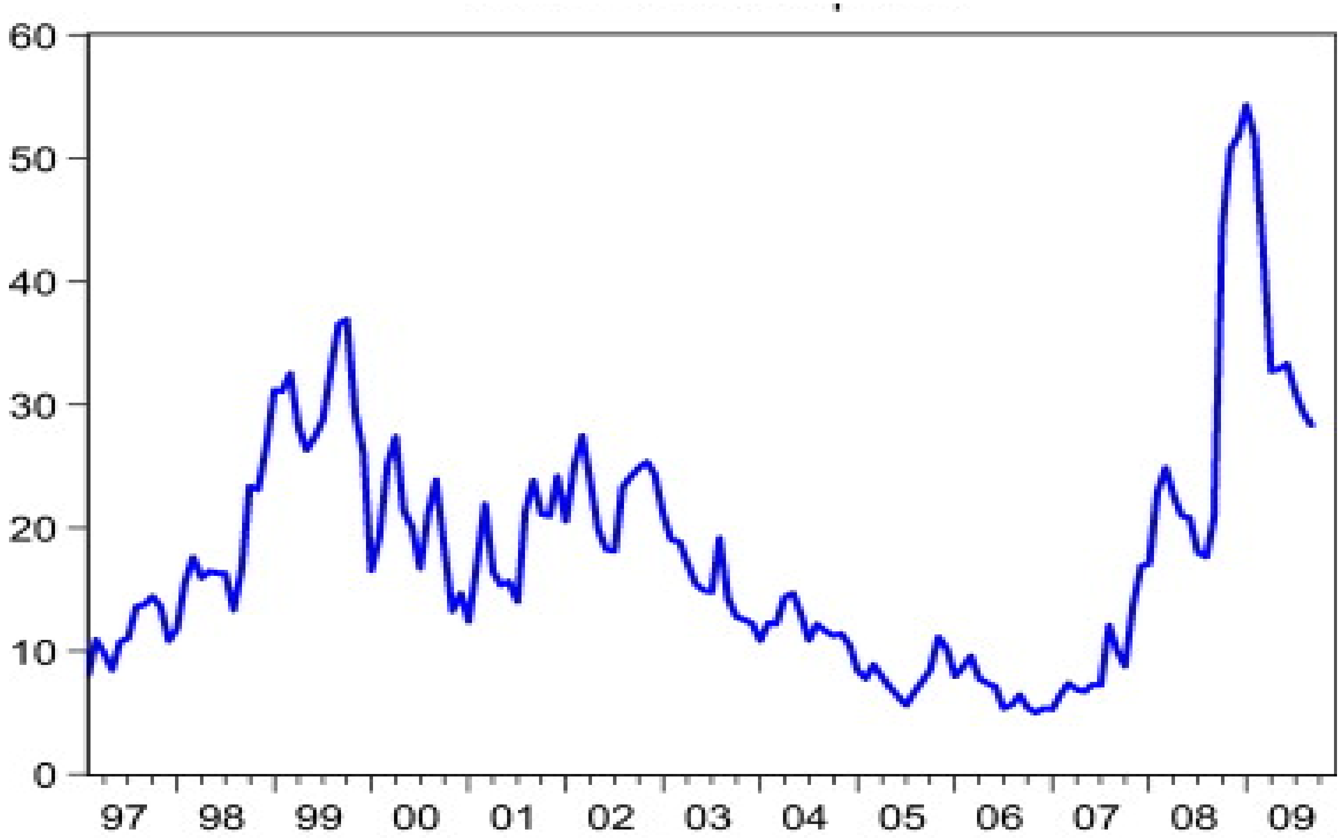
Closed-End Funds

- Closed End Funds buy assets, but shareholder cannot redeem the underlying stocks
- Could trade at a discount (or premium)
- Can trace in Bloomberg

Index Inclusions

- When a stock is added to the S&P 500 it jumps 3.5% on average
- But there are bound to be close substitutes
- Not a perfect arbitrage

On-the-run/Off-the-run spread



Dividend Discount Model and Required Return

- CAPM gave us required return:

$$k = r_f + \beta \left[E(r_M) - r_f \right]$$

- If the stock is priced correctly

$$E\left(\frac{P_1 + D_1 - P_0}{P_0}\right) = k \Rightarrow P_0 = \frac{E(P_1) + D_1}{1 + k}$$

Specified Holding Period

$$P_0 = \frac{D_1}{(1+k)} + \frac{D_2}{(1+k)^2} .... + \frac{D_H + E(P_H)}{(1+k)^H}$$

Dividend Discount Models: General Model

$$P_o = \sum_{t=1}^{\infty} \frac{D_t}{(1+k)^t}$$

D_t = Dividend

k = required return

No Growth Model

$$P_o = \frac{D}{k}$$

- Stocks that have earnings and dividends that are expected to remain constant
- Preferred stock (assuming divs get paid)
  - Do not share in the earnings or earnings growth
  - Do not have the security of bonds
  - Higher yield than bonds
  - TARP investments in banks are in preferred stock

No Growth Model: Example

$$P_o = \frac{D}{k}$$

$D_1 = \$5.00$

$k = .15$

$P_0 = \$5.00\,/.15 = \$33.33$

Estimating Dividend Growth Rates

$$g = ROE \times b$$

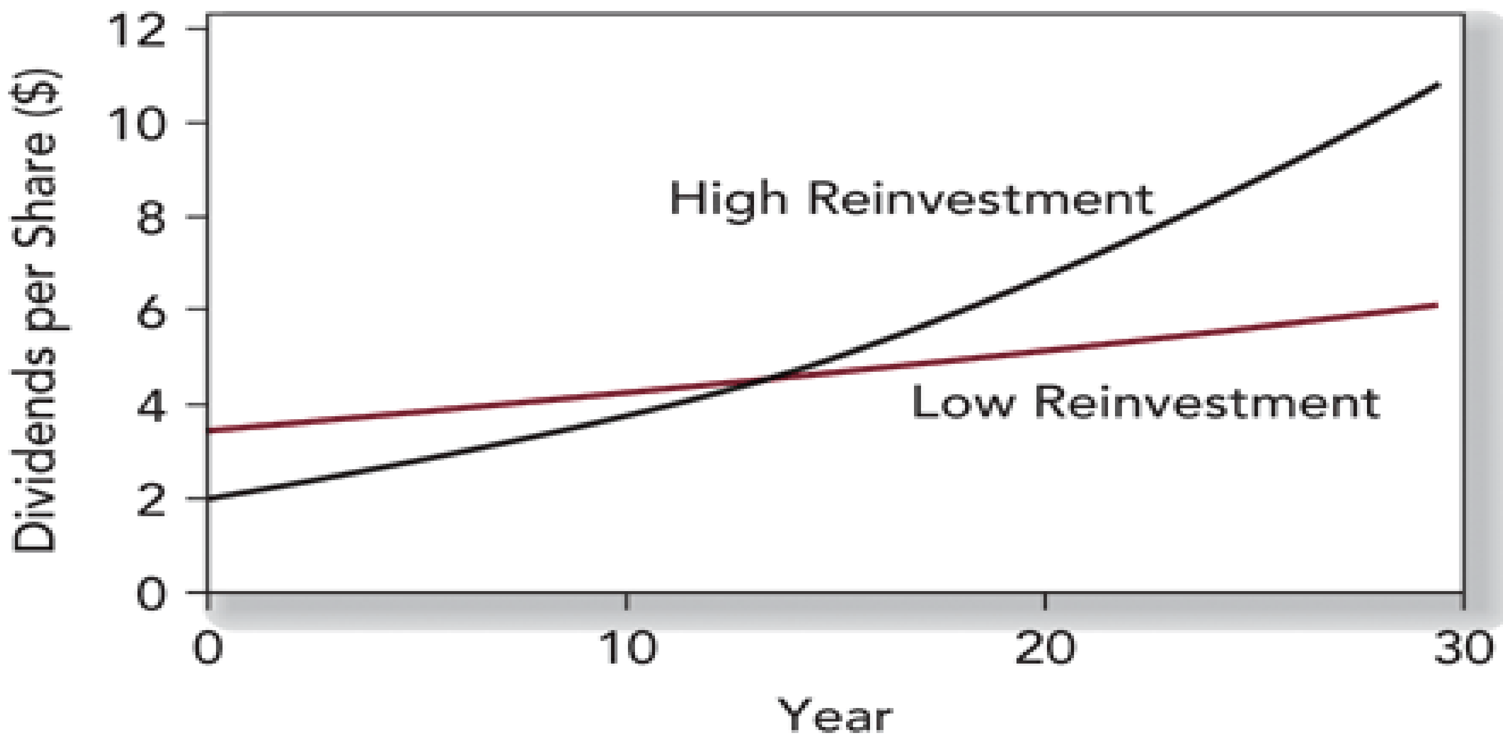
g = growth rate in dividends

ROE = Return on Equity for the firm

b = plowback or retention percentage rate

(1- dividend payout percentage rate)

Dividend Growth for Two Earnings Reinvestment Policies



Constant Growth Model

$$P_o = \frac{D_0(1+g)}{1+k} + \frac{D_0(1+g)^2}{(1+k)^2} = D_0 * \frac{1}{1-\frac{1+g}{1+k}} - D_0$$

$$= D_0 * \frac{1+k}{k-g} - D_0 = D_0 \frac{1+g}{k-g} = \frac{D_1}{k-g}$$

g = constant perpetual growth rate

Constant Growth Model: Example

$$Po = \frac{D_o(1+g)}{k-g} = \frac{D_1}{k-g}$$

E_1 = \$5.00 b = 40% k = 15%

$(1-b)$ = 60% D_1 = \$3.00 g = 8%

P_0 = 3.00 / (.15 - .08) = \$42.86

Bond Characteristics

- Face or par value
- Coupon rate
  - Zero coupon bond

Different Issuers of Bonds

- U.S. Treasury
  - Notes and Bonds
- Corporations
- Municipalities
- International Governments and Corporations
- Innovative Bonds
  - Floaters and Inverse Floaters
  - Asset-Backed
  - Indexe-Linked Bonds
  - Catastrophe Bonds

Listing of Treasury Issues

U.S. Government Bonds and Notes

Representative Over-the-Counter quotation based on transactions of $1 million or more.

Treasury bond, note and bill quotes are from midafternoon. Colons in bond and note bid-and-asked quotes represent 32nds; 101:01 means 101 1/32. Net change in 32nds. n-Treasury Note. i-inflation-indexed issue. Treasury bill quotes in hundredths, quoted in terms of a rate of discount. Days to maturity calculated from settlement date. All yields are to maturity and based on the asked quote. For bonds callable prior to maturity, yields are computed to the earliest call date for issues quoted above par and to the maturity date for issues quoted below par.

*-When issued. Daily change expressed in basis points.

RATE	MATURITY MO/YR	BID	ASKED	CHG	ASK YLD
3.125	Jan 07n	99:29	99:30	....	4.83
2.250	Feb 07n	99:24	99:25	....	4.88
6.250	Feb 07n	100:02	100:03	....	4.88
3.375	Feb 07n	99:25	99:26	....	4.97
3.750	Mar 07n	99:23	99:24	+1	4.97
3.625	Apr 07n	99:18	99:19	....	4.99
5.750	Aug 10n	103:09	103:10	+2	4.73
4.125	Aug 10n	98:00	98:01	+3	4.73
3.875	Sep 10n	97:03	97:04	+3	4.73
4.250	Oct 10n	98:10	98:11	+3	4.73
4.500	Nov 10n	99:05	99:06	+3	4.73
4.375	Dec 10n	98:22	98:23	+3	4.74
4.250	Jan 11n	98:07	98:08	+3	4.74
3.500	Jan 11i	103:26	103:27	+3	2.48
5.000	Feb 11n	101:03	101:04	+3	4.69
4.500	Feb 11n	99:04	99:05	+3	4.73
4.750	Mar 11n	100:01	100:02	+3	4.73
2.375	Apr 11i	99:11	99:12	+2	2.53
4.875	Apr 11n	100:16	100:17	+3	4.73
4.875	May 11n	100:17	100:18	+3	4.73
5.125	Jun 11n	101:17	101:18	+4	4.73
4.875	Jul 11n	100:18	100:19	+4	4.73
4.625	Dec 11n	99:15	99:16	+4	4.74
3.375	Jan 12i	104:01	104:02	+3	2.50
4.875	Feb 12n	100:24	100:25	+4	4.70
3.000	Jul 12i	102:17	102:18	+2	2.49
4.375	Aug 12n	98:13	98:14	+4	4.69
4.000	Nov 12n	96:13	96:14	+4	4.71
10.375	Nov 12	104:11	104:12	+2	4.87
3.375	Feb 13n	95:17	95:18	+4	4.72
3.625	May 13n	94:02	94:03	+5	4.71
1.375	Jul 13i	96:09	96:10	+4	2.49
4.250	Aug 13n	97:10	97:11	+6	4.72
5.250	Nov 28	104:12	104:13	+8	4.92
5.250	Feb 29	104:14	104:15	+9	4.92
3.875	Apr 29i	124:17	124:18	+16	2.44
6.125	Aug 29	116:12	116:13	+9	4.91
6.250	May 30	118:19	118:20	+10	4.90
5.375	Feb 31	106:20	106:21	+8	4.90
3.375	Apr 32i	119:09	119:10	+16	2.35
4.500	Feb 36	94:19	94:20	+9	4.84

Treasury Bills

MATURITY	DAYS TO MAT	BID	ASKED	CHG	ASK YLD
Mar 22 07	64	4.96	4.95	+0.02	5.06
Mar 29 07	71	4.96	4.95	+0.01	5.07
Apr 05 07	78	4.96	4.95	+0.01	5.07
Apr 12 07	85	4.96	4.95	....	5.08
Apr 19 07	92	4.98	4.97	+0.02	5.10
Apr 26 07	99	4.96	4.95	....	5.09
May 03 07	106	4.96	4.95	+0.01	5.09
May 10 07	113	4.96	4.95	....	5.10
May 17 07	120	4.97	4.96	+0.01	5.11
May 24 07	127	4.97	4.96	+0.01	5.12
May 31 07	134	4.95	4.94	+0.01	5.10
Jun 07 07	141	4.94	4.93	+0.01	5.10
Jun 14 07	148	4.94	4.93	....	5.10
Jun 21 07	155	4.94	4.93	....	5.11
Jun 28 07	162	4.94	4.93	....	5.11
Jul 05 07	169	4.95	4.94	....	5.13
Jul 12 07	176	4.95	4.94	....	5.13

Listing of Corporate Bonds

ISSUER NAME	SYMBOL	COUPON	MATURITY	RATING MOODY'S/S&P/ FITCH	HIGH	LOW	LAST	CHANGE	YIELD %
Gatx	GMT.IK	8.875%	Jun 2009	Baa1/BBB/BBB–	107.545	107.538	107.545	–0.100	5.433
Marshall & Ilsley	MI.YL	3.800%	Feb 2008	Aa3/A+/A+	98.514	98.470	98.514	0.064	5.263
Capital One	COF.HK	7.686%	Aug 2036	Baa2/BBB–/BBB–	113.895	113.390	113.733	0.257	6.621
Entergy Gulf States	ETR.KC	6.180%	Mar 2035	Baa3/BBB+/BBB	99.950	94.616	99.469	0.219	6.220
AOL Time Warner	AOL.HG	6.875%	May 2012	Baa2/BBB+/BBB	107.205	105.402	106.565	0.720	5.427
Household Intl	HI.HJG	8.875%	Feb 2008	Aa3/AA–/AA–	100.504	100.504	100.504	–0.109	5.348
SBC Comm	SBC.IF	5.875%	Feb 2012	A2/A/A	102.116	102.001	102.001	–0.156	5.415
American General Finance	AIG.GOU	5.750%	Sep 2016	A1/A+/A+	101.229	101.135	101.135	–0.530	5.595

Provisions of Bonds

- Secured or unsecured
- Call provision
- Convertible provision
- Floating rate bonds
- Preferred Stock

Preferred Stock

- Shares characteristics of equity & fixed income
  - Dividends are paid in perpetuity
  - Nonpayment of dividends does not mean bankruptcy
  - Preferred dividends are paid before common

Bond Pricing: Present value calculation

$$P_B = \sum_{t=1}^{T} \frac{C}{(1+r)^t} + \frac{ParValue}{(1+r)^T}$$

P_B = Price of the bond

C_t = interest or coupon payments

T = number of periods to maturity

r = semi-annual discount rate or the semi-annual yield to maturity

Price: 10-yr, 8% Coupon, Face = $1,000

$$P = \Sigma_{t=1}^{20} \frac{40}{1.03^t} + \frac{1000}{1.03^{20}}$$

$$P = \$1{,}148.77$$

C_t	= 40 (Semi Annual)
P	= 1000
T	= 20 periods
r	= 3% (Semi Annual)

Can also be calculated using the Excel PRICE function

Yield to Maturity

- Interest rate that makes the present value of the bond's payments equal to its price

Solve the bond formula for r

$$P_B = \sum_{t=1}^{T} \frac{C}{(1+r)^t} + \frac{ParValue}{(1+r)^T}$$

Yield to Maturity Example

$$950 = \sum_{t=1}^{20} \frac{35}{(1+r)^t} + \frac{1000}{(1+r)^{20}}$$

10 yr Maturity   Coupon Rate = 7%

Price = $950

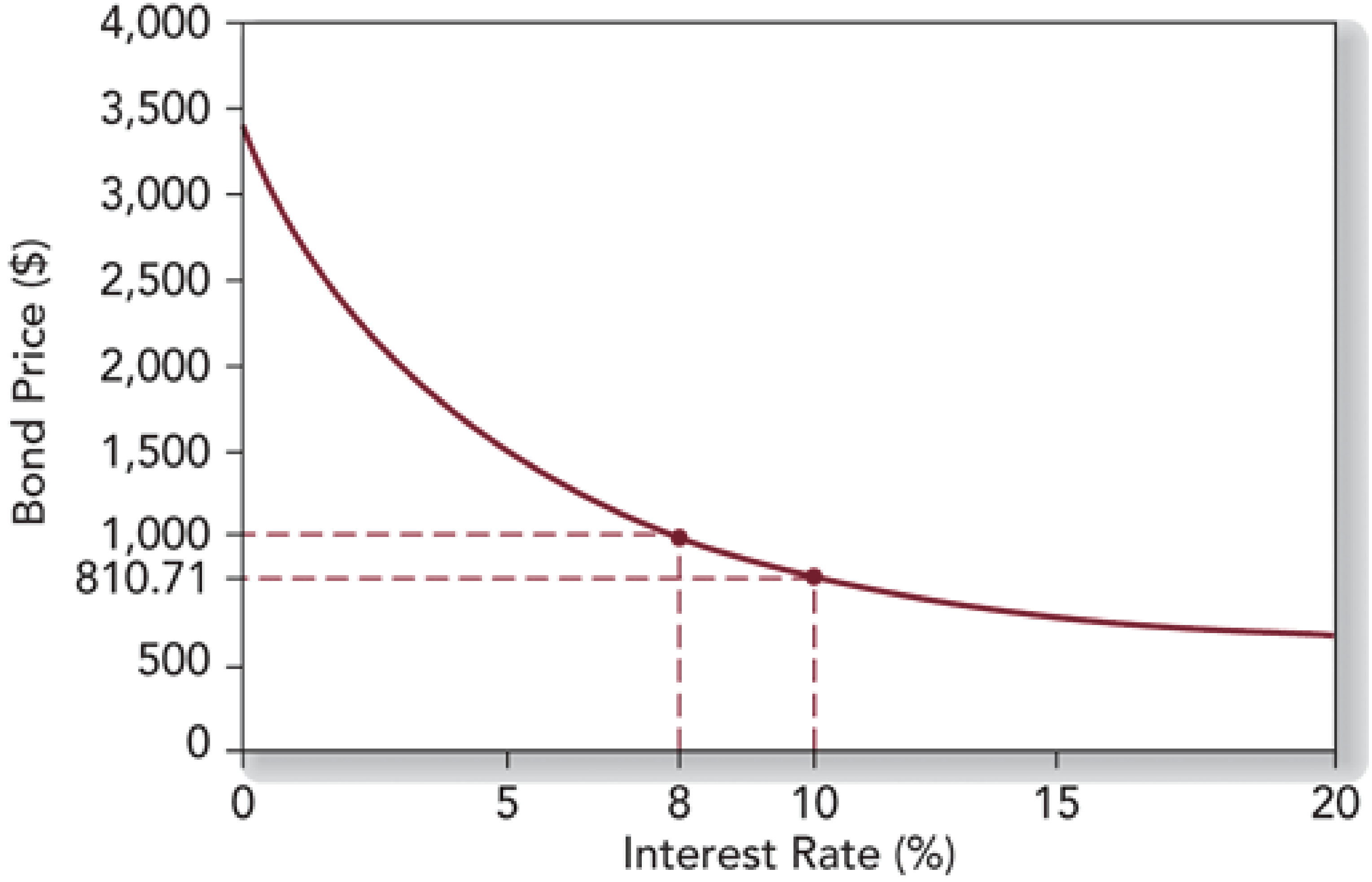
Solve for r = semiannual rate

***r* = 3.8635%**

Bond Prices and Yields

- Prices and Yields (required rates of return) have an inverse relationship
- When yields get very high the value of the bond will be very low
- When yields approach zero, the value of the bond approaches the sum of the cash flows

The Inverse Relationship Between Bond Prices and Yields



Bond Prices at Different Interest Rates (8% Coupon Bond)

Time to Maturity	4%	6%	8%	10%	12%
1 year	1038.83	1029.13	1000.00	981.41	963.33
10 years	1327.03	1148.77	1000.00	875.35	770.60
20 years	1547.11	1231.15	1000.00	828.41	699.07
30 years	1695.22	1276.76	1000.00	810.71	676.77

Yield Measures

Bond Equivalent Yield

7.72% = 3.86% x 2

Effective Annual Yield

$(1.0386)^2 - 1 = 7.88\%$

Current Yield

Annual Interest / Market Price

$70 / $950 = 7.37 %

Accrued Interest

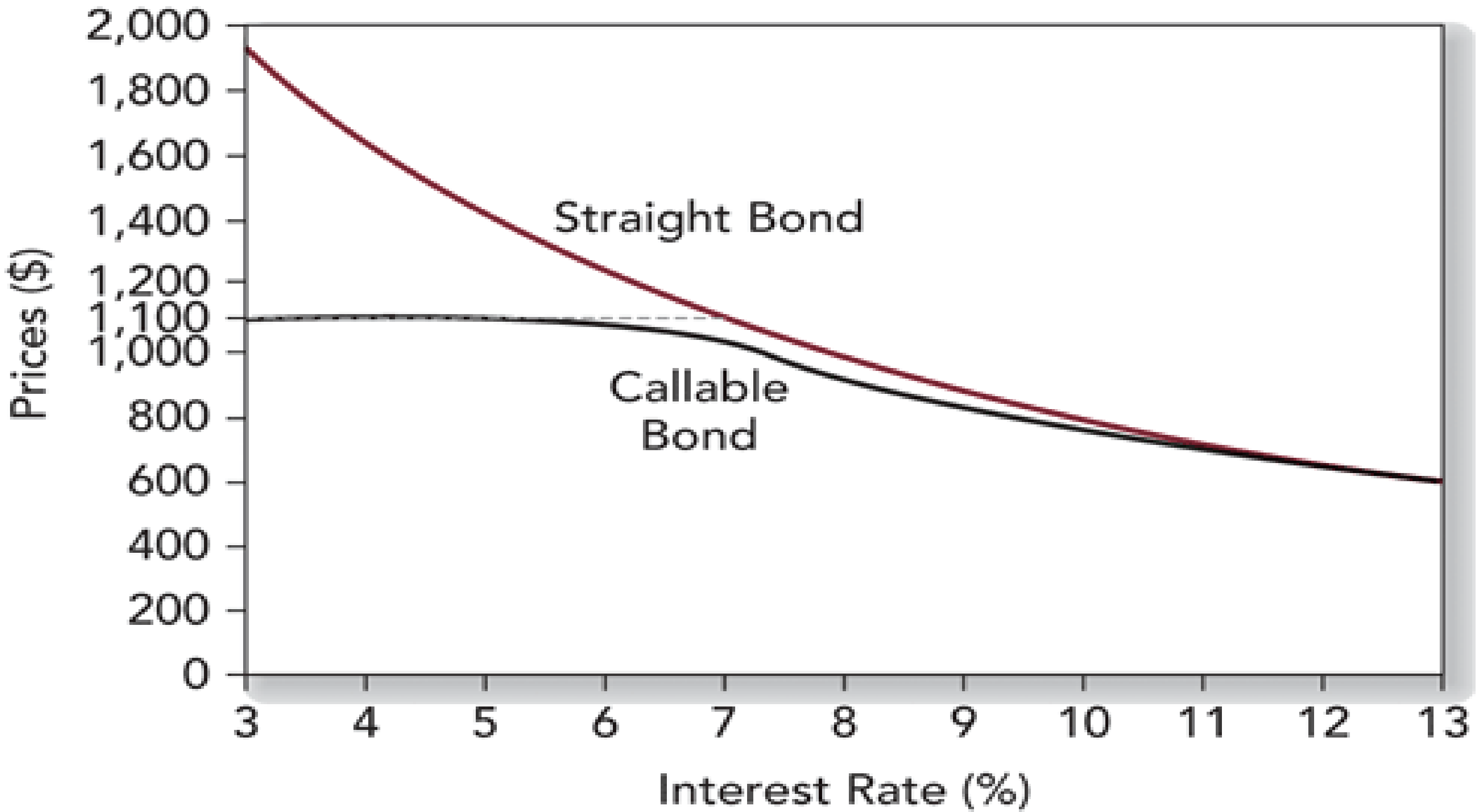
- Buyer of bond pays accrued interest

$$\frac{\text{Days since last coupon}}{\text{Days between coupons}} * \text{Coupon}$$

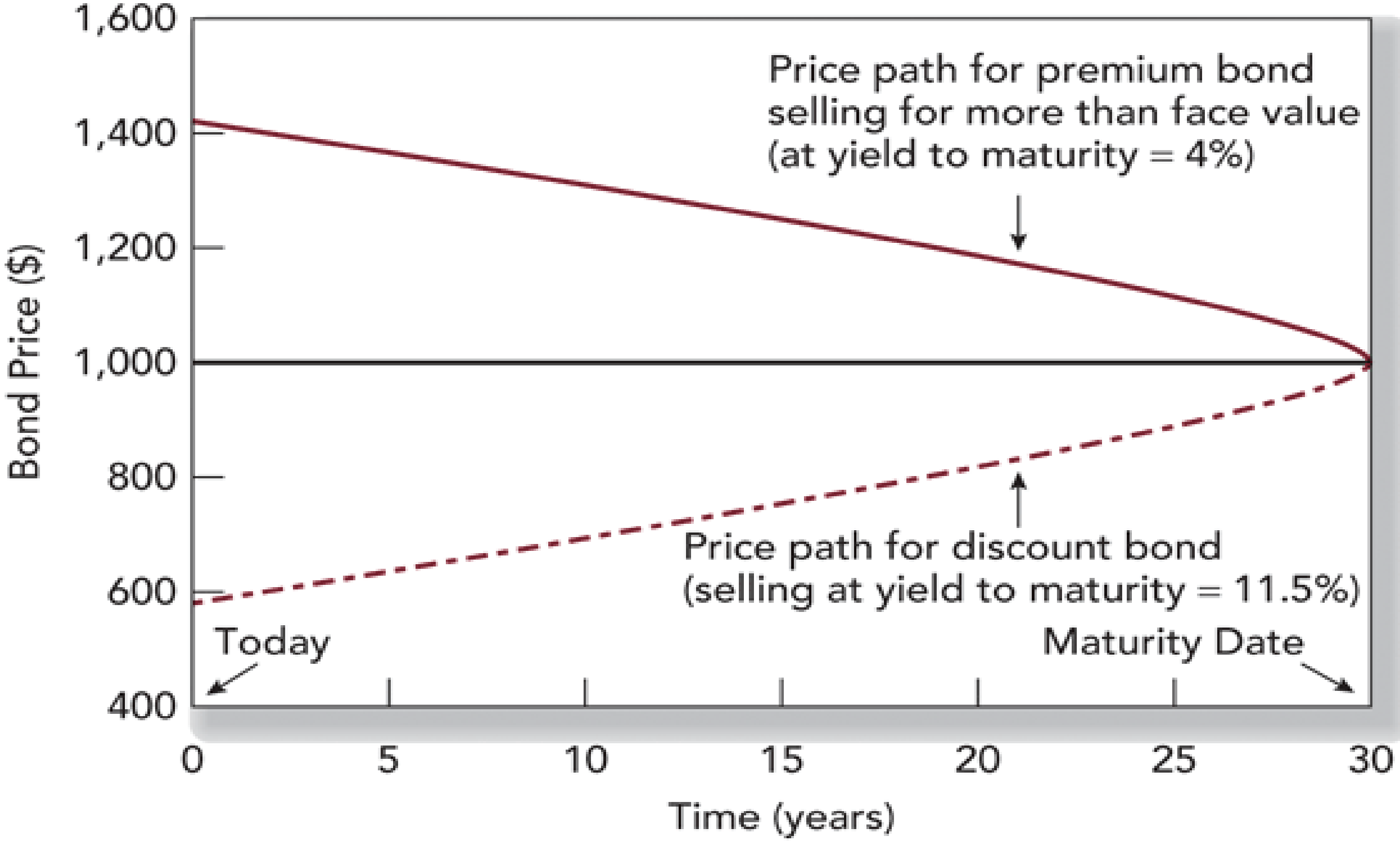
- Quoted price doesn’t include this
- Dirty Price = Clean Price + Accrued Interest

Bond Prices: Callable and Straight Debt

- Callable bonds are always worth less than regular debt



Prices over Time of 30-Year Maturity, 6.5% Coupon Bonds



Special Bonds

- Perpetuity (Coupons, but never redeemed)

$$P = \Sigma_{t=1}^{\infty} \frac{C}{(1+r)^t} = C\Sigma_{t=1}^{\infty} (\frac{1}{1+r})^t = \frac{C}{r}$$

- Zero coupon bonds (no coupons)

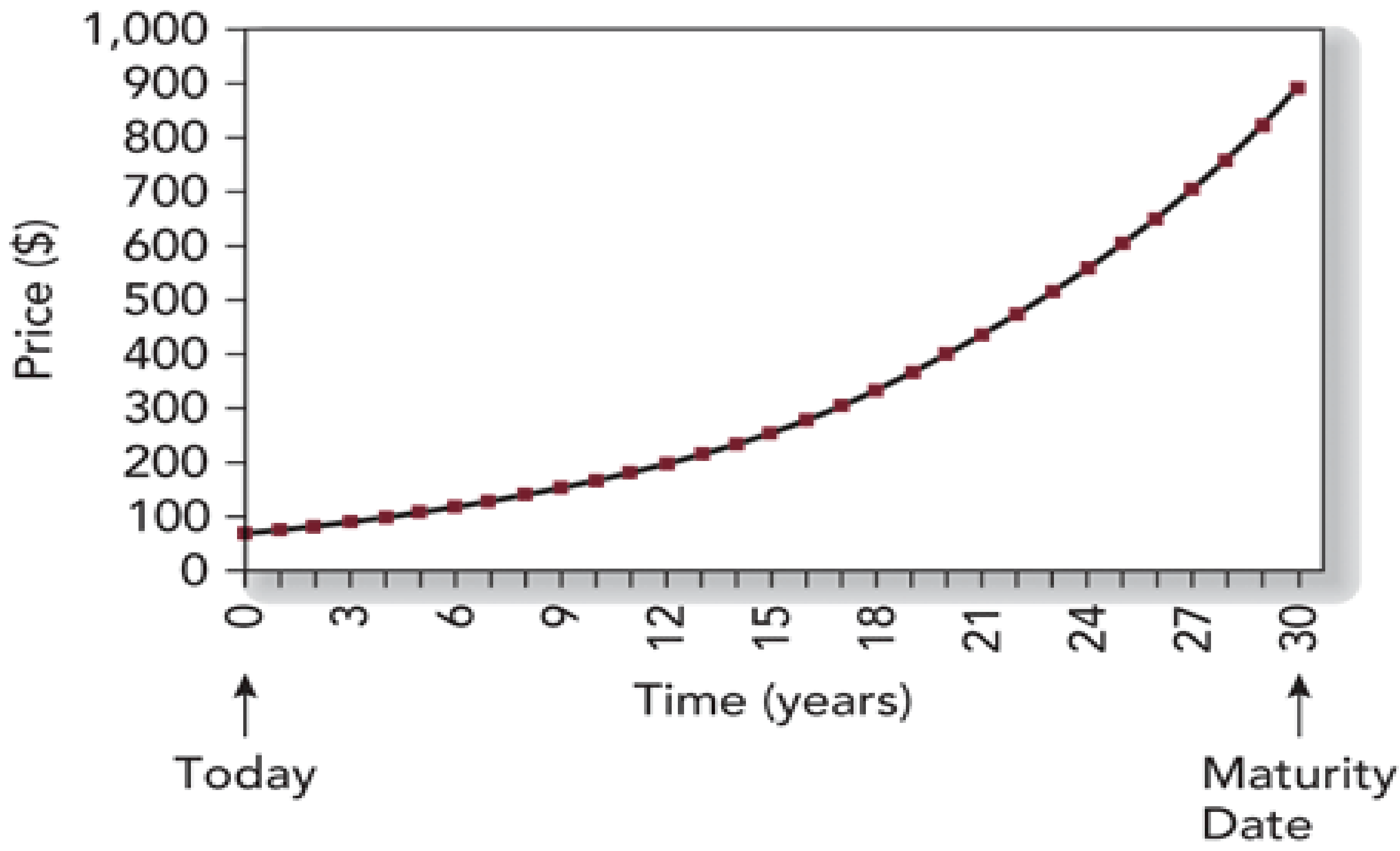
$$P = \frac{Par}{(1+r)^T}$$

- Treasury STRIPS…effectively zero-coupon bonds

Yields and Prices to Maturities on Zero-Coupon Bonds ($1,000 Face Value)

Maturity (years)	Yield to Maturity	Price
1	5%	952.38=1000/1.05
1	7.01%	934.50
2	6%	890.00
3	7%	816.30
4	8%	735.03

The Price of a 30-Year Zero-Coupon Bond over Time at a Yield to Maturity of 10%



Principal and Interest Payments for Treasury Inflation Protected Security (TIPS)

Time	Inflation in Year Just Ended	Par Value	Coupon Payment	+	Principal Repayment	=	Total Payment
0		$1,000.00					
1	2%	1,020.00	$40.80		$ 0		$ 40.80
2	3	1,050.60	42.02		0		42.02
3	1	1,061.11	42.44		1,061.11		1,103.55

- Rates on TIPS relative to nominal Treasury bonds are called "breakeven" rates and contain information about inflation expectations.

Holding-Period Return: Single Period

$$HPR = [I + (P_1 - P_0)] / P_0$$

where

I = interest payment

P_1 = price in one period

P_0 = purchase price

Holding-Period Return Example

CR = 8% YTM = 8% N=10 years

Semiannual Compounding P_0 = $1000

In six months the rate falls to 7%

P_1 = $1068.55

HPR = [40 + (1068.55 - 1000)] / 1000

HPR = 10.85% (semiannual)

Note that HPR and yield are two completely different things

Default Risk and Ratings

- Rating companies
  - Moody’s Investor Service
  - Standard & Poor’s
  - Fitch
- Rating Categories
  - Investment grade
    - BBB or higher for S&P
    - BAA or higher for Moody’s and Fitch
  - Speculative grade/Junk Bonds

Factors Used to assess financial stability

- Coverage ratios
- Leverage ratios

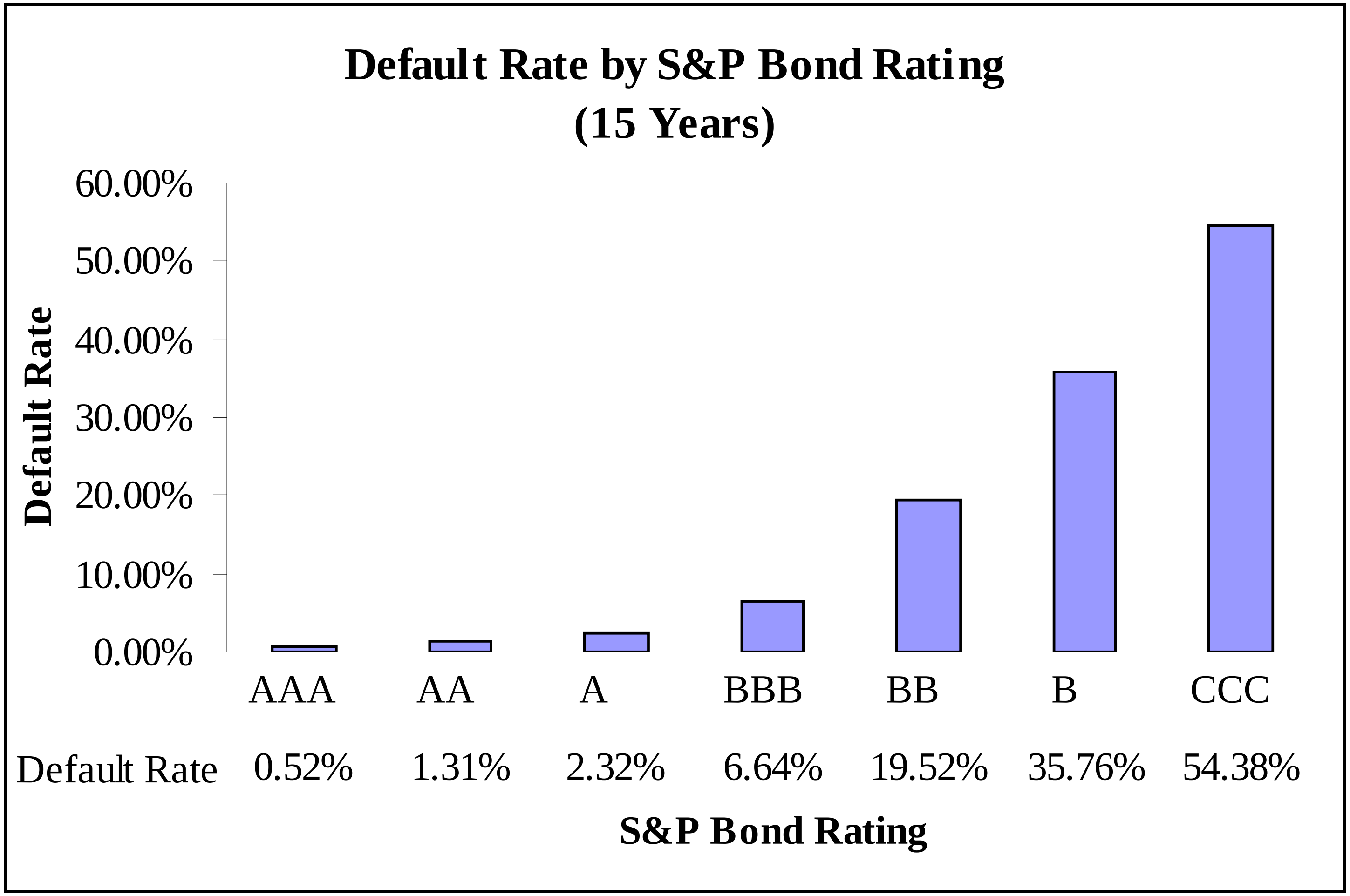
$$\frac{\text{Debt}}{\text{Equity}} \quad \text{or} \quad \frac{\text{Assets}}{\text{Equity}} = \frac{\text{Debt+Equity}}{\text{Equity}}$$

- Liquidity ratios
- Profitability ratios
- Cash flow to debt

Financial Ratios by S&P Ratings Class

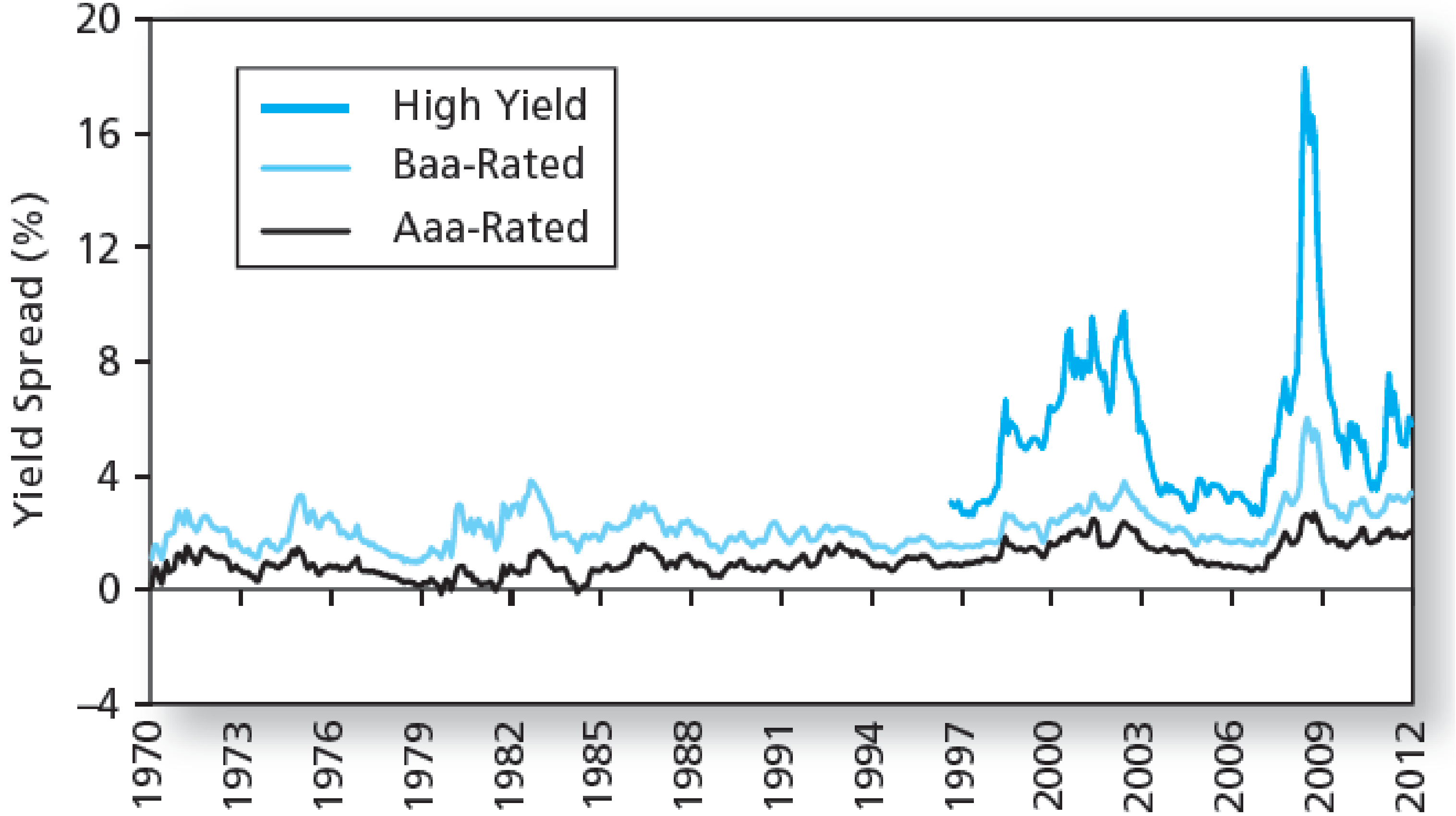
	3-year (2002 to 2004) medians						
	AAA	AA	A	BBB	BB	B	CCC
EBIT interest coverage multiple	23.8	19.5	8.0	4.7	2.5	1.2	0.4
EBITDA interest coverage multiple	25.5	24.6	10.2	6.5	3.5	1.9	0.9
Funds from operations/total debt (%)	203.3	79.9	48.0	35.9	22.4	11.5	5.0
Free operating cash flow/total debt (%)	127.6	44.5	25.0	17.3	8.3	2.8	(2.1)
Total debt/EBITDA multiple	0.4	0.9	1.6	2.2	3.5	5.3	7.9
Return on capital (%)	27.6	27.0	17.5	13.4	11.3	8.7	3.2
Total debt/total debt + equity (%)	12.4	28.3	37.5	42.5	53.7	75.9	113.5

Default Rates



Source: "The Credit-Raters: How They Work and How They Might Work Better", Business Week (8 April 2002), p. 40

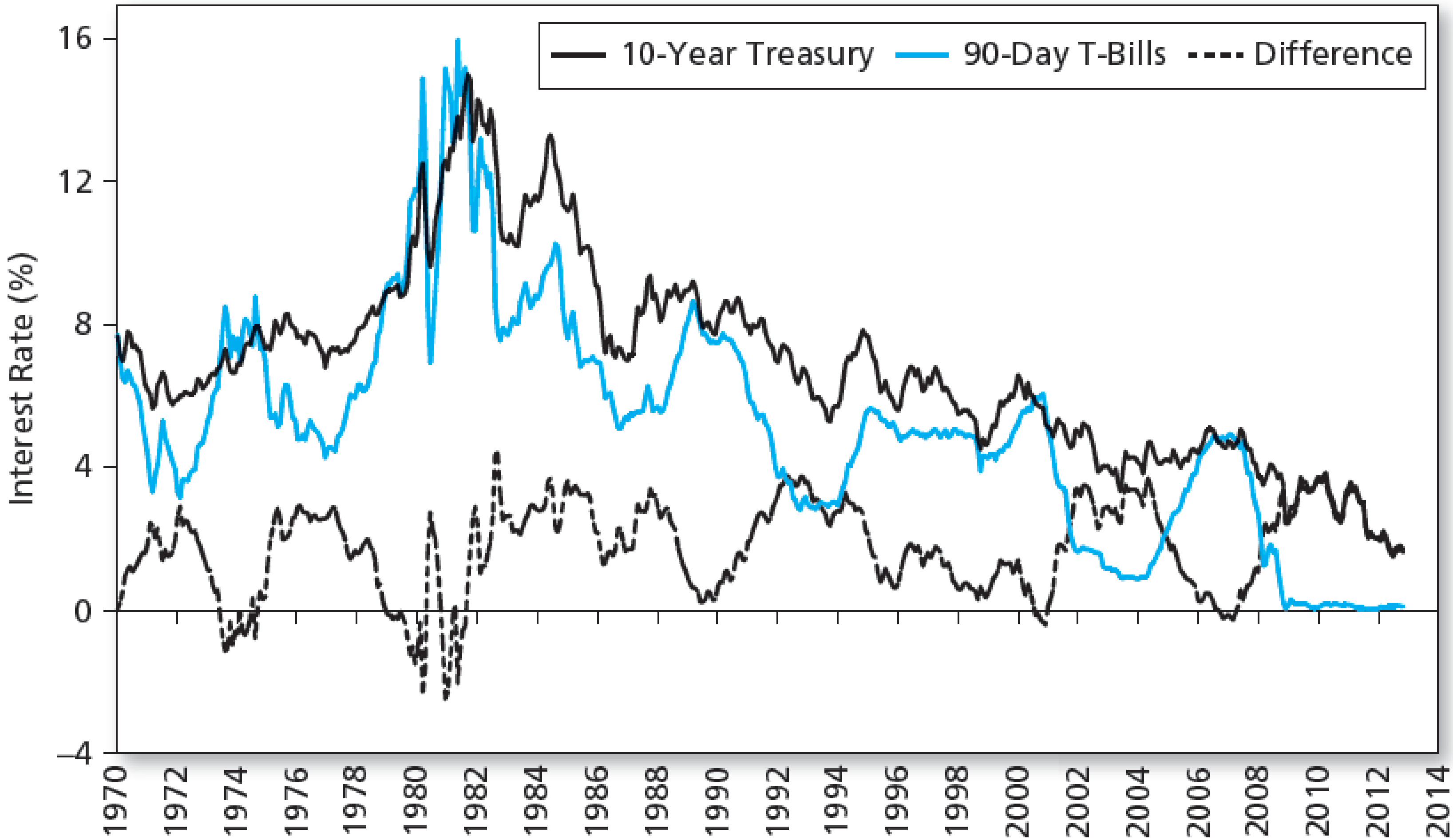
Yield Spreads between long-term corporates and Treasuries



Components of a corporate risk spread

- Expected default
- Recovery rate
- Risk premium

Treasury yields

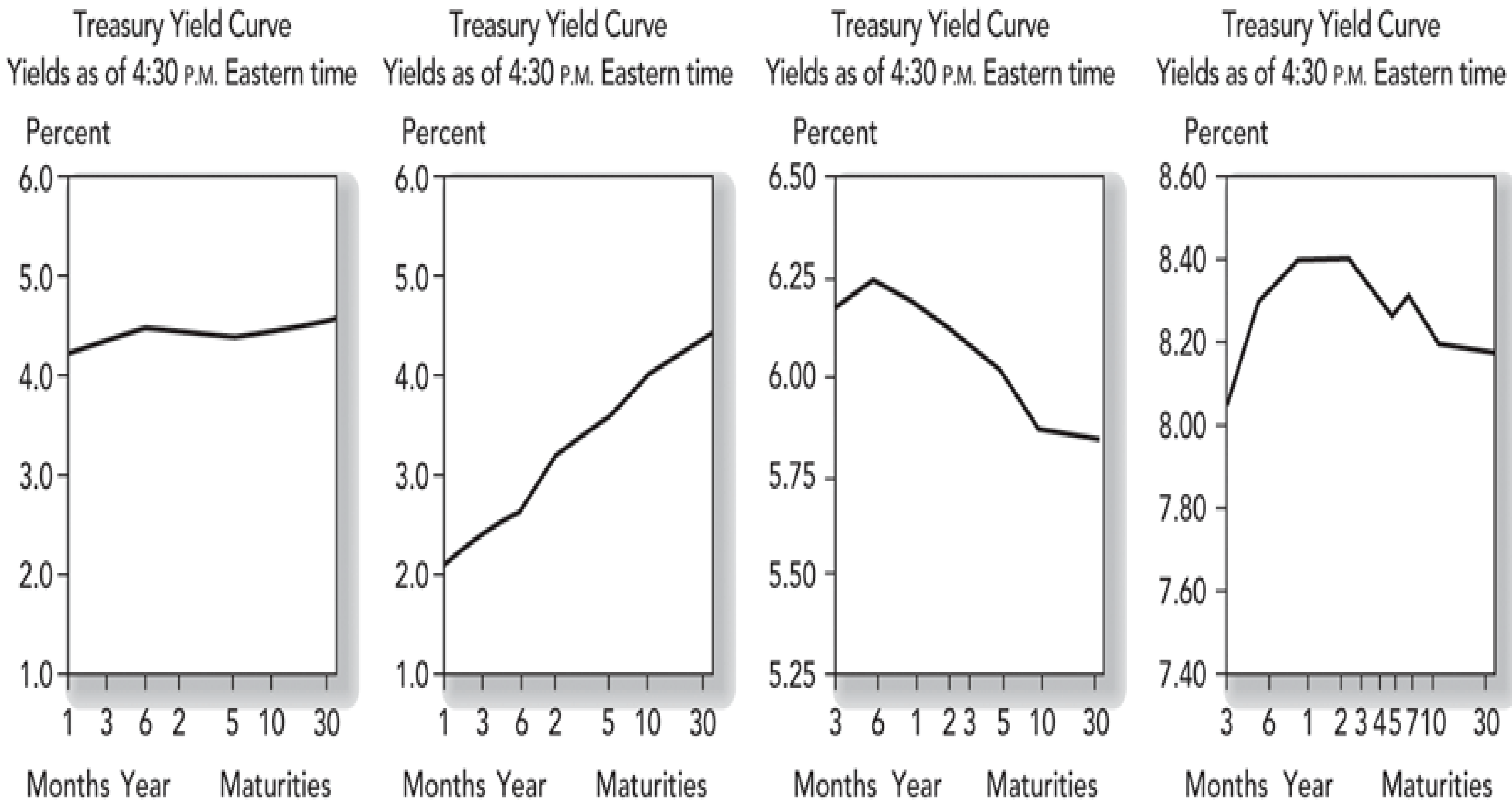


Overview of Term Structure

- Information on expected future short term rates can be implied from the yield curve

- The yield curve is a graph that displays the relationship between yield and maturity

Treasury Yield Curves



A. (January 2006)
Flat Yield Curve

B. (January 2005)
Rising Yield Curve

C. (September 11, 2000)
Inverted Yield Curve

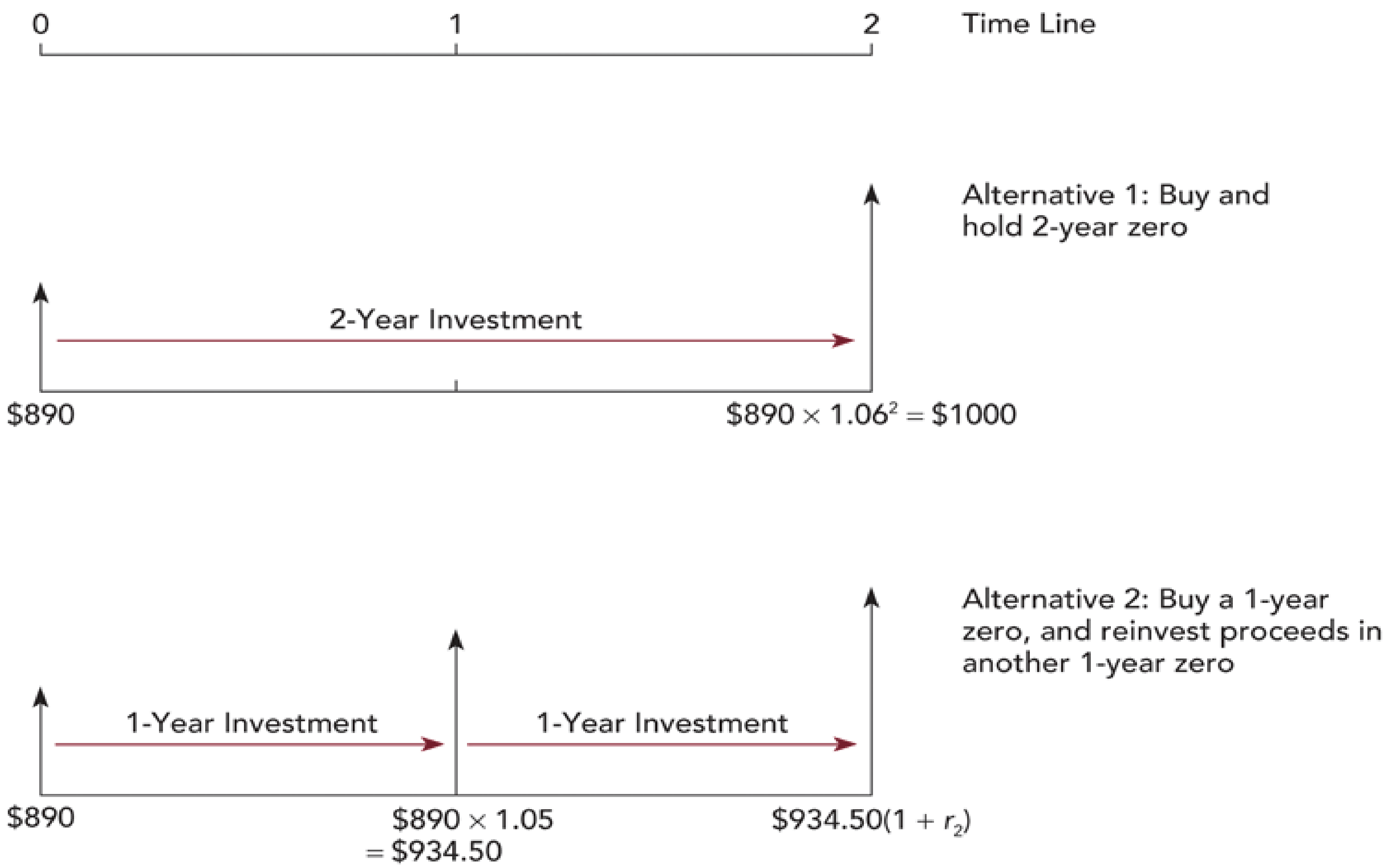
D. (October 4, 1989)
Hump-Shaped Yield Curve

Yield Curve Under Certainty

- Say we knew next year's interest rate

- An upward sloping yield curve implies that short-term rates are going to be higher next year

Two 2-Year Investment Programs



Yield Curve Under Certainty

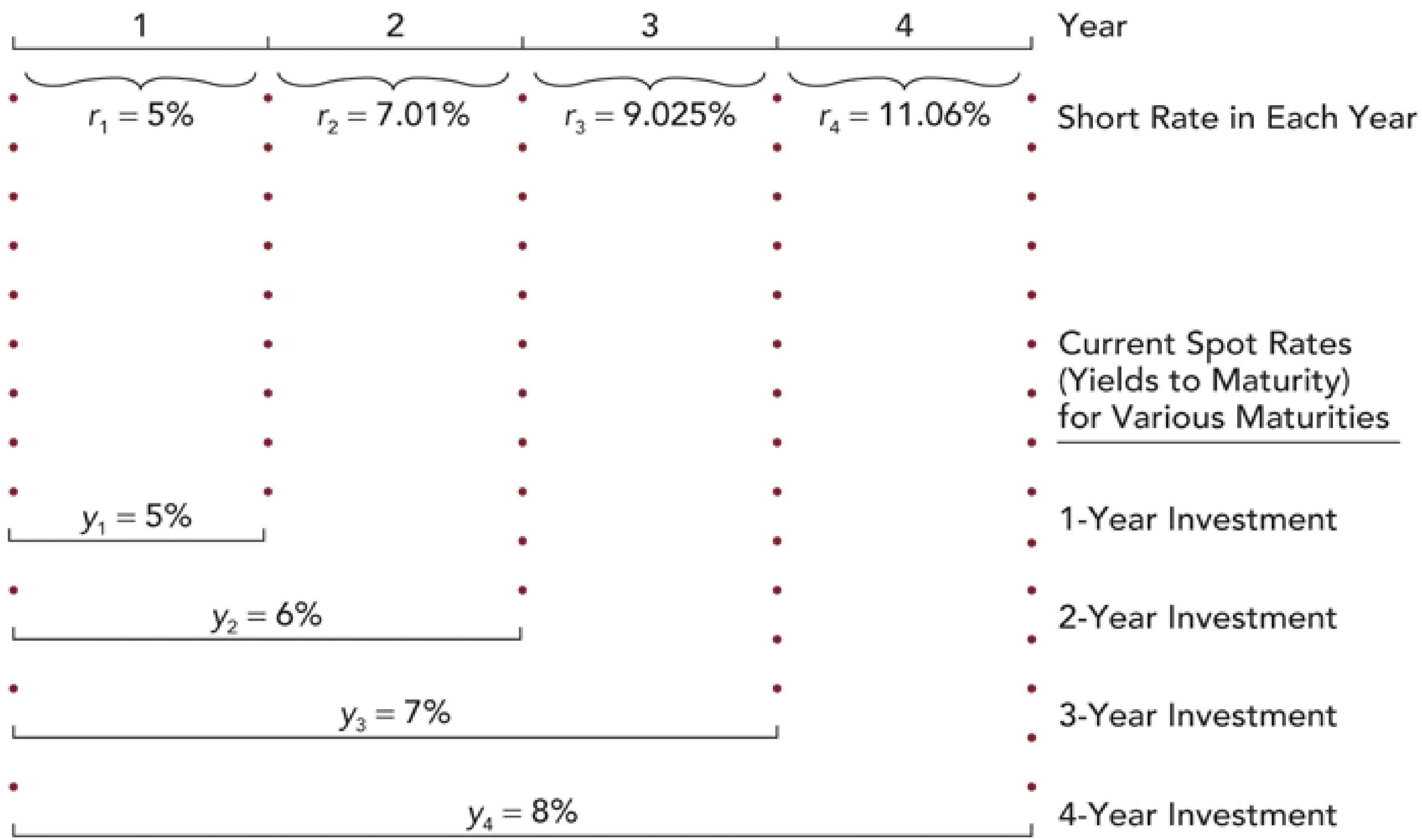
- The two programs must have the same yield

$$(1+y_2)^2 = (1+r_1)*(1+r_2)$$

$$1+y_2 = \left[(1+r_1)*(1+r_2)\right]^{\frac{1}{2}}$$

- So $y_2 > y_1$ if and only if $r_2 > r_1$

Short Rates versus Spot Rates



Yield Curve Under Certainty

$$(1+y_n)^n = (1+r_1)*(1+r_2)*....(1+r_n)$$

$$1+y_n = \left[(1+r_1)*(1+r_2)*...(1+r_n)\right]^{\frac{1}{n}}$$

Interest Rate Uncertainty

- What can we say when future interest rates are not known today?

- Suppose that today's rate is 5% and the *expected* short rate for the following year is $E(r_2) = 6\%$

Theories of Term Structure

- Expectations Hypothesis
  - Treat expected future rates as though they were known

$$(1+y_2)^2 = (1+r_1)*[1+E(r_2)] = 1.05*1.06$$
$$\Rightarrow y_2 = 5.5\%$$

- Liquidity Preference
  - Upward bias over expectations
  - Investors require extra yield to compensate them for the risk of capital loss if interest rates go up

Expectations Hypothesis

- Observed long-term rate is a function of today's short-term rate and expected future short-term rates

$$(1+y_n)^n = (1+r_1)*(1+E(r_2))*...(1+E(r_n))$$

$$y_n \approx n^{-1}(r_1 + E(r_2)...+E(r_n))$$

Liquidity Premium Theory

- Long-term bonds are more risky
- Investors will demand a premium for the risk associated with long-term bonds
- The yield curve has an upward bias built into the long-term rates because of the risk premium (or term premium)
- Risk premium may change over time

Engineering a Synthetic Forward Loan

- The one-year rate next year is not known
- But the one- and two-year yields today are
- Can
  - Sell a two-year zero coupon bond for $\frac{1000}{(1+y_2)^2}$
  - Buy $\frac{1+y_1}{(1+y_2)^2}$ one-year zero coupon bonds for $\frac{1000}{(1+y_2)^2}$
- Cash flows:
  - Today: Nothing
  - In one year receive $ $1000*(1+y_1)/(1+y_2)^2$
  - In two years pay $1000

Engineering a Synthetic Forward Loan

- In this way, I can lock in a rate to borrow at some point in the future
- In one year, I receive $1000*(1+y_1)/(1+y_2)^2$ and in two years I pay $1000
- So the interest rate that I am locking in is

$$f = \frac{(1+y_2)^2}{1+y_1} - 1$$

and this is called a **forward** rate

Forward Rates from Observed Rates

$$f_n = \frac{(1+y_n)^n}{(1+y_{n-1})^{n-1}} - 1$$

***f_n* = one-year forward rate for period n**

***y_n* = yield for a security with a maturity of n**

Example: Forward Rates

4 yr = 8.00%   3yr = 7.00%   *fn* = ?

$f_n = (1.08)^4 / (1.07)^3 - 1$

f_n = .1106 or 11.06%

Downward Sloping Spot Yield Curve Example

Zero-Coupon Rates	Bond Maturity
12%	1
11.75%	2
11.25%	3
10.00%	4
9.25%	5

Forward Rates for Downward Sloping Y C Example

1yr Forward Rates

1yr	$[(1.1175)^2 / 1.12] - 1$	=	0.115006
2yrs	$[(1.1125)^3 / (1.1175)^2] - 1$	=	0.102567
3yrs	$[(1.1)^4 / (1.1125)^3] - 1$	=	0.063336
4yrs	$[(1.0925)^5 / (1.1)^4] - 1$	=	0.063008

Forward rates and future interest rates

- If the path of future interest rates is known for certain, then forward rates are equal to future interest rates
- With interest rate uncertainty,
  - Under the expectations hypothesis, forward rates are equal to expected future short-term interest rates
  - Under liquidity preference theory, forward rates are greater than expected future short-term interest rates

Yield curve slope

- Typically yield curve slopes up
- Consistent with liquidity preference
- Slope of yield curve related to bank profitability
  - Banks lend long-term and finance themselves short-term

Prices of 8% Coupon Bond (Coupons Paid Semiannually)

Yield to Maturity	1 year	10 year	20 year
8%	1000.00	1000.00	1000.00
9%	990.64	934.96	907.99
Percent Fall in Price	0.94%	6.50%	9.20%

Prices of Zero-Coupon Bond

Yield to Maturity	1 year	10 year	20 year
8%	924.56	456.39	208.29
9%	915.73	414.64	171.93
Percent Fall in Price	0.96%	9.15%	17.46%

Bond Pricing Relationships

- Price is more sensitive to change in yield for
  - Longer maturity bonds
  - Lower coupon bonds
  - Lower initial yield to maturity bonds

Change in Bond Price as a Function of Change in Yield to Maturity

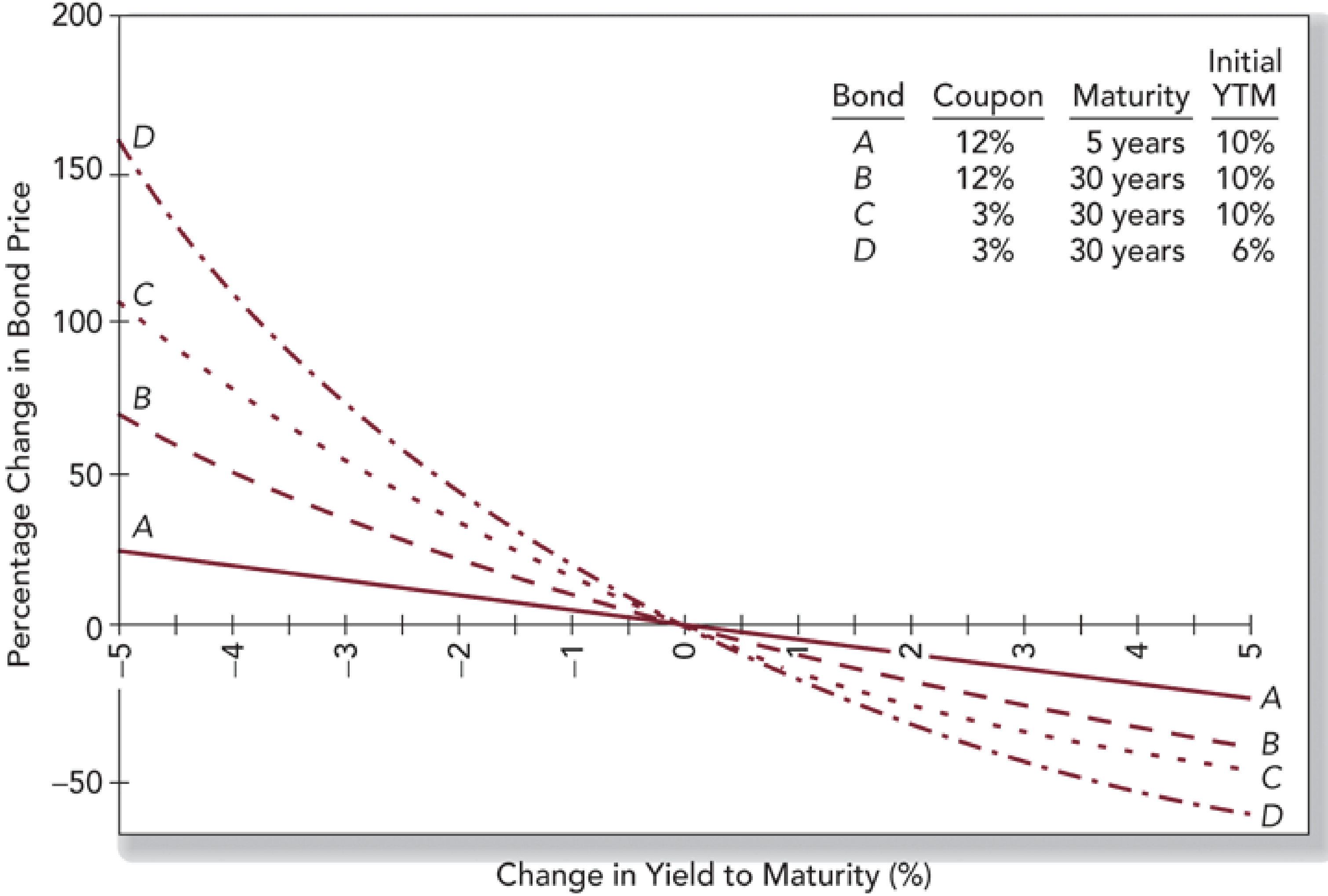
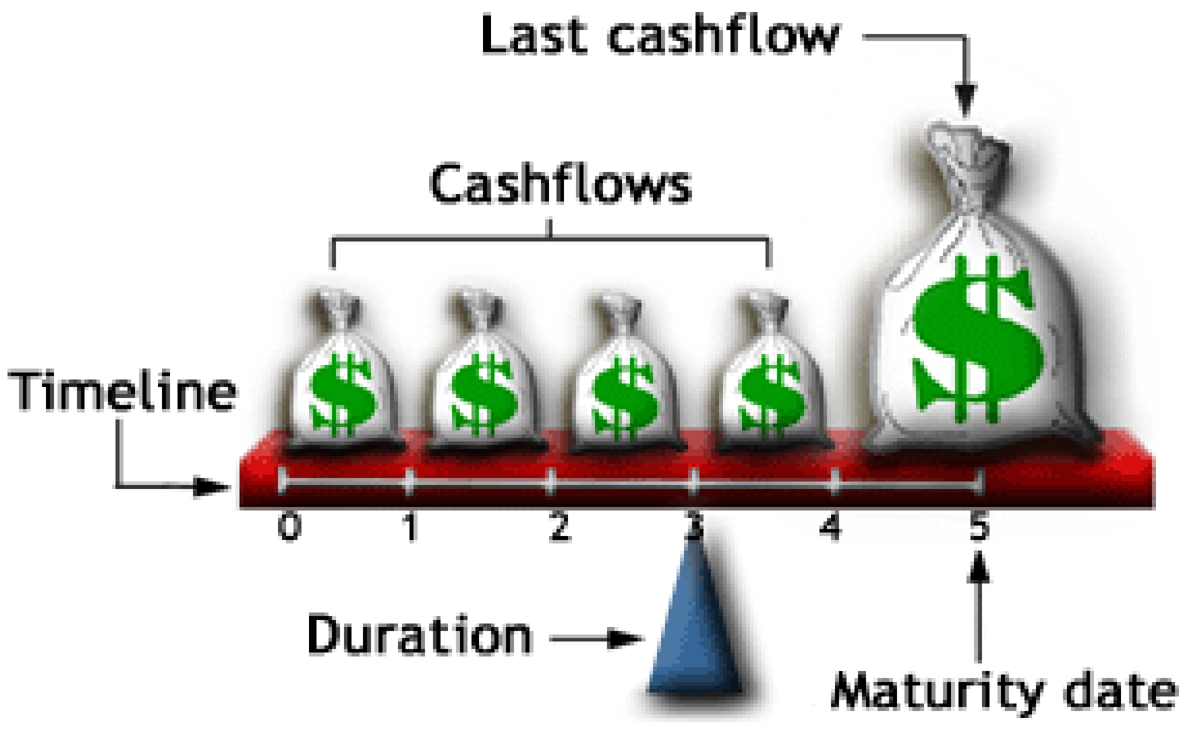


Illustration of Duration



Duration

- A measure of the effective maturity of a bond
- The weighted average of the times until each payment is received, with the weights proportional to the present value of the payment
- Duration is shorter than maturity for all bonds except zero coupon bonds
- Duration is equal to maturity for zero coupon bonds

Duration: Calculation

$$w_t = \frac{CF_t}{(1+y)^t} \frac{1}{\text{Price}}$$

$$D = \Sigma_{t=1}^{T} t w_t$$

Spreadsheet
Calculating the Duration of Two Bonds

	A	B	C	D	E	F	G
1			Time until		PV of CF		Column (C)
2			Payment		(Discount rate =		times
3		Period	(Years)	Cash Flow	5% per period)	Weight*	Column (F)
4	**A.** 8% coupon bond	1	0.5	40	38.095	0.0395	0.0197
5		2	1.0	40	36.281	0.0376	0.0376
6		3	1.5	40	34.554	0.0358	0.0537
7		4	2.0	1040	855.611	0.8871	1.7741
8	Sum:				964.540	1.0000	1.8852
9							
10	**B.** Zero-coupon	1	0.5	0	0.000	0.0000	0.0000
11		2	1.0	0	0.000	0.0000	0.0000
12		3	1.5	0	0.000	0.0000	0.0000
13		4	2.0	1000	822.702	1.0000	2.0000
14	Sum:				822.702	1.0000	2.0000
15							
16	Semiannual int rate:	0.05					
17							
18	*Weight = Present value of each payment (column E) divided by the bond price.						

Duration/Price Relationship

Suppose that there is a level change in interest rates

$$\frac{\Delta P}{P} \approx -D * [\frac{\Delta y}{1+y}]$$

$D_{MOD} = D/(1+y)$ *modified duration*

with semiannual compounding y is yield per 6 months

$$\frac{\Delta P}{P} \approx -D_{MOD} \Delta y$$

Rules for Duration

Rule 1 The duration of a zero-coupon bond equals its time to maturity

Rule 2 Holding maturity constant, a bond's duration is higher when the coupon rate is lower

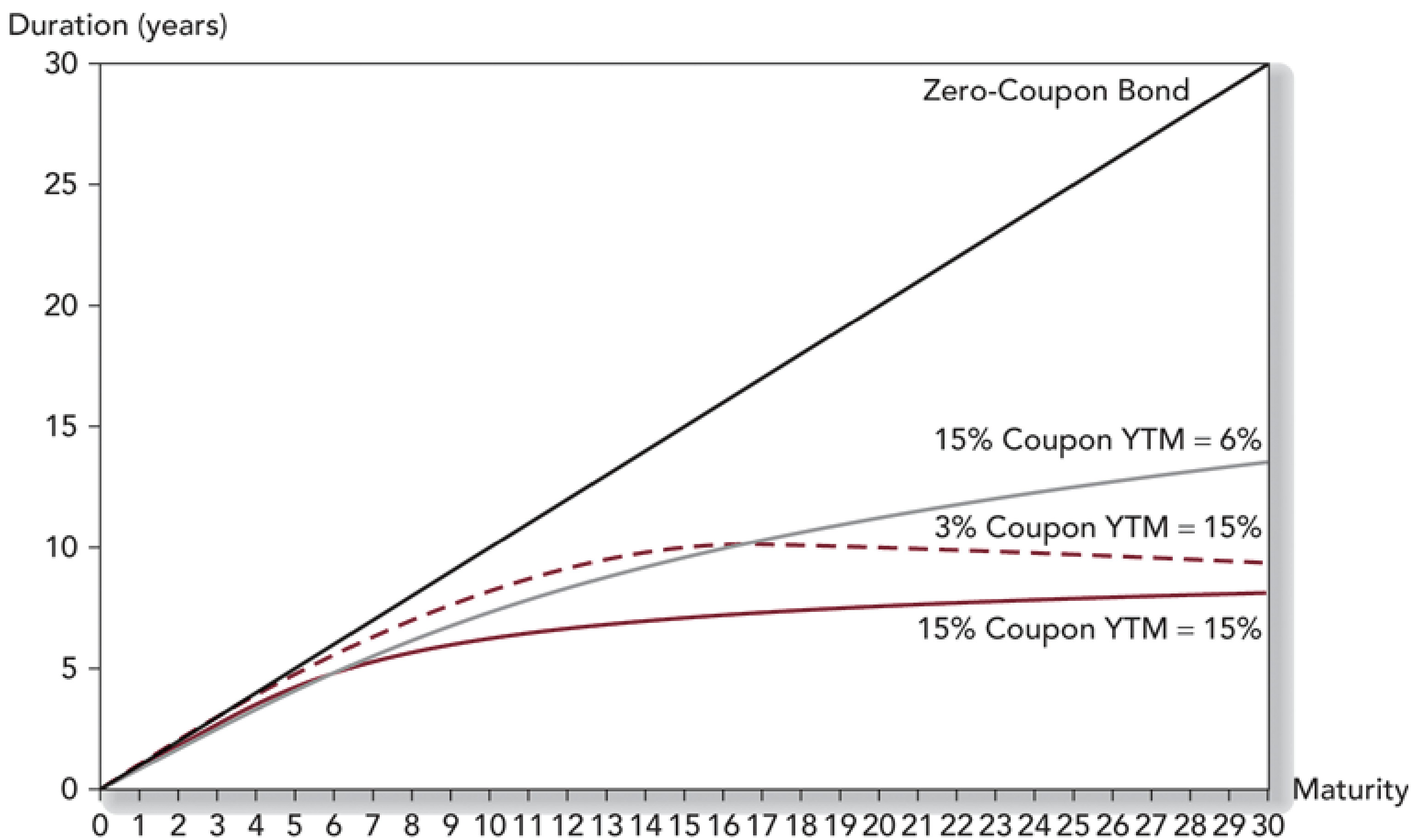
Rule 3 Holding the coupon rate constant, a bond's duration generally increases with its time to maturity

Rule 4 Holding other factors constant, the duration of a coupon bond is higher when the bond's yield to maturity is lower

Rule 5 The duration of a perpetuity is equal to: $(1+y) / y$

Rule 6 The duration of a portfolio with weight w_k on a bond with duration is D_k is $\Sigma_k w_k D_k$

Bond Duration versus Bond Maturity



Bond Durations (Yield to Maturity = 8% APR; Semiannual Coupons)

Coupon Rate (Per Year)

Years to Maturity	6%	8%	10%	12%
1	0.985	0.981	0.976	0.972
5	4.361	4.218	4.095	3.990
10	7.454	7.067	6.772	6.541
20	10.922	10.292	9.870	9.568

Perpetuity: 13 years

Duration, Modified Duration and DV01

- DV01 is the “dollar value of a basis point”
  - How much the price rises when the interest rate falls by one hundredth of one percentage point
- Relations:

$$D_{MOD} = D / (1 + y)$$

$$DV01 \approx D_{MOD} * P * 0.0001$$

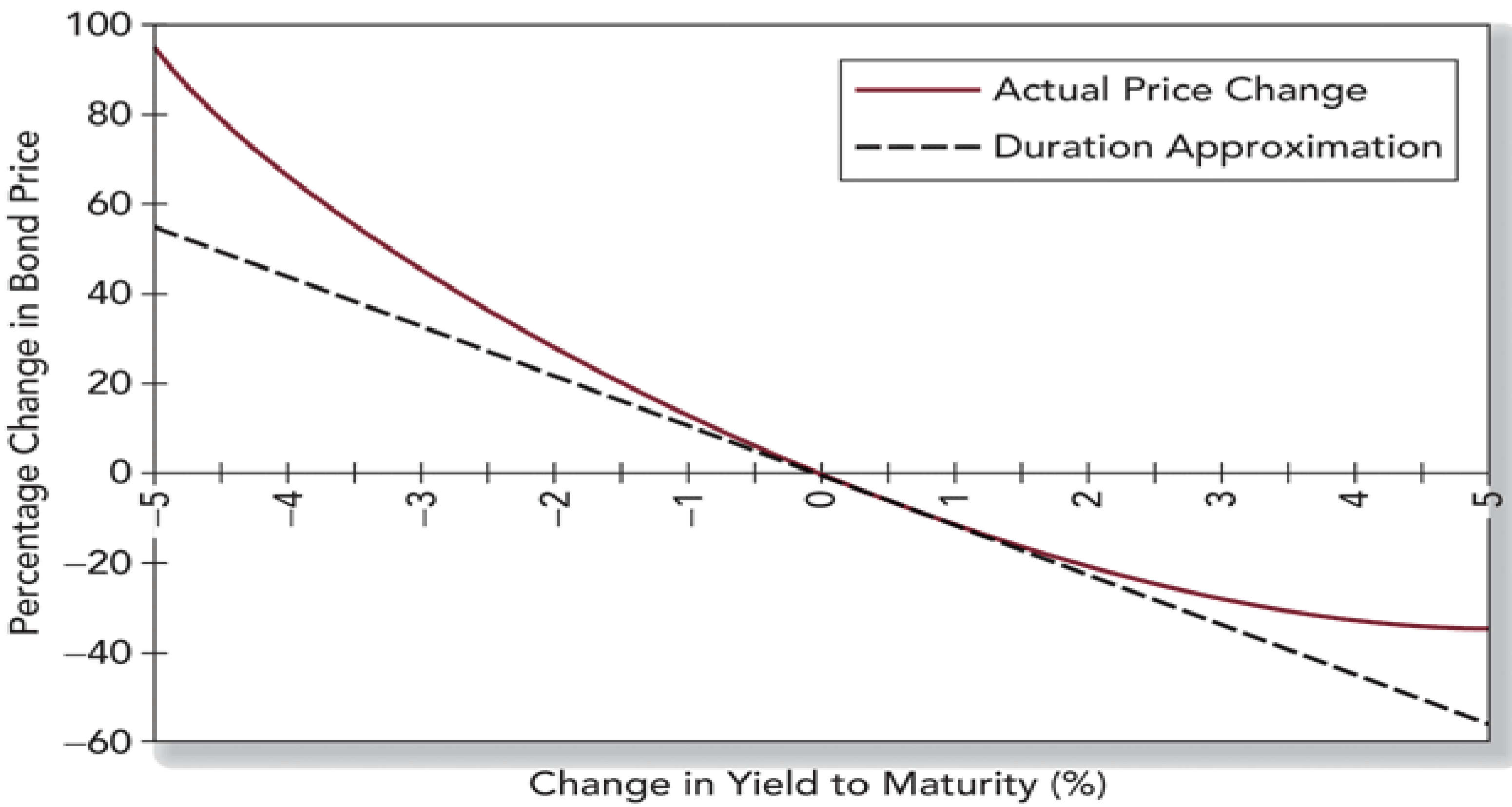
Duration, Modified Duration and DV01 Calculation Example

- Consider a two-year 8% bond with a 10% yield
- The duration is 1.8852 (calculated earlier)
- The modified duration is 1.8852/1.05=1.7954
- The price of the bond is $96.45405
- If the interest rate were 10.01%, the price would be $96.43673
- The DV01 is 1.732 cents
- And D_{MOD}*0.0001*P=1.732 cents

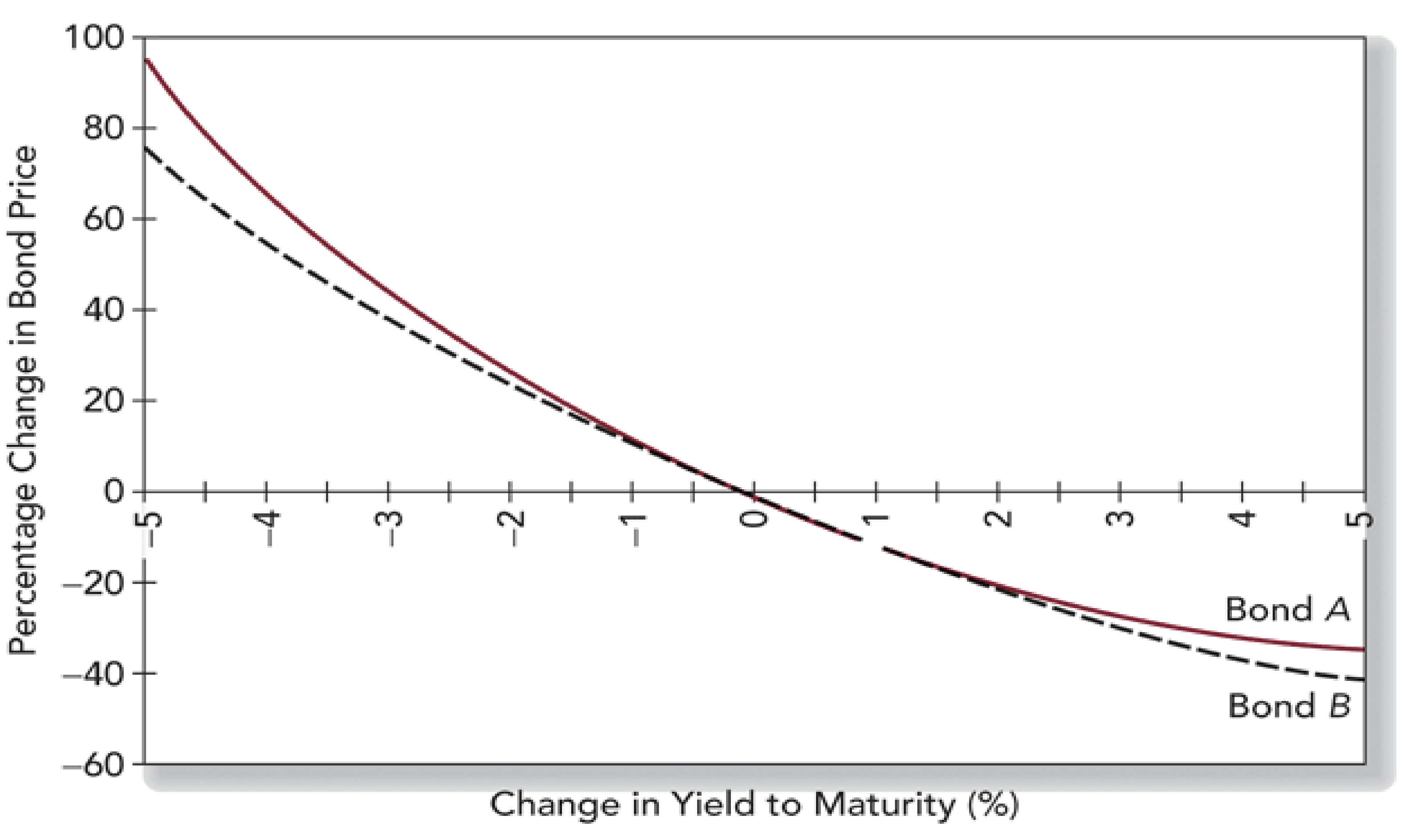
Convexity

- The relationship between bond prices and yields is not linear
- Duration rule is a good approximation for only small changes in bond yields

Bond Price Convexity: 30-Year Maturity, 8% Coupon; Initial Yield to Maturity = 8%



Convexity of Two Bonds



Correction for Convexity

$$w_t = [CF_t / (1+y)^t] / \text{Price}$$

$$\text{Convexity} = \frac{1}{(1+y)^2} \Sigma_{t=1}^{n} w_t (t + t^2)$$

Correction for Convexity:

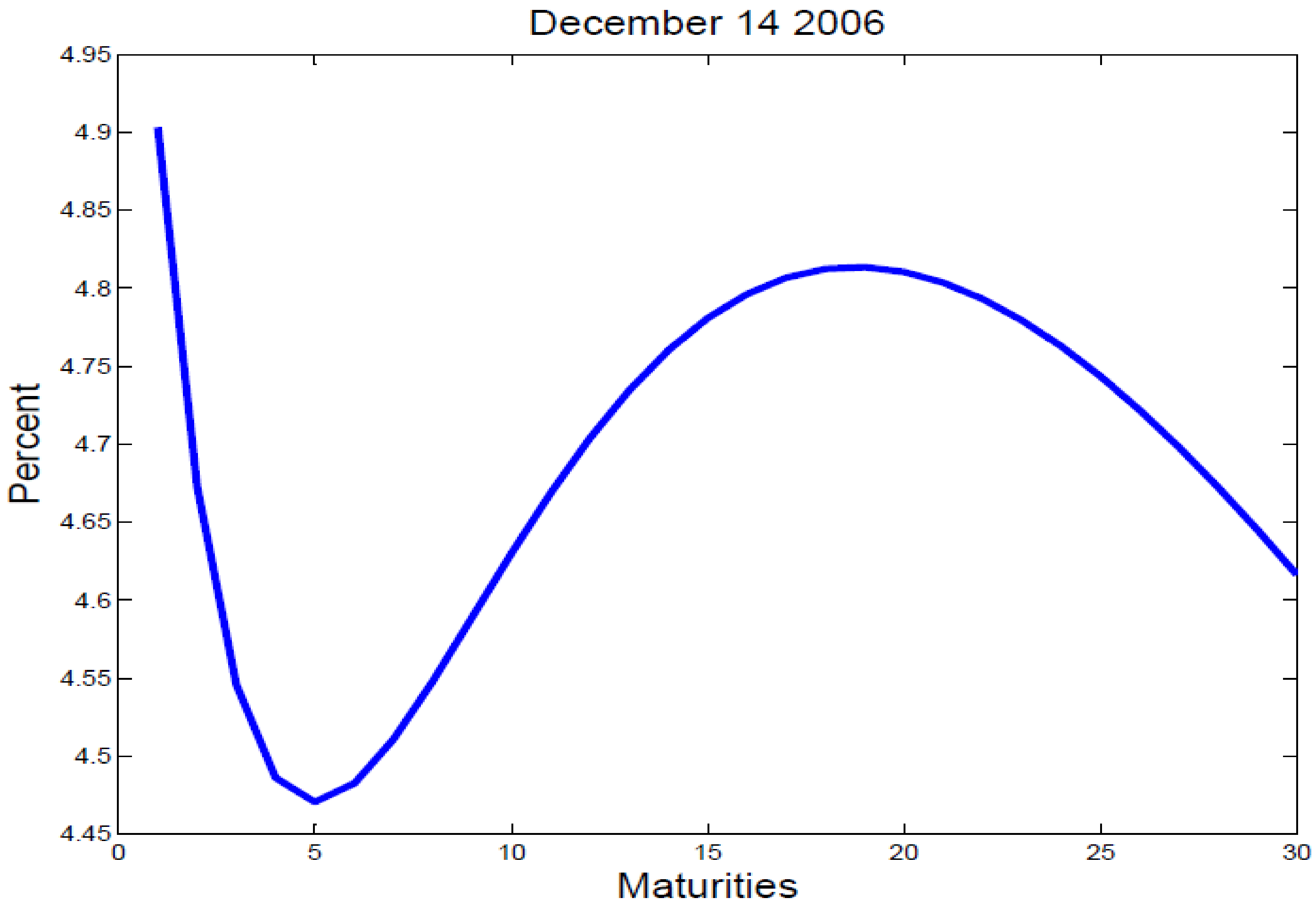
$$\frac{\Delta P}{P} \approx -D_{MOD} \Delta y + \frac{1}{2} \text{Convexity}(\Delta \text{y})^2$$

Convexity Example

- Suppose that a bond trades at par and pays an 8% coupon once a year with 10 years to maturity
- What is its duration, modified duration, DV01 and convexity?
- From EXCEL, the answers are

Duration	**7.25**
Modified Duration	**6.71**
DV01	**0.0671**
Convexity	**60.53**

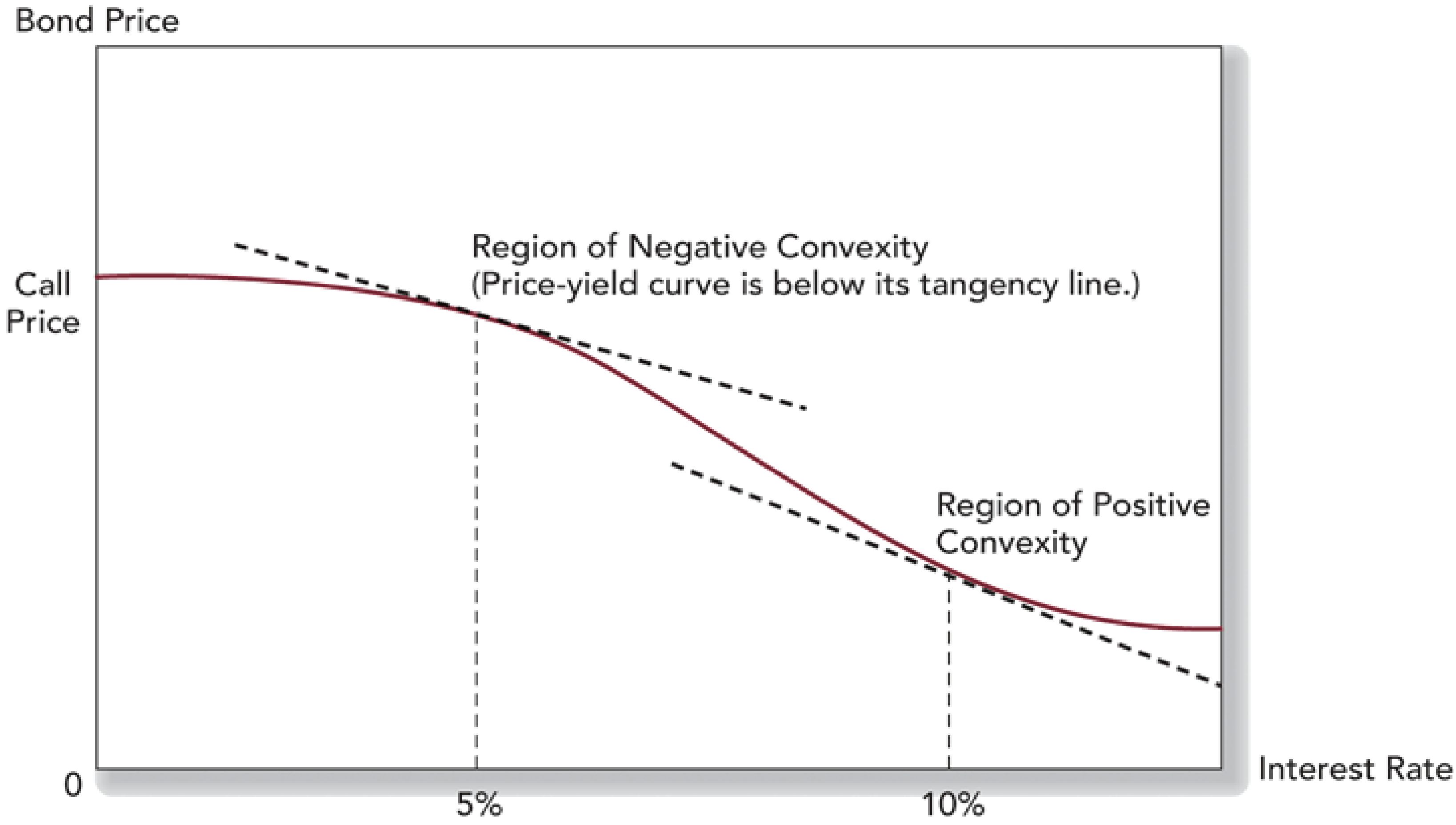
Effects of convexity: Typical Treasury ZC Yield Curve



Callable Bonds

- As rates fall, there is a ceiling on possible prices
  - The bond cannot be worth more than its call price
- Negative convexity

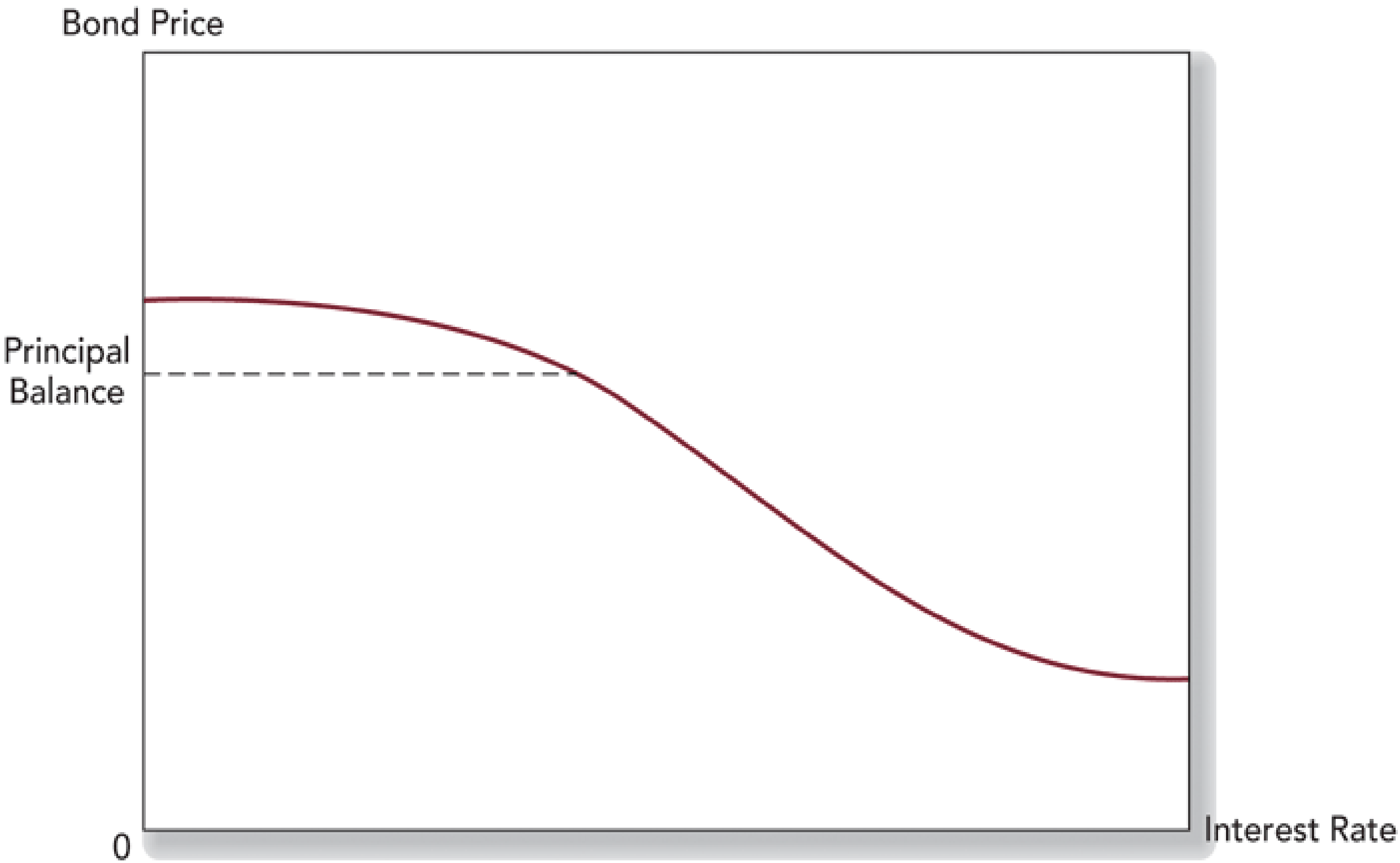
Price –Yield Curve for a Callable Bond



Mortgage backed securities

- Prepayment risk is important for MBS
- Homeowners will refinance if interest rates fall
- Implies negative convexity
- Because homeowners are sometimes slow to refinance, the value can exceed the principal balance

Price -Yield Curve for a Mortgage-Backed Security



Immunization of Interest Rate Risk

- Suppose an insurance company issues a guaranteed investment contract for $10,000 paying 8% over 5 years
- In 5 years, they need $\$10{,}000 \times (1.08)^5 = \$14.693.28$

- Suppose the insurance company buys an 8% 5 year bond for $10,000 to hedge this risk

Alternative Scenarios

Interest Rates Rise to 9%	
Year 1	$\$800x(1.09)^4=\$1129.27$
Year 2	$\$800x(1.09)^3=\$1036.02$
Year 3	$\$800x(1.09)^2=\$ 950.48$
Year 4	$\$800x(1.09)^1=\$ 872.00$
Year 5	$10800
TOTAL	$14787.77
Needed	$14.693.28
PROFIT	$94.99

Alternative Scenarios

Interest Rates Fall to 7%	
Year 1	$\$800x(1.07)^4=\$1048.64$
Year 2	$\$800x(1.07)^3=\$ 980.03$
Year 3	$\$800x(1.07)^2=\$ 915.92$
Year 4	$\$800x(1.07)^1=\$ 856.00$
Year 5	$10800
TOTAL	$14600.59
Needed	$14.693.28
PROFIT	($92.69)

Immunization of Interest Rate Risk

- The hedge did not work
- Intuitively the bond front loaded the coupons too much opening the strategy to reinvestment risk

- But now suppose the insurance company buys an 8% 6 year bond for $10,000 to hedge this risk
  - This bond has a duration of about 5 years

Alternative Scenarios

Interest Rates Rise to 9%	
Year 1	$800x(1.09)^4$=$1129.27
Year 2	$800x(1.09)^3$=$1036.02
Year 3	$800x(1.09)^2$=$ 950.48
Year 4	$800x(1.09)^1$=$ 872.00
Year 5 Coupon	$800 =$800
Year 5 Sell Bond	$10800/1.09 =$9,908.26
TOTAL	$14,696.03
Needed	$14,693.28
PROFIT	$2.75

Alternative Scenarios

Interest Rates Fall to 7%	
Year 1	$\$800x(1.07)^4 = \$1048.64$
Year 2	$\$800x(1.07)^3 = \$\ 980.03$
Year 3	$\$800x(1.07)^2 = \$\ 915.92$
Year 4	$\$800x(1.07)^1 = \$\ 856.00$
Year 5 Coupon	$800 =$800
Year 5 Sell Bond	$10800/1.07 =$10,093.46
TOTAL	$14694.05
Needed	$14.693.28
PROFIT	$0.77

Immunization of Interest Rate Risk

- General principle:

Immunize a liability with an asset of the same duration and the same present value

- A liability in 5 years should be matched with an asset of 5 years duration.

Constructing an immunized portfolio: Example

- The interest rate is 5%. An insurance company must pay \$1 million*1.05^3=\$1.158 million in 3 years
- Immunize this with
  - A one year bill (weight x) and
  - A 10 year strip (weight 1-x)

- Duration of liability: 3 years
- Duration of immunizing portfolio: 3 years
  - $3=x+10*(1-x)$: Solving this yields $x=7/9$
- The immunizing portfolio is \$778k in bills and \$222k in strips.

Constructing an immunized portfolio: Example

- The interest rate is 10%. An insurance company must pay $\$10{,}000*1.1^7=\$19{,}487$ in 7 years
- Immunize this with
  - A perpetuity and
  - A three-year zero coupon bond

- Duration of liability: 7 years
- Duration of immunizing portfolio: 7 years

Constructing an immunized portfolio: Example….continued

- The duration of the perpetuity is 1.10/0.1=11
- The duration of the zero coupon bond is 3 years
- The duration of the immunizing portfolio is

$$3\omega + 11(1-\omega)$$

- Setting this to 7 implies that $\omega = 1/2$
- The immunizing portfolio is
  - $5000 in zero coupon bonds
  - $5000 in perpetuities

Rebalancing the immunized portfolio: Example

- 1 year has passed. The interest rate is 10%. What change should be made to the portfolio?
- Both the present value of the liability and the asset are $11,000 and are equal.
- The duration of the liability is now 6 years. So the portfolio weights solve

$$2\omega + 11(1-\omega) = 6 \Rightarrow \omega = 5/9$$

- So now the immunizing portfolio is
  - $6,111.11 in two-year zero coupon bonds
  - $4,888.89 in perpetuities

Swaps

- Interest rate swap
- Inflation swaps
- Credit default swaps

Interest rate swap

- Agreement between two parties to exchange a fixed rate a notional underlying principal for a floating rate

- For example:
  - Pay LIBOR times $100 million
  - Receive fixed rate times $100 million
  - Only net amount changes hands

Interest rate swap: example

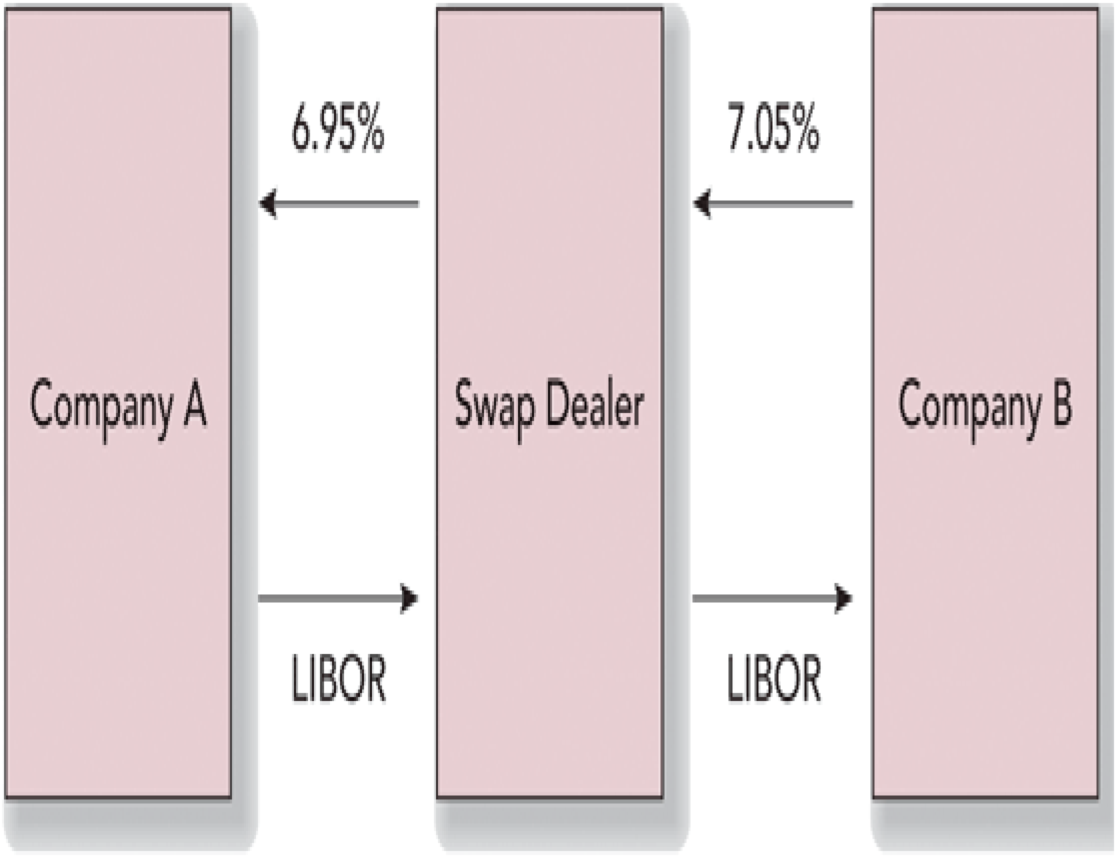
- Suppose that the 3 month LIBOR rate is 4% and the fixed rate is 7%

- Party paying fixed gives the counterparty
  0.25*(7%*$100 million-4%*$100million)=$750,000

The Swap Dealer

- Dealer enters a swap with Company A
  - Pays fixed rate and receives LIBOR
- Dealer enters another swap with Company B
  - Pays LIBOR and receives a fixed rate
- When two swaps are combined, dealer’s position is effectively neutral on interest rates

Interest Rate Swap



Uses of Interest Rate Swaps

- Converting liabilities or assets from fixed to floating
- Banks have short-term liabilities and long-term assets
  - Banks generally pay fixed, receive floating
- Betting on interest rate movements
- Managerial or investor myopia

Example of Interest Rate Swap

- Companies X and Y have been offered the following rates per annum on a $20 million 5-year loan:

	Fixed	Floating
Company X	12%	LIBOR+0.1%
Company Y	13.4%	LIBOR+0.6%

- Company X wants a floating rate loan
- Company Y wants a fixed rate loan
- Swap dealer charges 10 bp spread

Example of Interest Rate Swap

- Company X borrows at 12%
- Enters swap to pay LIBOR and get 12.3%
- Effectively X pays LIBOR - 0.3%

- Company Y borrows at LIBOR + 0.6%
- Enters swap to receive LIBOR and pay 12.4%
- Effectively Y pays 13%

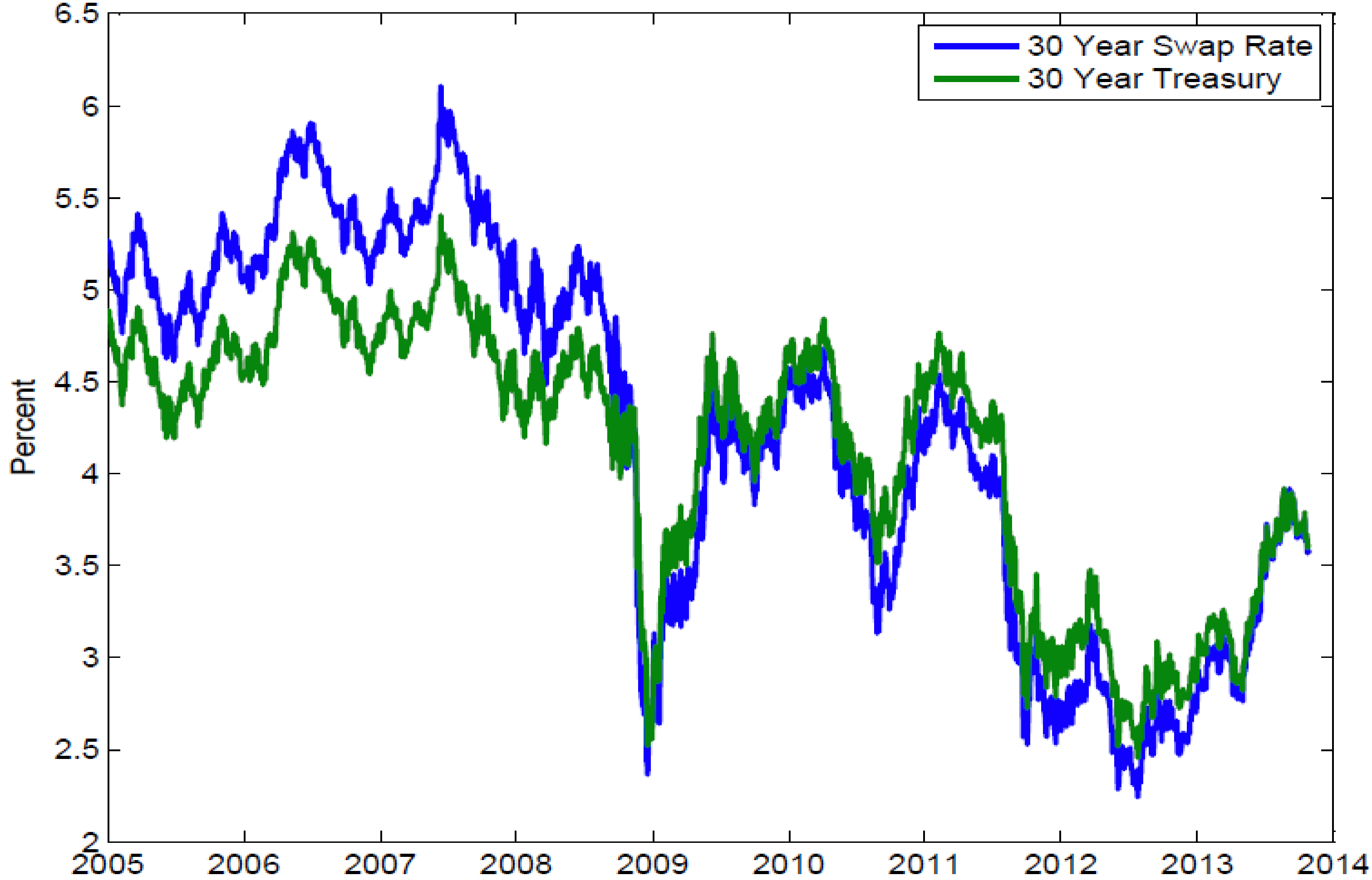
Case Study: Harvard and Use of Swaps

- In 2004 Harvard planned big expansion
- Planned to borrow $2.3 billion starting in 2008
- Entered into ***forward*** swap agreements to pay fixed and receive floating
  - No upfront cost, unlike a forward rate agreement

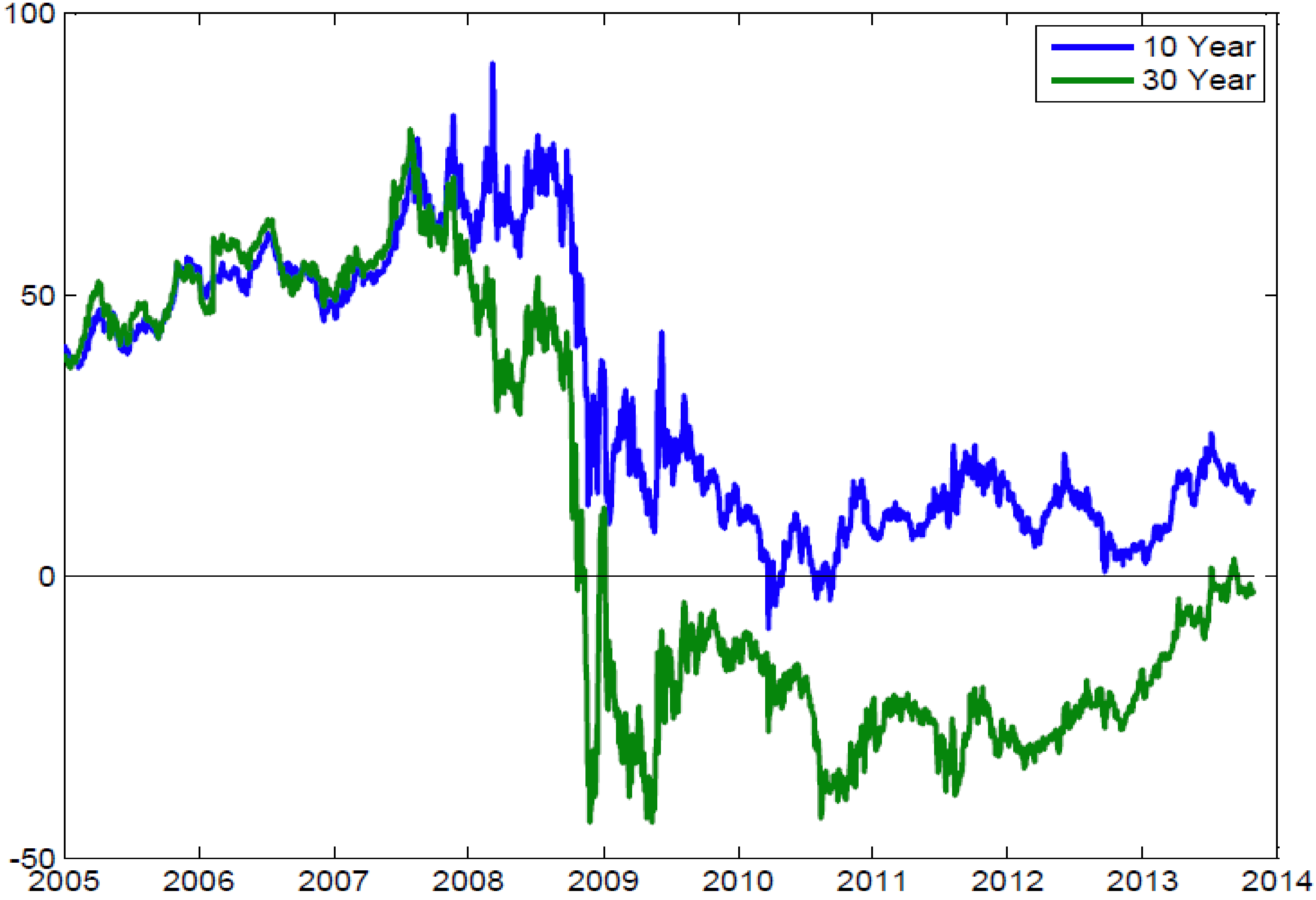
Case Study: Harvard and Use of Swaps

- In 2008 Harvard didn’t want to borrow
- But they still had swaps
- With short rates falling, pay fixed receive floating is costly
- Had to post margin
- Paid nearly $1 billion to exit swap contracts at worst possible time

Treasury and Swap Rates



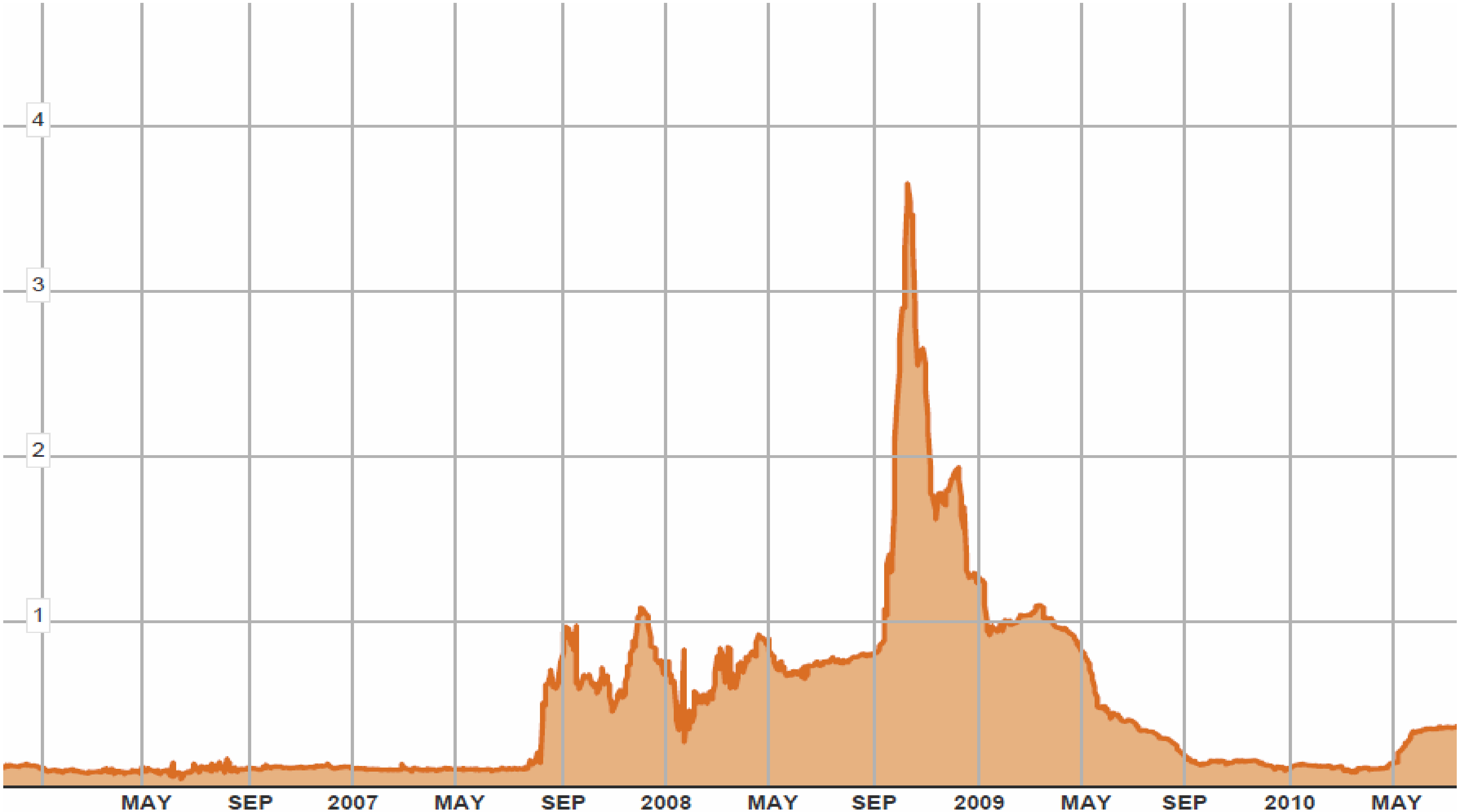
Swap Spreads



Swap Bond Arbitrage

- If swap rate is above bond rate
  - Short the bond
  - Invest the proceeds in floating
  - Receive fixed in a swap contract
- Limitation is default risk
- If swap rate is below bond rate
  - Borrow at the floating rate
  - Pay fixed
  - Go long the bond
- Why isn't this being done (more)?

3 month LIBOR-OIS spreads



Inflation Swaps

- Buyer of inflation protection pays a fixed rate on a notional principle
- Seller of inflation protection pays whatever CPI inflation turns out to be over next n years
- Pension funds might want to buy inflation protection

Credit Default Swaps

- Payment on a CDS is tied to the financial status of a bond
- The buyer of credit protection pays a fixed rate
- If the bond defaults, the issuer of the protection has to buy the bond at par value
  - Settlement can be *physical* or *cash*

Credit Default Swaps: Example

- Investor buys protection for $10 million of Risky Bank Debt
- CDS spread is 30 bps
- Each year, buyer of protection pays seller of protection $30,000
- On default, the seller pays the buyer $10 million less the value of the defaulted bonds

Credit Default Swaps: Pricing Example

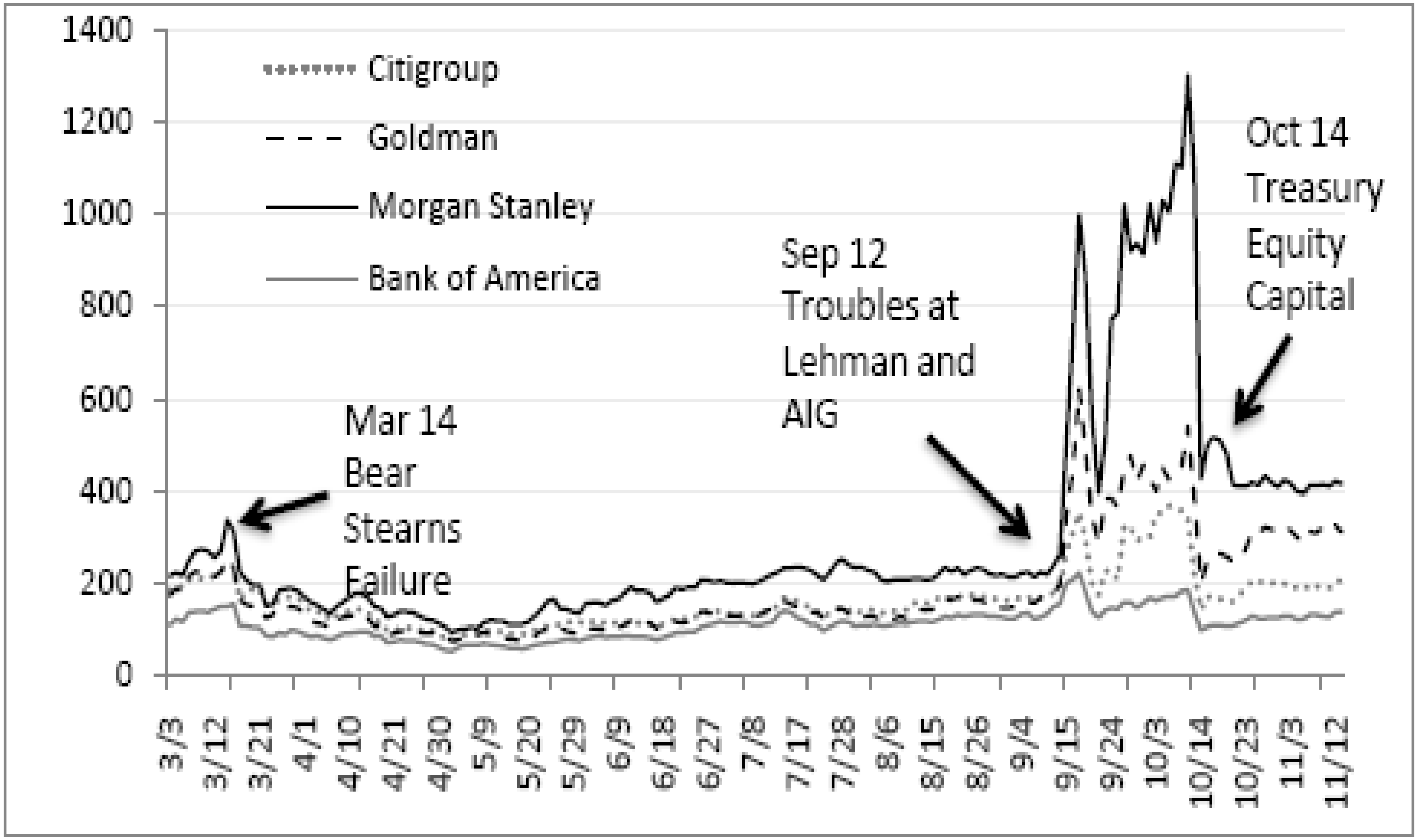
- Suppose investors are risk neutral
- Risky Bank has a 20% chance of failing in 5 years
- If it fails, recovery will be 60%
- Q. What should the CDS spread be?

- A. Cost = Expected Benefit

  5*S=0.2*0.4

  S=0.016 (160 basis points)

Bank CDS rates in 2008



CDS Bond Arbitrage

- In theory

Corporate Bond + CDS Protection = Risk-free Bond

Corporate Bond Spread = CDS Rate

CDS Bond Arbitrage

- CDS are more liquid
- CDS are joint bets on the issuer and the counterparty
- The definition of what constitutes default can be manipulated

Option Terminology

- Buy - Long
- Sell - Short
- Call
- Put
- Key Elements
  - Exercise or Strike Price
  - Premium or Price
  - Maturity or Expiration

Market and Exercise Price Relationships

<u>In the Money</u> - exercise of the option would be profitable

Call: market price>exercise price

Put: exercise price>market price

<u>Out of the Money</u> - exercise of the option would not be profitable

Call: market price<exercise price

Put: exercise price<market price

<u>At the Money</u> - exercise price and asset price are equal

American vs. European Options

American - the option can be exercised at any time before expiration or maturity

European - the option can only be exercised on the expiration or maturity date

Different Types of Options

- Stock Options
- Index Options
- Futures Options
- Foreign Currency Options
- Interest Rate Options

Payoffs and Profits at Expiration - Calls

Notation

Stock Price = S_T Exercise Price = X

Payoff to Call Holder

$(S_T - X)$ if $S_T > X$

0   if $S_T \leq X$

Profit to Call Holder

Payoff - Purchase Price

Payoffs and Profits at Expiration - Calls

<u>Payoff to Call Writer</u>

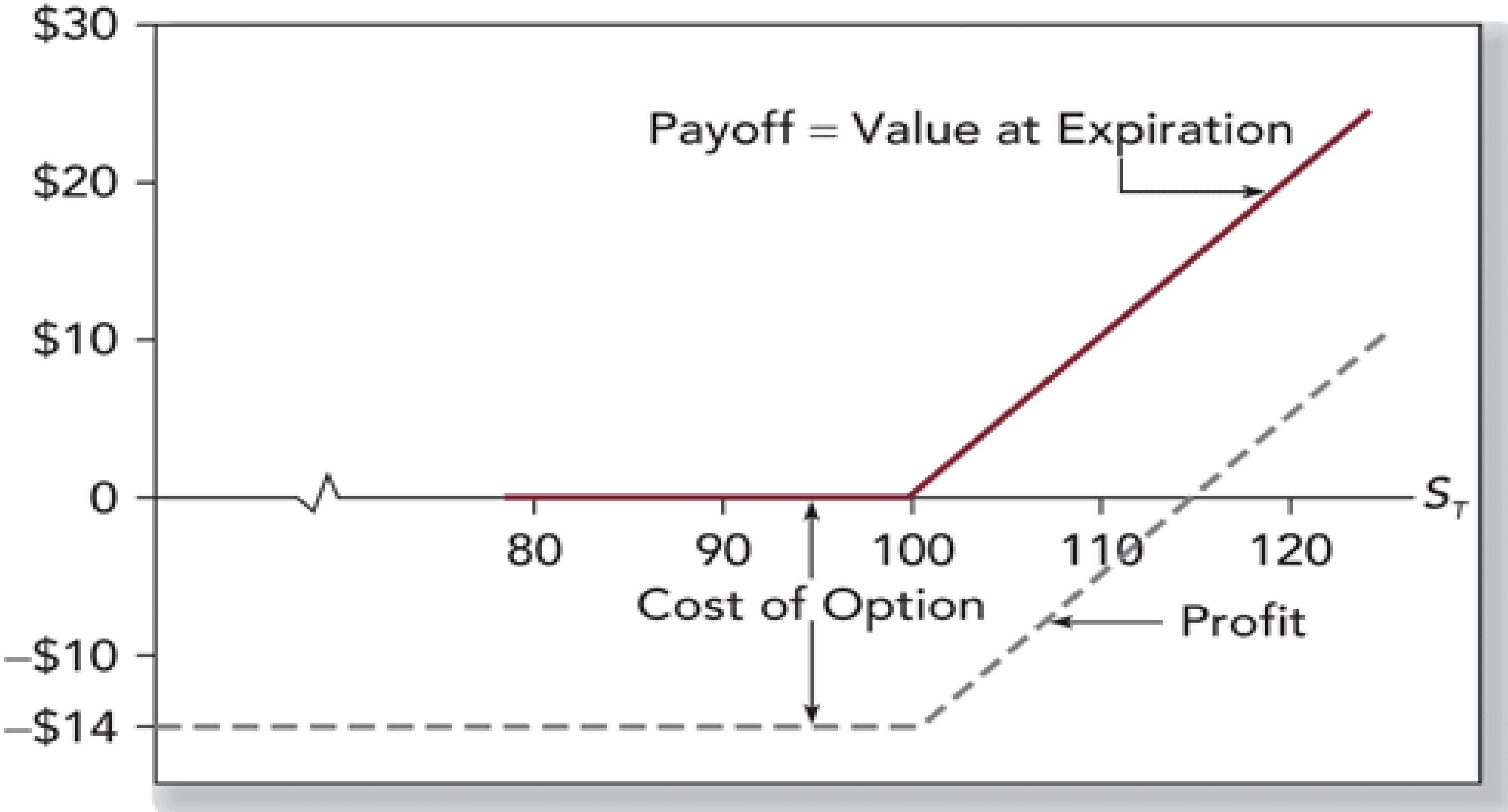
$-(S_T - X)$ if $S_T > X$

0 if $S_T \leq X$

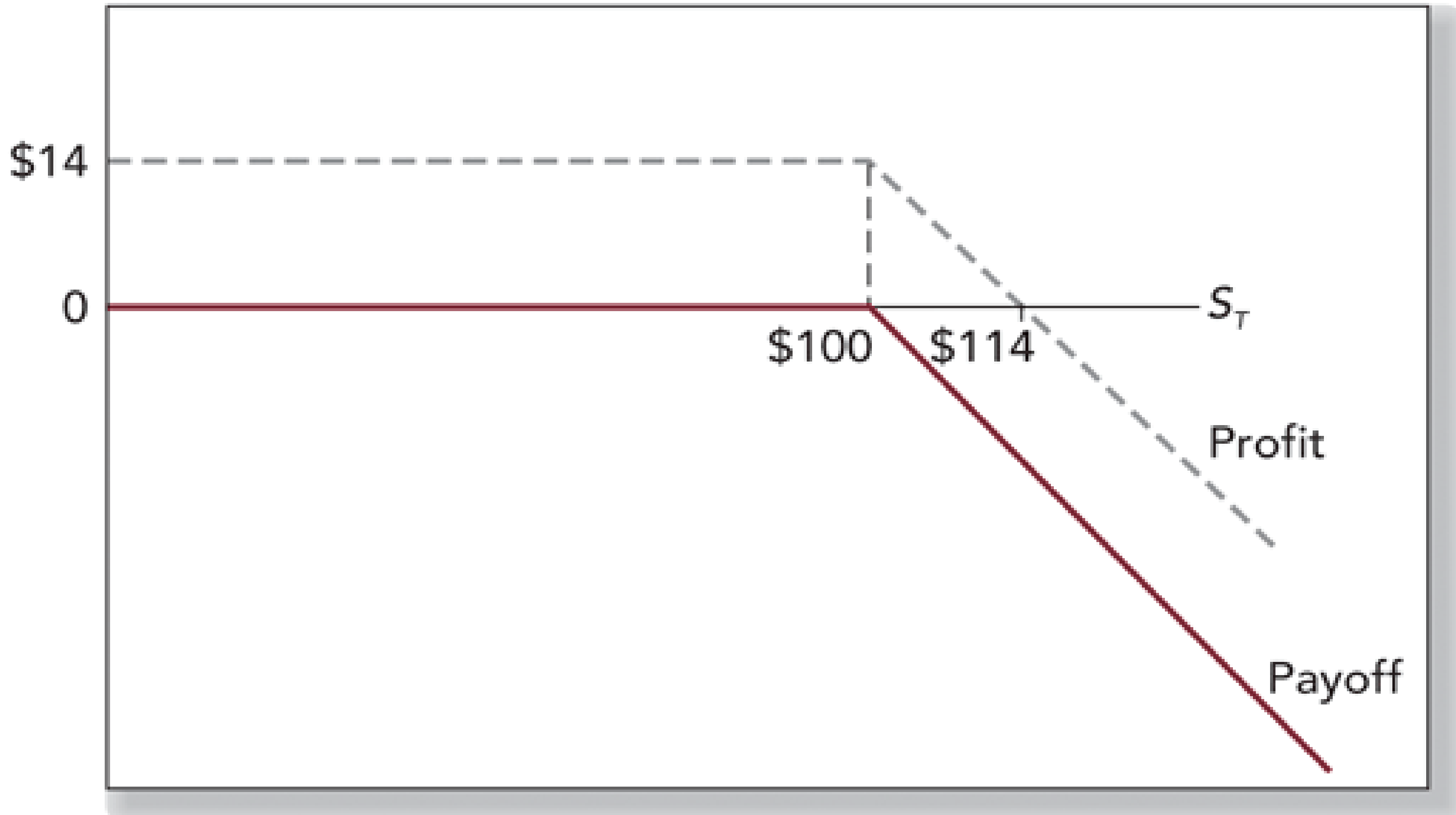
<u>Profit to Call Writer</u>

Payoff + Premium

Payoff and Profit to Call Option at Expiration



Payoff and Profit to Call Writers at Expiration



Payoffs and Profits at Expiration - Puts

<u>Payoffs to Put Holder</u>

0 if $S_T \geq X$

$(X - S_T)$ if $S_T < X$

<u>Profit to Put Holder</u>

Payoff - Premium

Payoffs and Profits at Expiration – Puts Continued

<u>Payoffs to Put Writer</u>

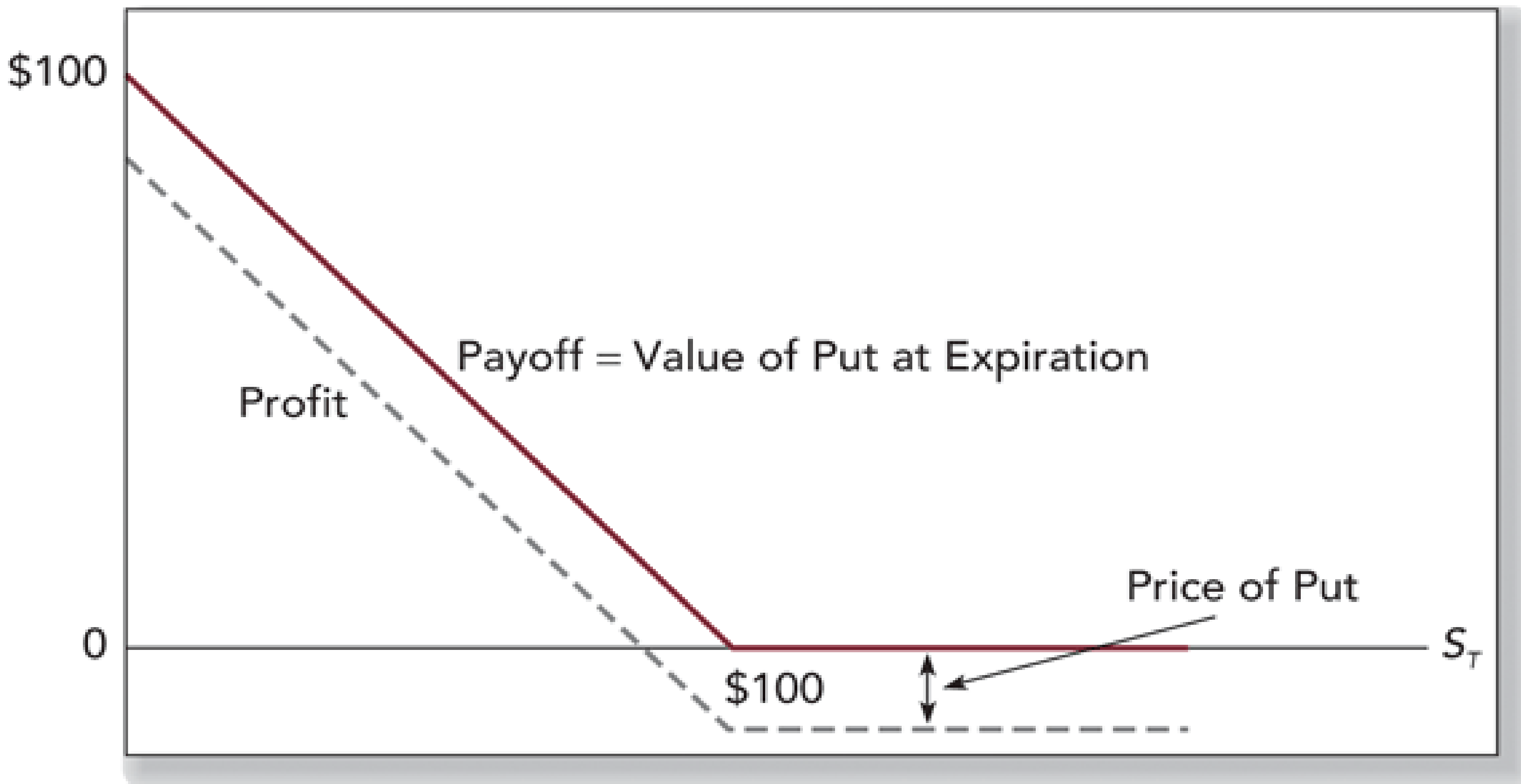
0 if $S_T \geq X$

$-(X - S_T)$ if $S_T < X$

<u>Profits to Put Writer</u>

Payoff + Premium

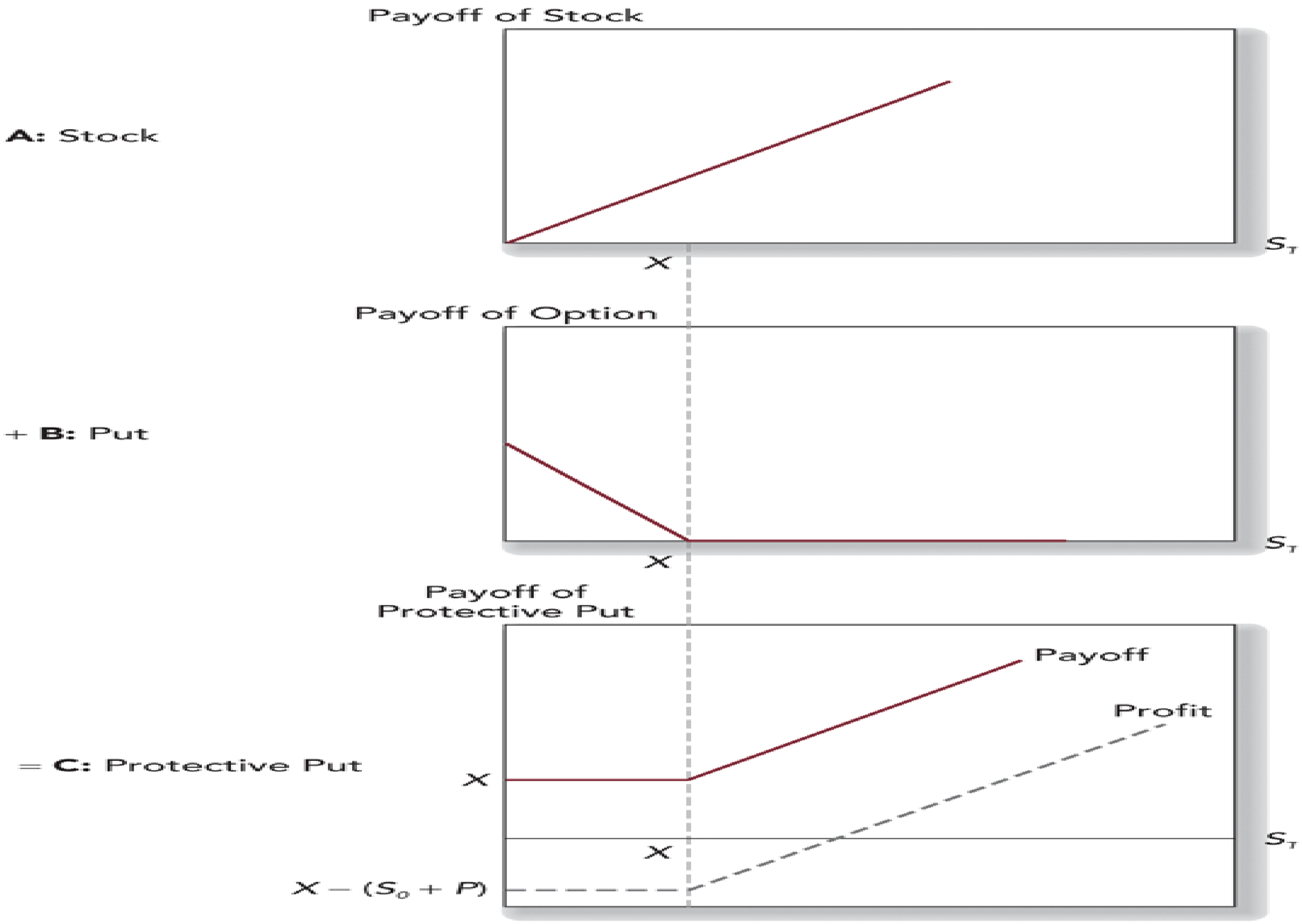
Payoff and Profit to Put Option at Expiration



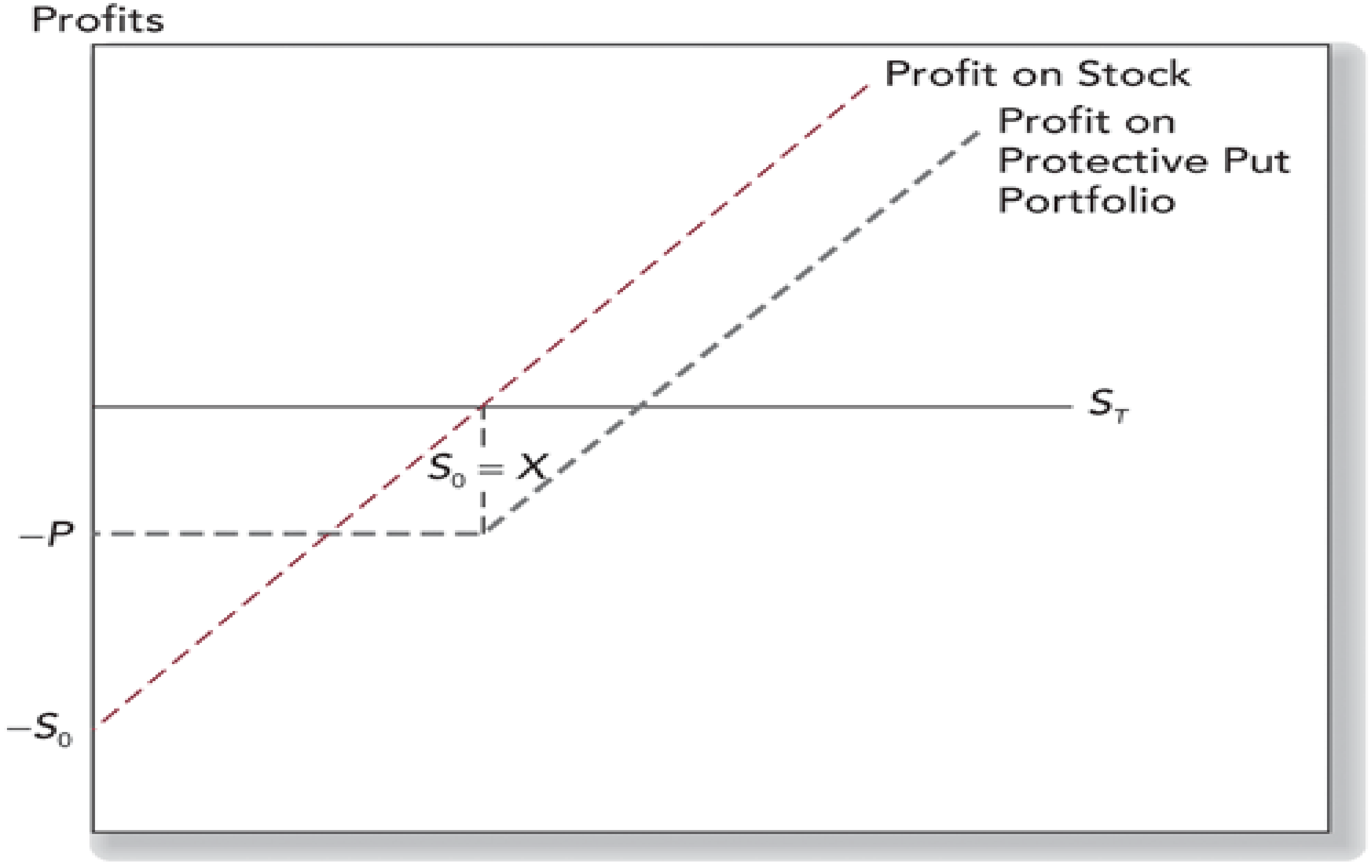
Value of Protective Put Portfolio at Option Expiration

	$S_T \le X$	$S_T > X$
Stock	S_T	S_T
+ Put	$X - S_T$	0
= TOTAL	X	S_T

Value of a Protective Put Position at Option Expiration



Protective Put versus Stock Investment (at-the-money option)



Option Strategies

Straddle (Same Exercise Price)

- Long Call and Long Put

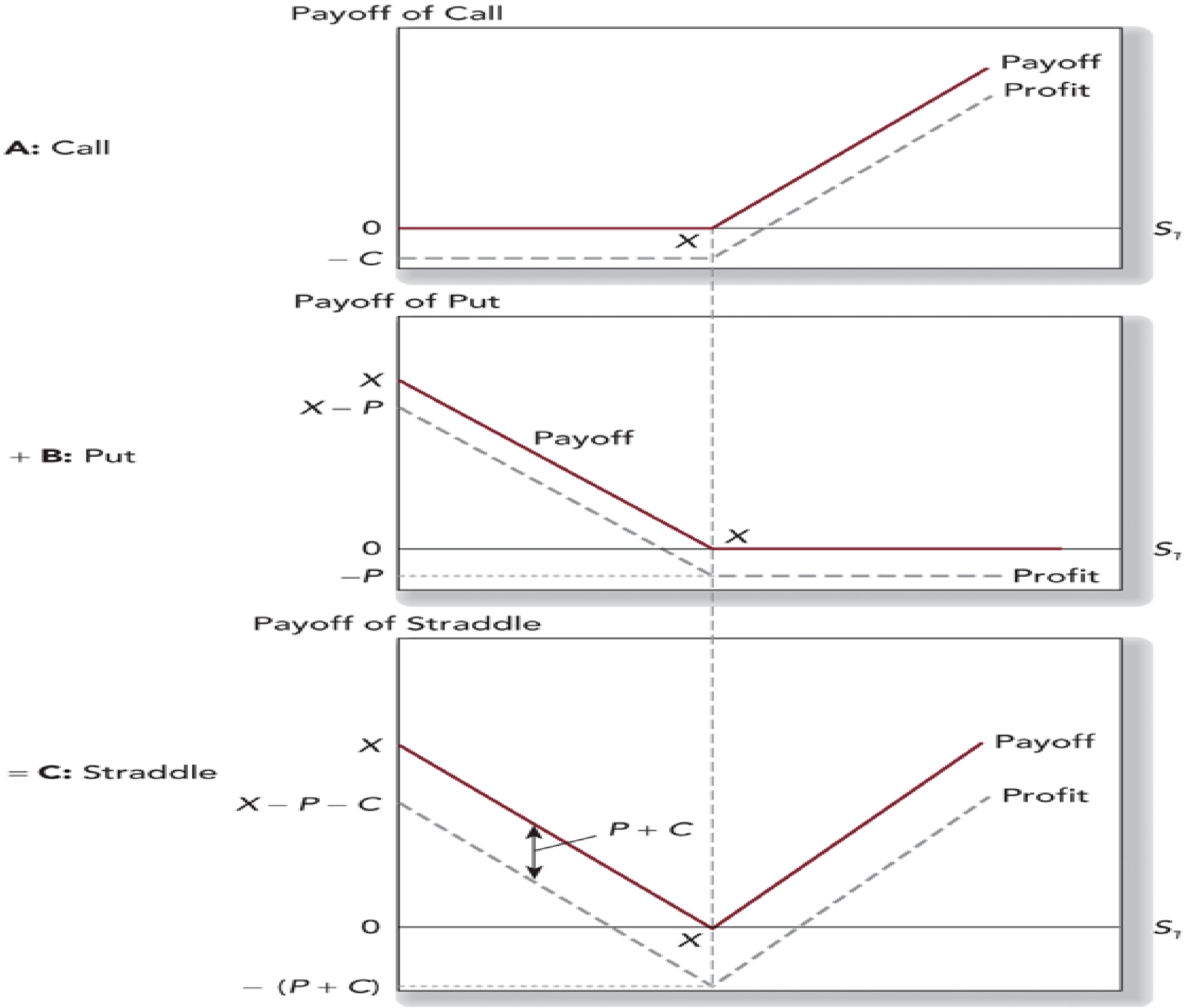
Spreads - A combination of two or more call options or put options on the same asset with differing exercise prices or times to expiration.

- Vertical or money spread:
  - Same maturity
  - Different exercise price
- Horizontal or time spread:
  - Different maturity dates

Value of a Straddle Position at Option Expiration

	$S_T < X$	$S_T \geq X$
Payoff of call	0	$S_T - X$
+ Payoff of put	$X - S_T$	0
= TOTAL	$X - S_T$	$S_T - X$

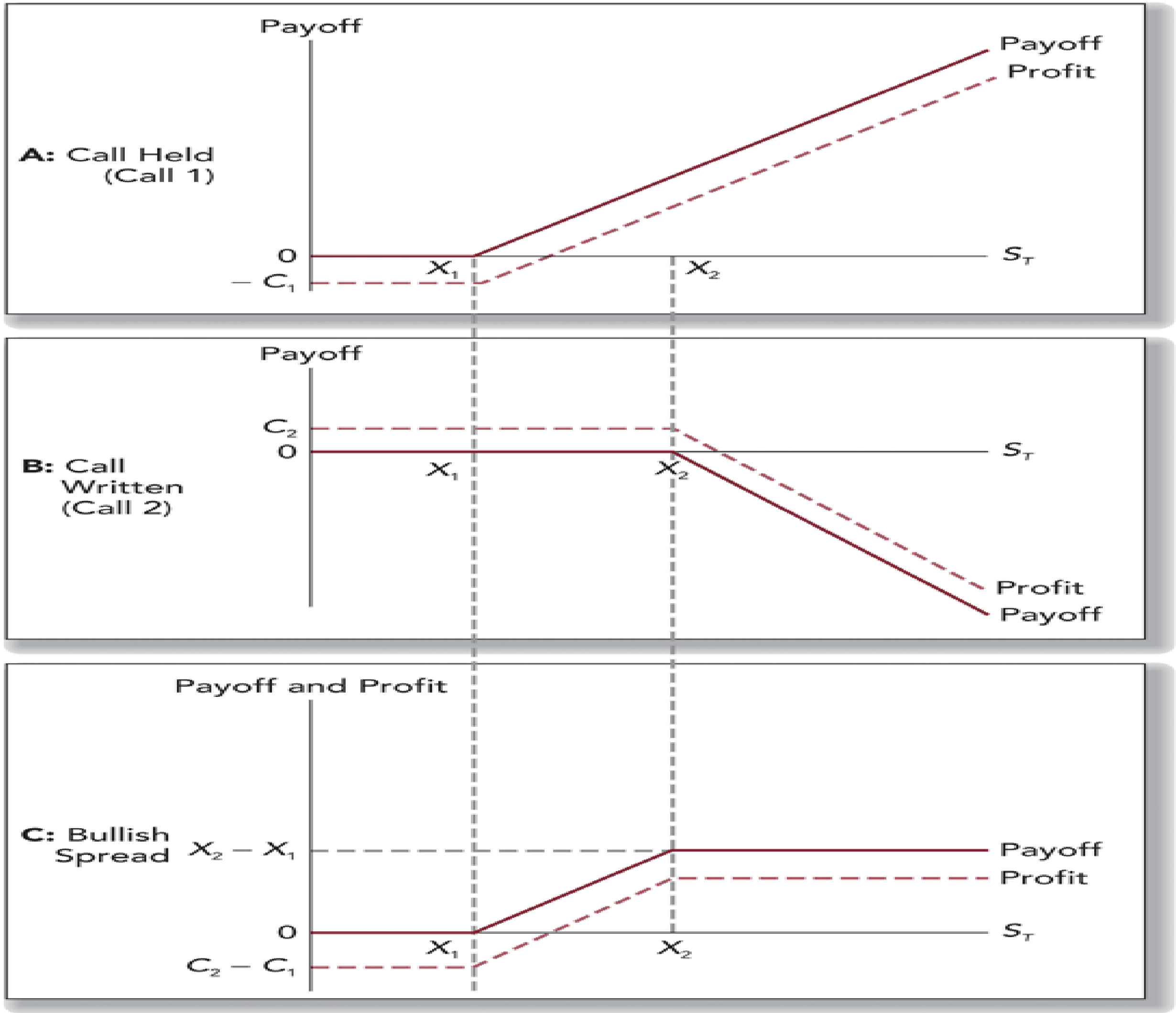
Value of a Straddle at Expiration



Value of a Bullish Spread Position at Expiration

	$S_T \le X_1$	$X_1 < S_T \le X_2$	$S_T \ge X_2$
Payoff of purchased call, exercise price = X_1	0	$S_T - X_1$	$S_T - X_1$
+ Payoff of written call, exercise price = X_2	-0	-0	$-(S_T - X_2)$
= *TOTAL*	0	$S_T - X_1$	$X_2 - X_1$

Value of a Bullish Spread Position at Expiration



Put Call Parity

Violations of relationship mean arbitrage will be possible

$$C + \frac{X}{(1 + r_f)^T} = S_0 + P$$

- C is the price of a call option at strike X
- P is the price of a put option at strike X
- T is the maturity time of the options
- r_f is the riskfree rate
- S_0 is the stock price today

Put Call Parity - Disequilibrium Example

Stock Price = 110   Call Price = 17

Put Price = 5   Risk Free = 5%

Maturity = 1 yr   X = 105

$$C + \frac{X}{(1 + r_f)^T} = S_0 + P$$

117 > 115

Implies an arbitrage opportunity

Arbitrage Strategy

Position	Immediate Cash Flow	Cash Flow in 1 year	
		$S_T < 105$	$S_T \geq 105$
Buy stock	−110	S_T	S_T
Borrow \$105/1.05 = \$100	+100	−105	−105
Sell call	+17	0	$-(S_T - 105)$
Buy put	−5	$105 - S_T$	0
TOTAL	2	0	0

Put Call Parity - Example

Stock Price = 80   Call Price for a strike at 90= 10

Risk Free = 2%   Maturity = 1 yr

What is the put price for a strike of 90 (1 year maturity)

$$C + \frac{X}{(1+r_f)^T} = S_0 + P$$

$$\therefore P = C + \frac{X}{(1+r_f)^T} - S_0 = 10 + \frac{90}{1.02} - 80 = 18.24$$

Risk-Neutral Implied Densities

- Suppose that there are K possible outcomes
  - Called “states of the world”
- An “Arrow Debreu security” pays off $1 in one particular state of the world and $0 in all others
- Let $v(k)$ denote the price of the Arrow Debreu security that pays $1 in the kth state of the world
  - Probability of payoff under risk neutrality

Risk-Neutral Implied Densities

- Now suppose that there are K different options.
- Suppose that the *i*th option has a payoff *p(i,k)* in the *k*th state of the world
- Price of the option

$$\Sigma_{k=1}^{K} p(i,k)v(k)$$

Risk-Neutral Implied Densities

- Given the prices of K-1 options can reverse-engineer the probabilities of the different states.

- Example: The price of oil will be $50, $60 or $70
  - Price of an option to buy at $60 is $4
  - Price of an option to buy at $50 is $12

4=P70*10

12=(P70*20)+(P60*10)

1=P50+P60+P70

Implies P70=0.4;   P60=0.4;   P50=0.2

Arbitrage Restrictions on Option Values

- Values cannot be negative (call or put)
- American options are always at least as valuable as European options

Arbitrage Restrictions on Option Value: Call Stock Pays no Dividends

$$C \geq 0$$

$$C \leq S_0$$

$$C \geq S_0 - \frac{X}{(1 + r_f)^T}$$

$$C \geq S_0 - X \text{ for an American option only}$$

Arbitrage Restrictions on Option Value: Put Stock Pays no Dividends

$$P \geq 0$$

$$P \leq X$$

$$P \geq \frac{X}{(1+r_f)^T} - S_0$$

$$P \geq X - S_0 \text{ for an American option only}$$

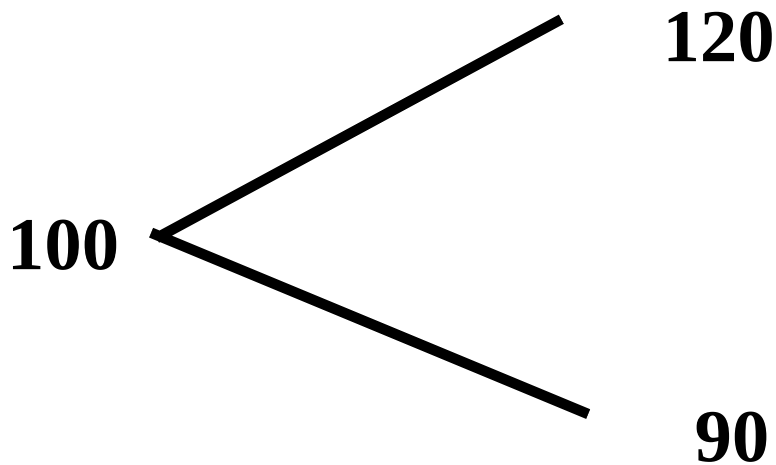
Early Exercising of an American Option

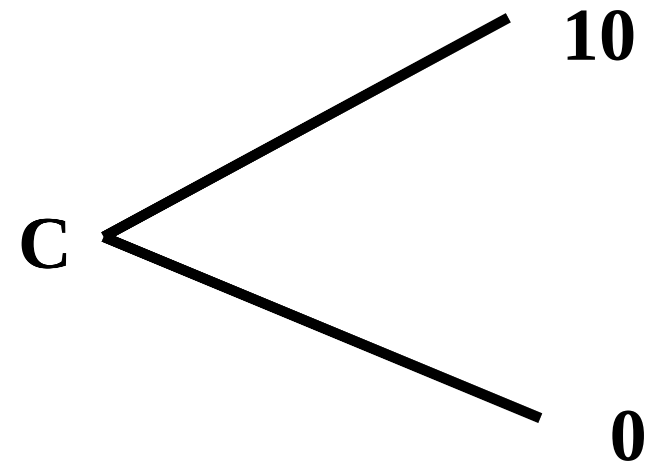
- It may be rational to exercise an American Option early
- *Exception: It is never rational to exercise an American Call option early on a non-dividend paying stock*

Binomial Option Pricing

- Binomial option pricing approximates stock movements by two possible outcomes up or down
- Creates a portfolio of a bond and the stock which has the same payoff as the option
- And so should have the same price
- Called a **replication** pricing method

Binomial Option Pricing: Example





Stock Price

Call Option Value
X = 110

Binomial Option Pricing: Example Continued

<u>Alternative Portfolio</u>

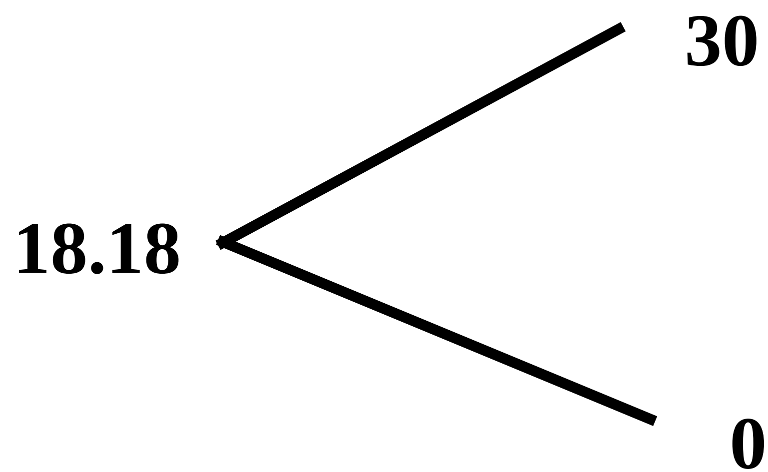
Buy 1 share of stock at $100

Borrow $81.82 (10% Rate)

Net outlay $18.18

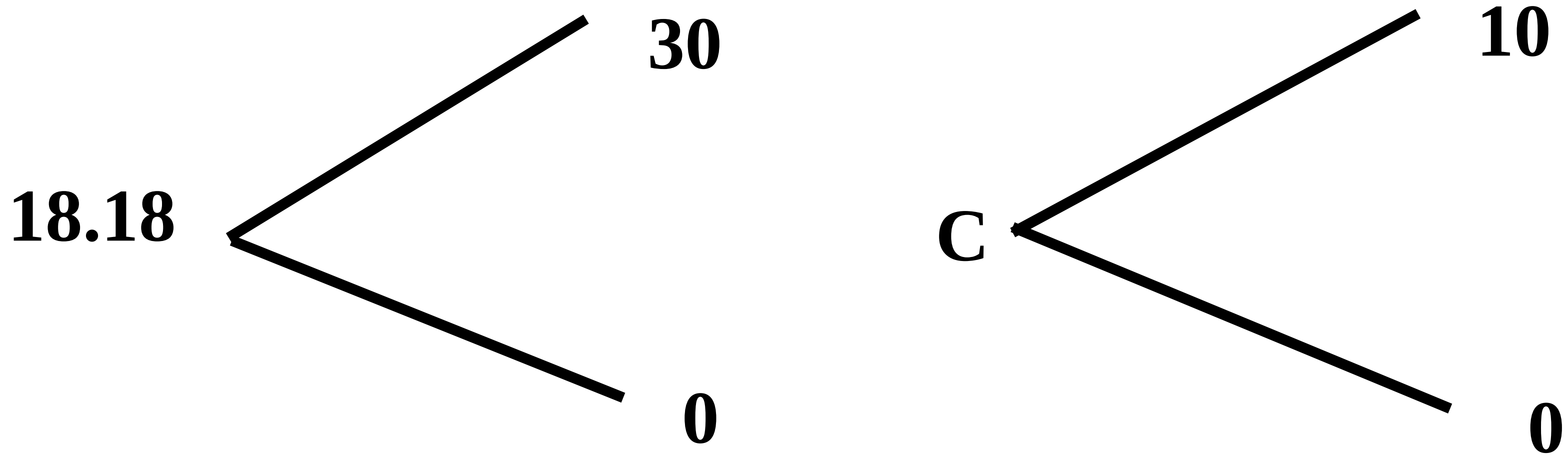
Payoff

Value of Stock	**90**	**120**
Repay loan	**- 90**	**- 90**
Net Payoff	**0**	**30**



Payoff Structure is exactly 3 times the Call

Binomial Option Pricing: Text Example Continued



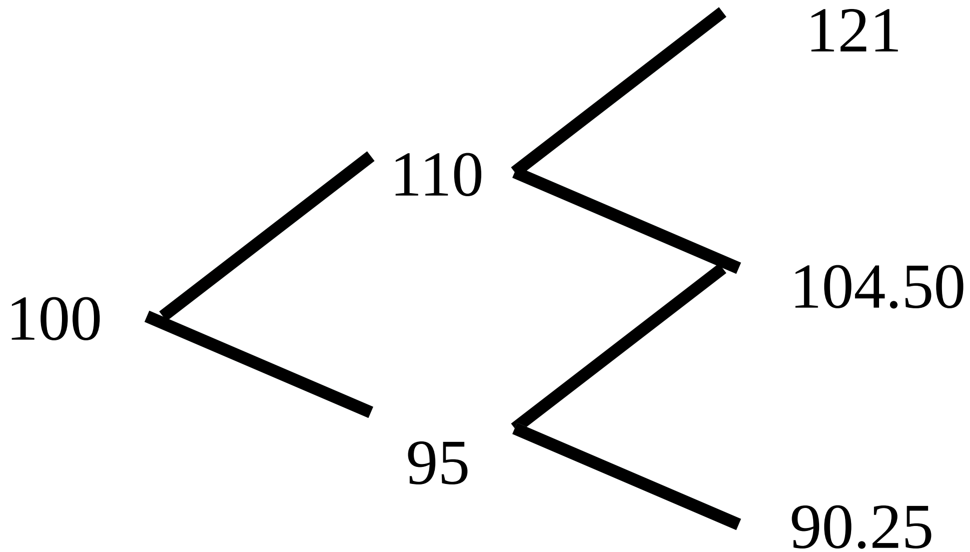
3C = $18.18

C = $6.06

Generalizing the Two-State Approach

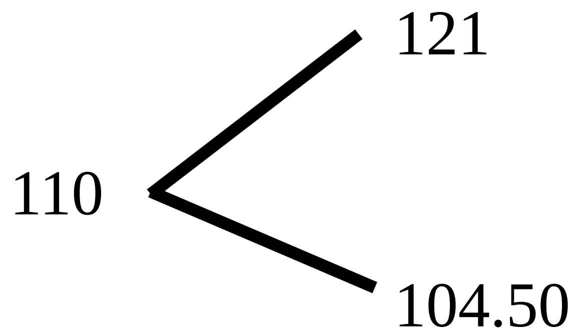
- Assume that we can break the year into two six-month segments
- In each six-month segment the stock could increase by 10% or decrease by 5%
- Assume the stock is initially selling at 100
- Possible outcomes:
  - Increase by 10% twice
  - Decrease by 5% twice
  - Increase once and decrease once (2 paths)

Generalizing the Two-State Approach Continued



Generalizing the Two-State Approach Continued

Work backwards from the last node

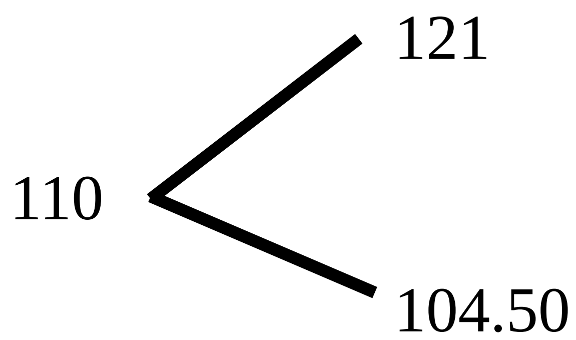


A call option with a strike of $110 has a payoff of $11 or $0.

Alternative portfolio: Buy 1 share for $110 and borrow $99.52

	Top Branch	Bottom Branch
Stock	121	104.5
Repay Loan	104.5	104.5
Total	16.5	0

Generalizing the Two-State Approach Continued



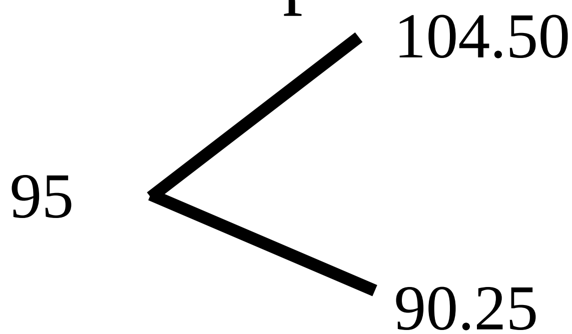
Call costs C and has a payoff of $11 or $0.

Alternative portfolio costs $10.48 and has a payoff of $16.50 or $0

Hence C=6.99

Generalizing the Two-State Approach Continued

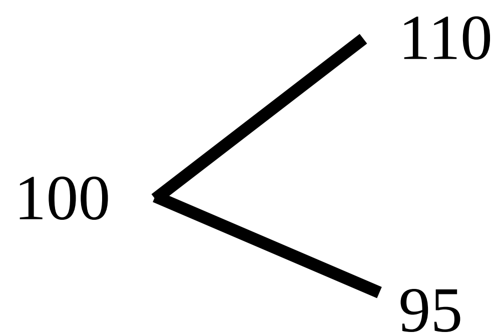
At the other end node, the stock price is



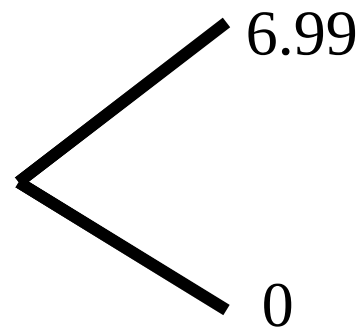
Call option is worthless

Generalizing the Two-State Approach Continued

At the first node



Call option payoff



Generalizing the Two-State Approach Continued

The call option costs C and has a payoff of $6.99 or $0.

Alternative portfolio: Buy 1 share for $100 and borrow $90.47

	Top Branch	Bottom Branch
Stock	110	95
Repay Loan	95	95
Total	15	0

Alternative portfolio costs $9.53 and has a payoff of $15 or $0

So the call option costs $4.44

Example A

- The price of a stock today is $50.
- In one year's time, it will either go up to $55 or down to $45.
- The risk-free interest rate is 5 percent.
- Find the price of a put option with a strike
- price of $50.

Example A

- Price the call option
  - Call option worth \$5 if price rises
  - Buy 1 share and borrow \$45/1.05=\$42.86
  - Price of the call option is \$3.57
- By put-call parity

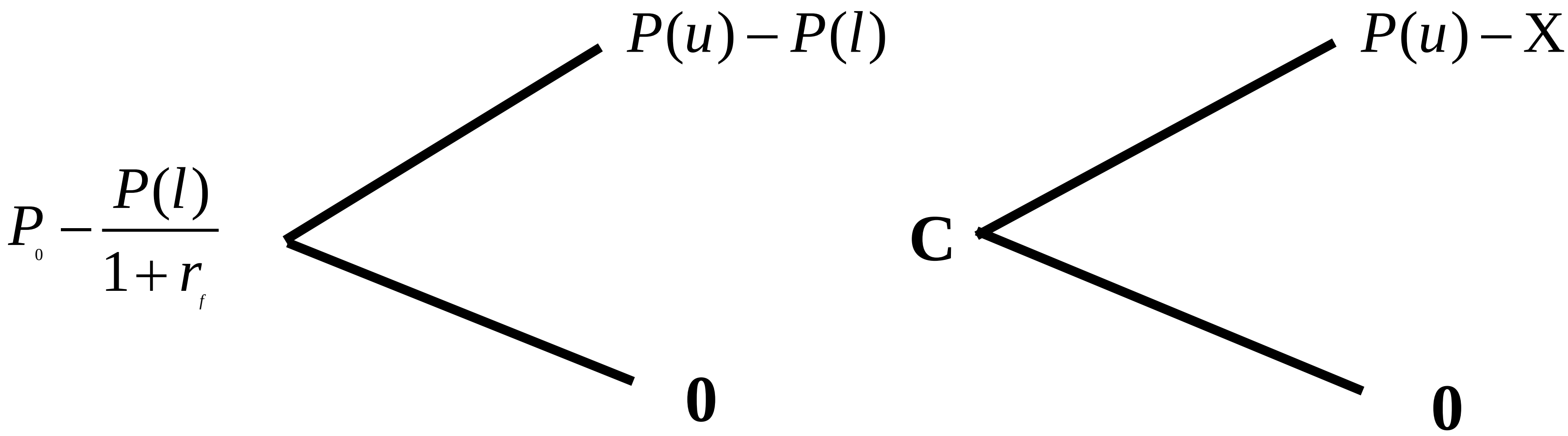
$$3.57+\frac{50}{1.05}=50+P$$

- Put option is worth \$1.19

A general formula

- The price of a stock today is P(0).
- In one year's time, it will either go up to P(u) or down to P(l).
- The risk-free interest rate is r.
- Find the price of a call option with a strike price of X where $P(l) \leq X \leq P(u)$.

General Formula: Continued

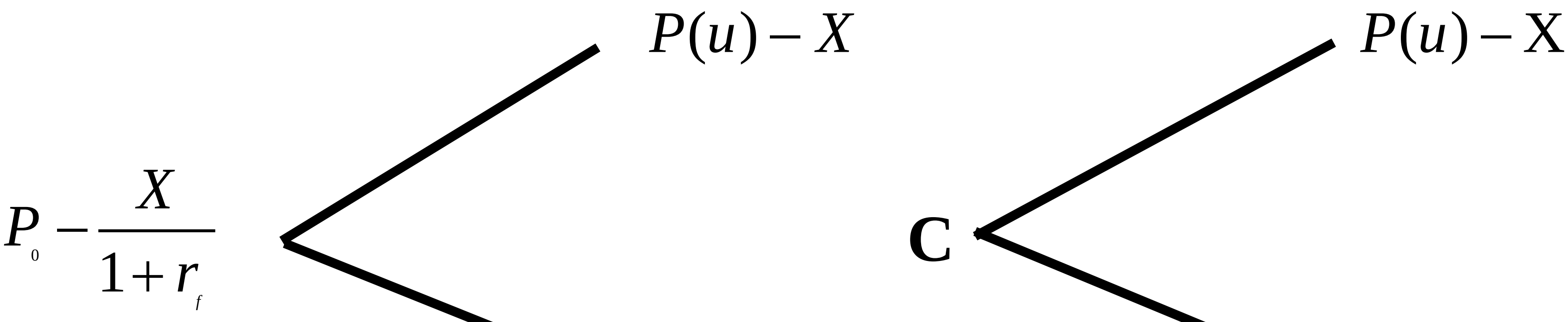


$$C = [P_0 - \frac{P(l)}{1 + r_f}] \frac{P(u) - X}{P(u) - P(l)}$$

A general formula

- Same setup as before except that P(l)>X.
- Option expires in the money on both branches.
- Turns out to be simpler.

General Formula: Continued



$$C = [P_0 - \frac{X}{1+r_f}]$$

Example B

- The price of a stock today is $50. The risk-free rate is 0. One of the following scenarios occurs:

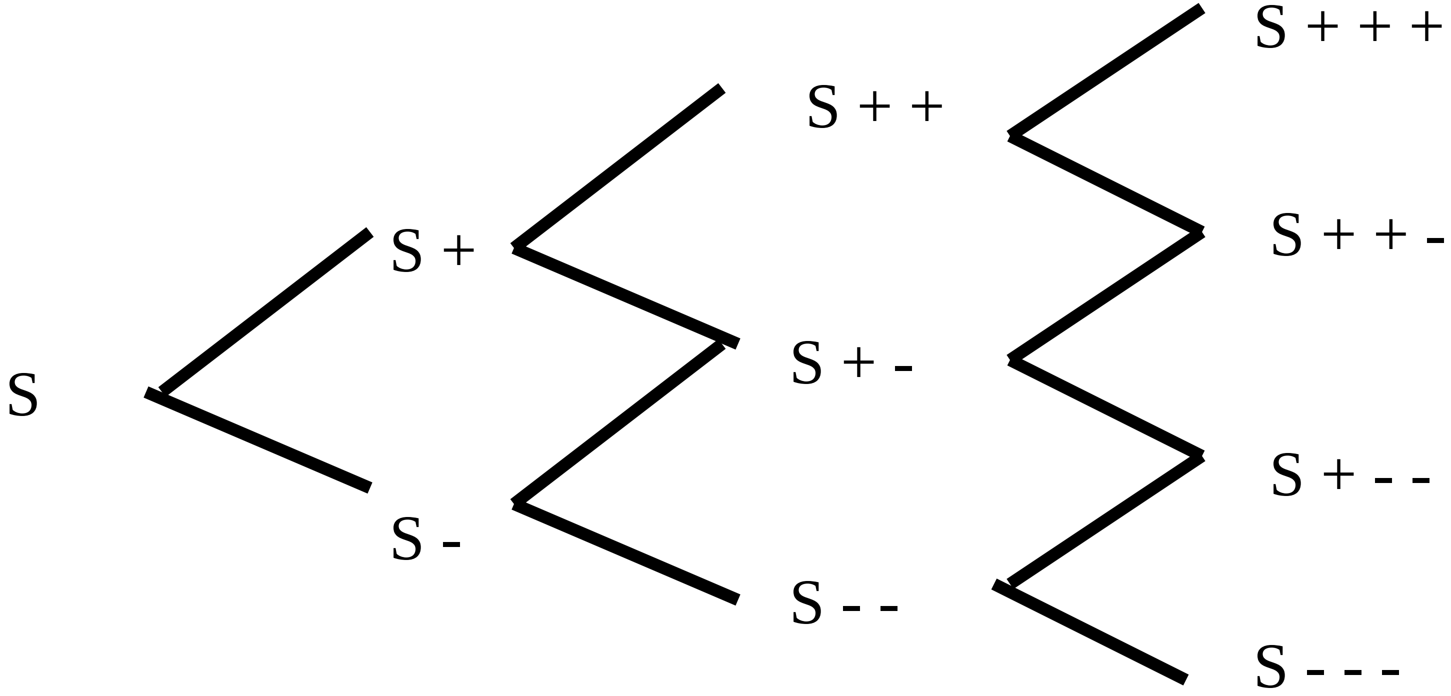
	Price in 6 months	Price in 1 year
A	52	55
B	52	50
C	48	50
D	48	46

- Price a call option at $52 in 1 Year

Expanding to Consider Three Intervals

- Assume that we can break the year into three intervals
- For each interval the stock could increase by 5% or decrease by 3%
- Assume the stock is initially selling at 100

Expanding to Consider Three Intervals Continued



Possible Outcomes with Three Intervals

Event	Probability	Final Stock Price	
3 up	1/8	$100\ (1.05)^3$	=115.76
2 up 1 down	3/8	$100\ (1.05)^2\ (.97)$	=106.94
1 up 2 down	3/8	$100\ (1.05)\ (.97)^2$	= 98.79
3 down	1/8	$100\ (.97)^3$	= 91.27

Binomial Option Pricing

- Note that binomial option pricing makes no assumption on preferences
  - Agents can be risk-averse or risk-neutral

Black-Scholes Option Valuation

$C_o = S_o N(d_1) - Xe^{-rT} N(d_2)$

$d_1 = [\ln(S_o/X) + (r + \sigma^2/2)T] / (\sigma T^{1/2})$

$d_2 = d_1 - (\sigma T^{1/2})$

where

C_o = Current call option value

S_o = Current stock price

$N(d)$ = probability that a random draw from a standard normal distribution will be less than d

Black-Scholes Option Valuation Continued

X = Exercise price

e = 2.71828, the base of the natural log

r = Risk-free interest rate (annualizes continuously compounded with the same maturity as the option)

T = time to maturity of the option in years

ln = Natural log function

σ = Standard deviation of annualized cont. compounded rate of return on the stock

Call Option Example

$S_o = 100$ $\quad X = 95$

$r = .10$ $\quad T = .25$ (quarter)

$\sigma = .50$

$d_1 = [\ln(100/95) + (.10+(.5^{2}/2))*0.25] / (.5\ .25^{1/2})$

$= .43$

$d_2 = .43 - ((.5)(.25^{1/2})$

$= .18$

N(0.43)= 0.6664

N(0.18)=0.5714

Call Option Value

$C_o = S_o N(d_1) - Xe^{-rT} N(d_2)$

$C_o = 100 \text{ X } .6664 - 95\, e^{-.10 \text{ X } .25} \text{ X } .5714$

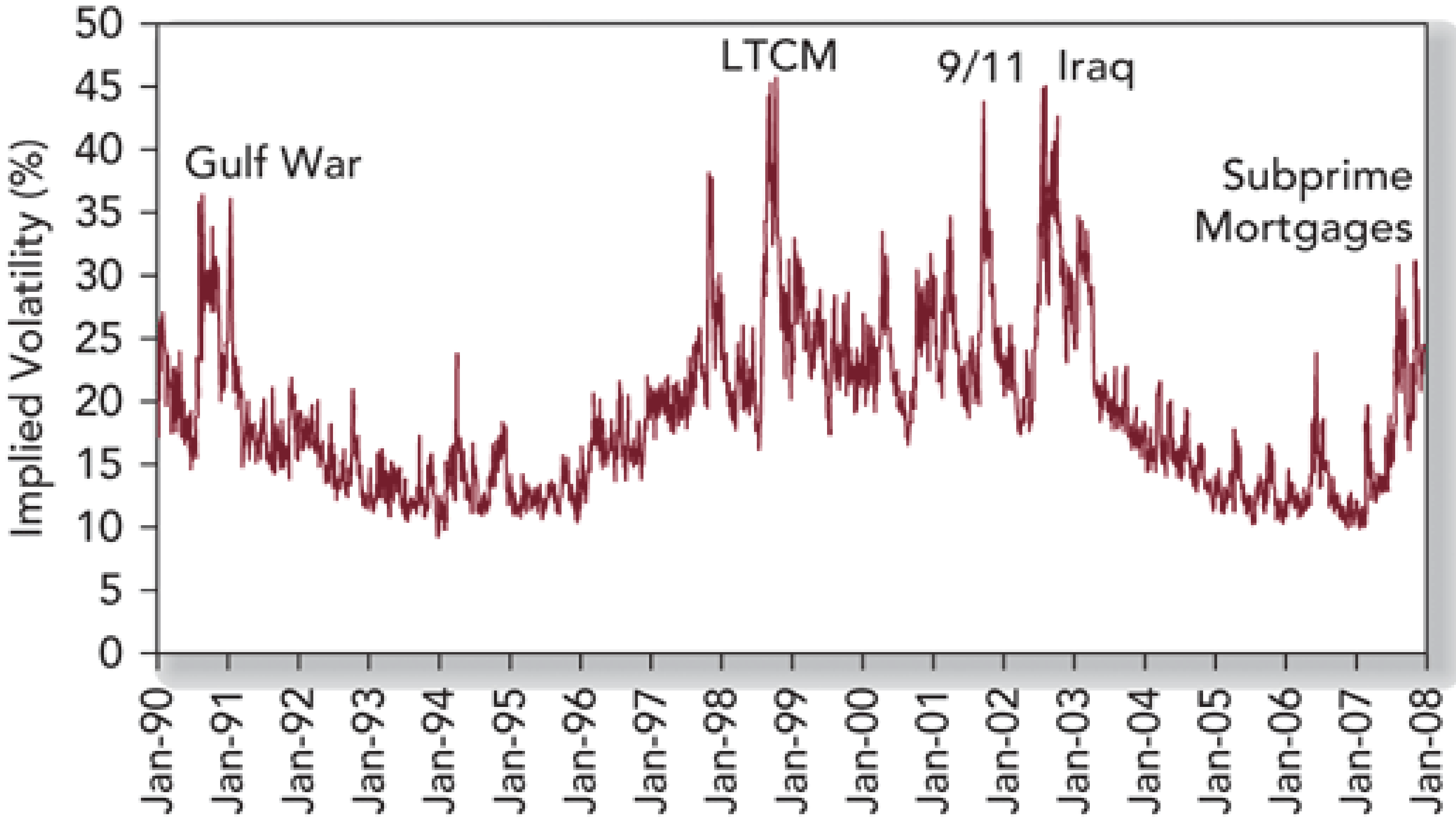
$C_o = 13.70$

Implied Volatility

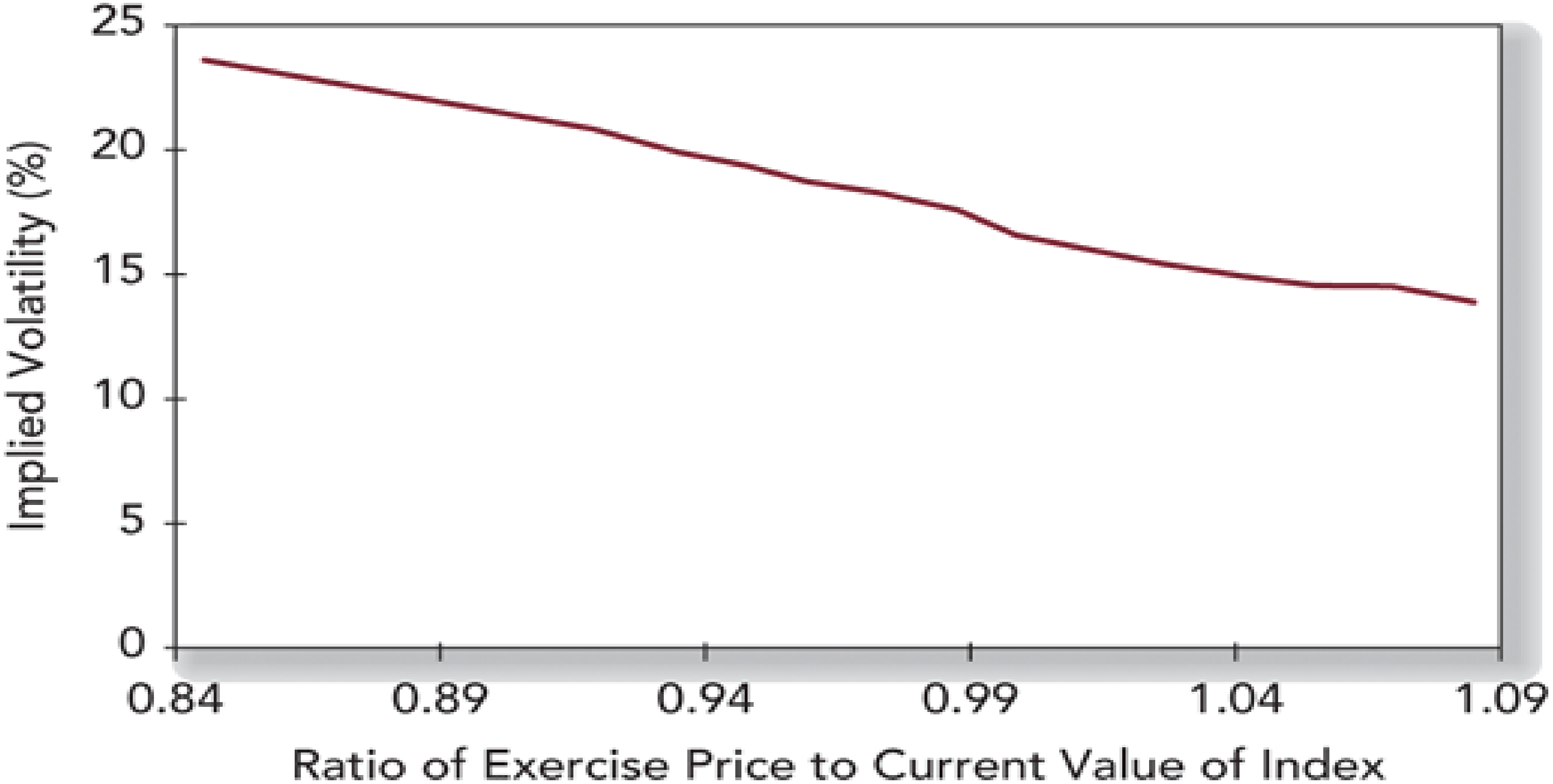
Using Black-Scholes and the actual price of the option, solve for volatility.

Is the implied volatility consistent with the stock volatility?

Implied Volatility of the S&P 500



Implied Volatility of the S&P 500 Index as a Function of Exercise Price



Put Value Using Black-Scholes

$P = Xe^{-rT} [1\text{-}N(d_2)] - S_0 [1\text{-}N(d_1)]$

Using the sample call data

$S = 100$ $r = .10$ $X = 95$ $g = .5$ $T = .25$

$95e^{-10x.25}(1-.5714)-100(1-.6664) = 6.35$

Put Option Valuation: Using Put-Call Parity

$$C + Xe^{-rT} = S_o + P$$

Using the example data

$C = 13.70$ $X = 95$ $P = 6.35$ $S = 100$

$r = .10$ $T = .25$

$C + Xe^{-rT} = 13.70 + 95\, e^{-.10 \text{ X } .25} = 106.35$

$S + P = 106.35$

Call Option Example – Varying stock price

S_o=various X = 95

r = .10 T = .25 (quarter)

σ = .50

d_1 = [ln(100/95) + (.10+(.5 ^{2}/2))*0.25] / (.5 .25$^{1/2}$)

= .43

d_2 = .43 - ((.5)(.25$^{1/2}$)

= .18

N(0.43)= 0.6664

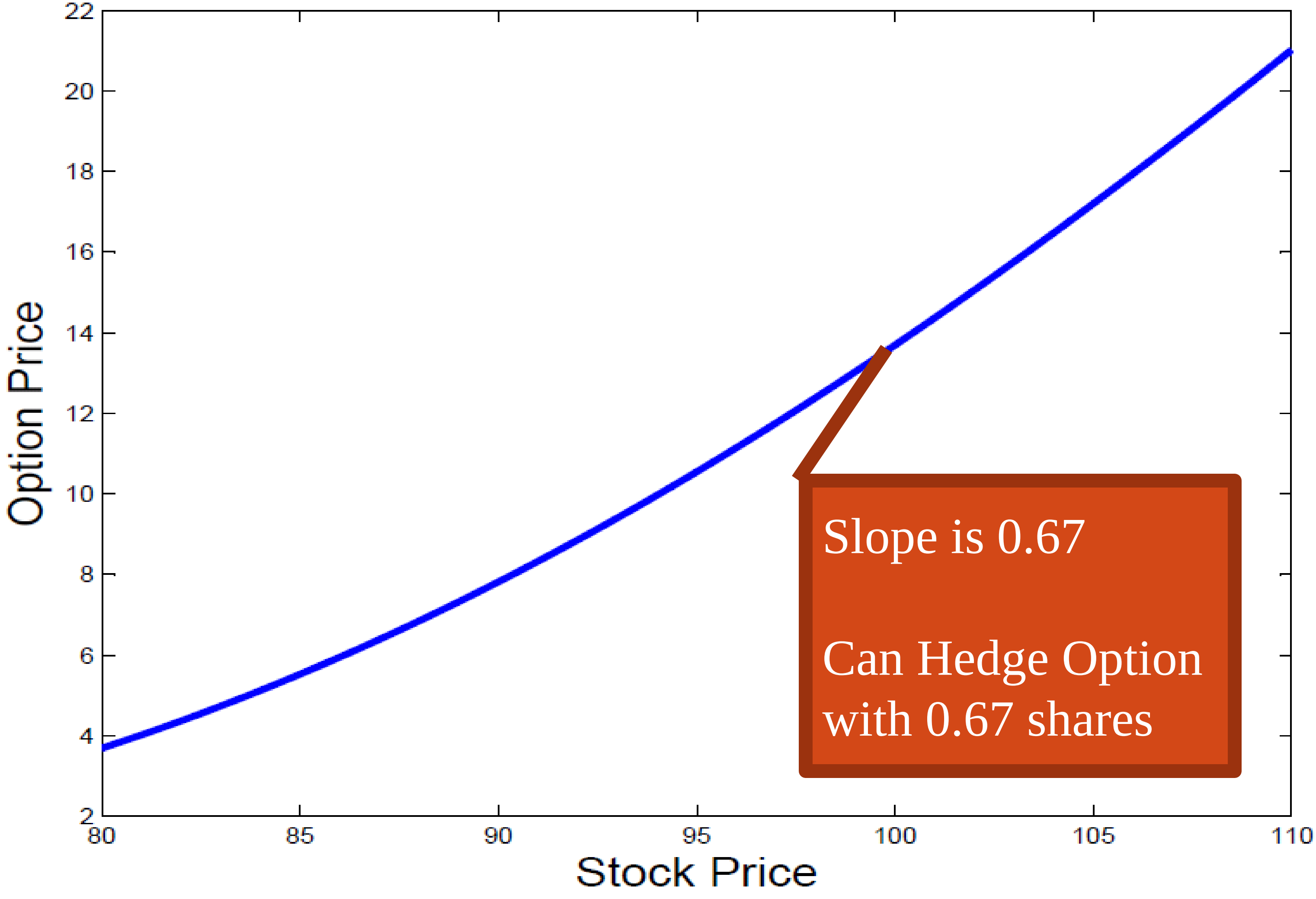
N(0.18)=0.5714

Call Option Example – Varying stock price

Stock Price	Call Option Price
98	12.3900
99	13.0400
100	13.7000
101	14.3700
102	15.0600

Slope: 0.67

Call Option Value and Hedge Ratio



Using the Black-Scholes Formula

Hedging: Hedge ratio or delta

The number of stocks required to hedge against the price risk of holding one option

$$\text{Call} = N(d_1)$$

$$\text{Put} = N(d_1) - 1$$

Option Elasticity

Percentage change in the option's value given a 1% change in the value of the underlying stock

Black-Scholes Greeks

Delta: Sensitivity of call option price to stock price

Vega: Sensitivity of call option price to volatility

Theta: Minus sensitivity of call option price to time

Rho: Sensitivity of call option price to risk-free rate

Hedging Bets On Mispriced Options

- Option value is positively related to volatility
  - If an investor believes implied volatility in an option's price is too low, a profitable trade is possible
  - *Delta* is the slope of the option pricing curve and tells us precisely how many shares of stock we must hold to offset our exposure

$$Delta = \frac{\Delta\, Option\, Value}{\Delta\, Stock\, Value}$$

Profit on a Hedged Put Portfolio

Table 21.3

Profit on hedged put portfolio

A. Cost to Establish Hedged Position

1,000 put options @ $4.495/option	$ 4,495
453 shares @ $90/share	40,770
Total outlay	$45,265

B. Value of Put Option as a Function of the Stock Price at Implied Volatility of 35%

Stock price:	**89**	**90**	**91**
Put price	$ 5.254	$ 4.785	$ 4.347
Profit (loss) on each put	0.759	0.290	(0.148)

C. Value of and Profit on Hedged Put Portfolio

Stock price:	**89**	**90**	**91**
Value of 1,000 put options	$ 5,254	$ 4,785	$ 4,347
Value of 453 shares	40,317	40,770	41,223
Total	$45,571	$45,555	$45,570
Profit (= Value – Cost from Panel A)	306	290	305

Delta Neutral

- **Delta neutral** means the value of the options portfolio is not affected by changes in the value of the underlying asset
  - In other words, the portfolio has no tendency to either increase or decrease in value when the stock price fluctuates

Profits on Delta-Neutral Options Portfolio

Table 21.4

Profits on delta-neutral options portfolio

A. Cost Flow When Portfolio Is Established			
Purchase 1,000 calls ($X = 90$) @ \$3.6202 (option priced at implied volatility of 27%)	\$3,620.20 cash outflow		
Write 1,589 calls ($X = 95$) @ \$2.3735 (option priced at implied volatility of 33%)	3,771.50 cash inflow		
Total	\$ 151.30 net cash inflow		
B. Option Prices at Implied Volatility of 30%			
Stock price:	**89**	**90**	**91**
90-strike-price calls	\$3.478	\$3.997	\$4.557
95-strike-price calls	1.703	2.023	2.382
C. Value of Portfolio after Implied Volatilities Converge to 30%			
Stock price:	**89**	**90**	**91**
Value of 1,000 calls held	\$3,478	\$3,997	\$4,557
−Value of 1,589 calls written	2,705	3,214	3,785
Total	\$ 773	\$ 782	\$ 772

Dividends and Black Scholes

- Original version of Black Scholes assumes no dividends
- Q. What if the dividend yield is d?
- A. Both call and put formulas go through with

$$C_0 = S_0 e^{-dT} N(d_1) - X e^{-rT} N(d_2)$$

$$P_0 = X e^{-rT}[1 - N(d_2)] - S_0 e^{-dT}[1 - N(d_1)]$$

$$d_1 = [\ln(\frac{S_0}{X}) + (r - d + \sigma^2 / 2)T] / (\sigma T^{1/2})$$

$$d_2 = d_1 - (\sigma T^{1/2})$$

Black Scholes and American Options

- Black Scholes applies to European Options
- Since right of early exercise is disposable, it gives a *lower bound* on the price of American options.
- More precise adjustments of Black Scholes for the possibility of early exercise are available
  - Barone-Adesi and Whaley (Journal of Finance; 1987)
- Note: Options traded on exchanges are mainly American; OTC options are mainly European.

Warrants

- Warrants are an option-like security

Warrants	**Options**
Issued by firms	Contracts between investors
Exercising warrants increases number of shares outstanding and firm receives price	No change in outstanding shares. Firm gets no money.
Long expirations	Short expirations (usually)

Futures and Forwards

- Forward - an agreement calling for a future delivery of an asset at an agreed-upon price
- Futures - similar to forward
- How futures are different from forwards: futures are
  - Standardized and traded on exchanges
  - Secondary trading - liquidity
  - Clearinghouse warrants performance

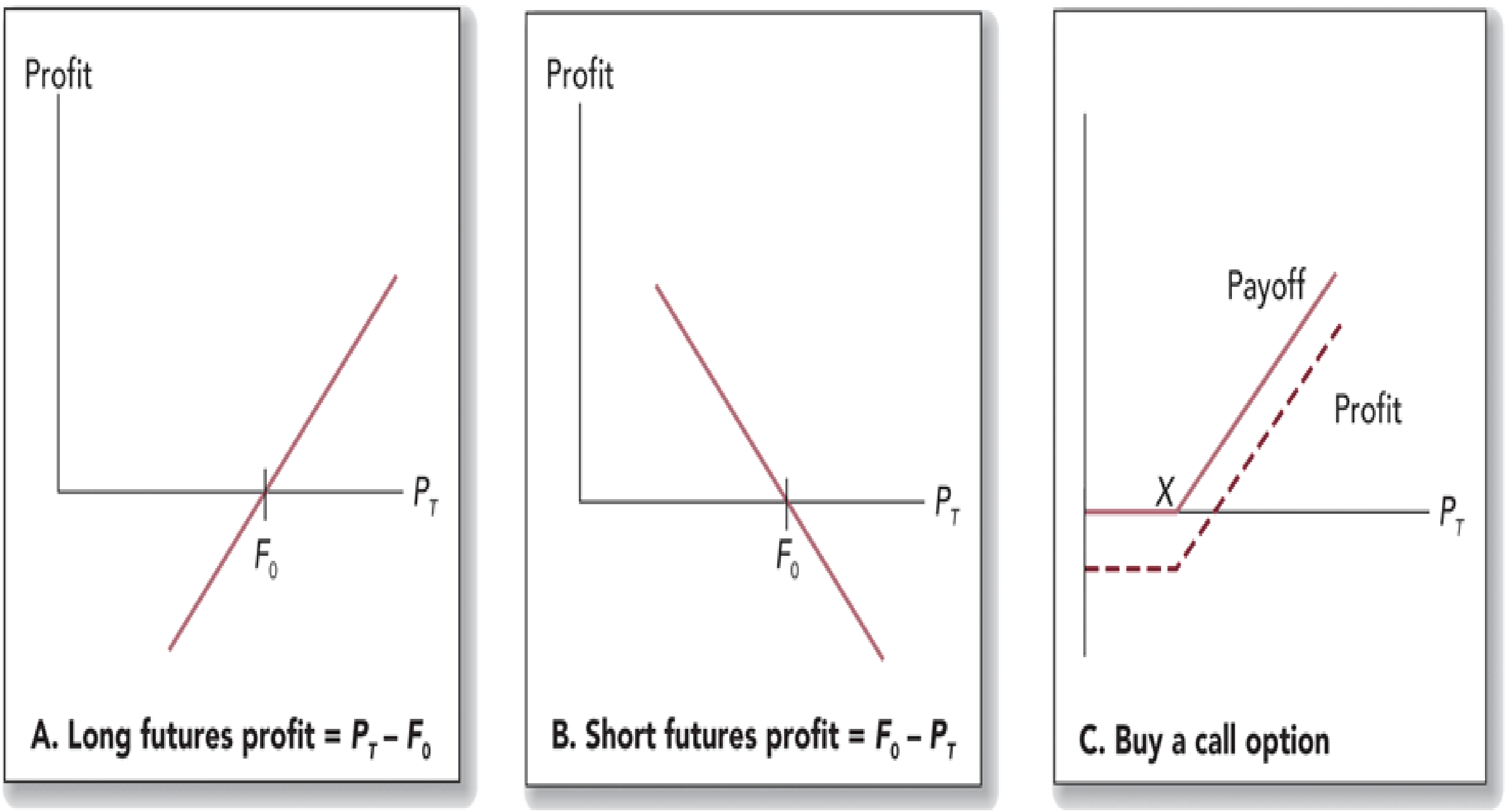
Key Terms for Futures Contracts

- Futures price - agreed-upon price at maturity
- Long position - agree to purchase
- Short position - agree to sell
- Profits on positions at maturity

  Long = spot minus original futures price

  Short = original futures price minus spot

Profits to Buyers and Sellers of Futures and Option Contracts



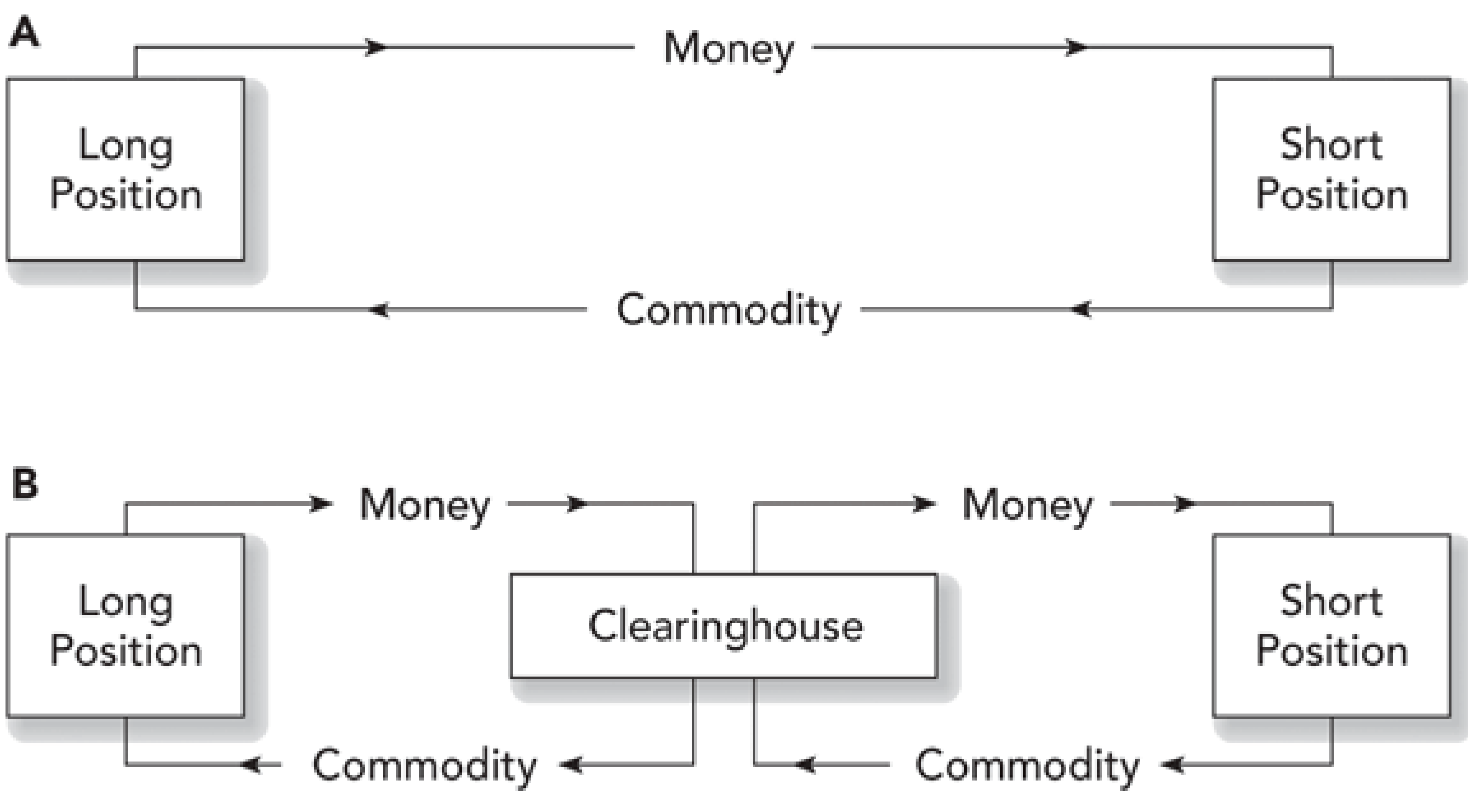
Sample of Future Contracts

Foreign Currencies	Agricultural	Metals and Energy	Interest Rate Futures	Equity Indexes
Euro	Soybean	Copper	Eurodollars	S&P 500
Pound	Corn	Gold	Federal Funds	Nasdaq
Yen	Coffee	Oil	Treasury Bonds	FTSE Index

Trading Mechanics

- Clearinghouse - acts as a party to all buyers and sellers
  - Obligated to deliver or supply delivery
- Closing out positions
  - Reversing the trade
  - Take or make delivery
  - Most trades are reversed and do not involve actual delivery
- Open Interest

Panel A, Trading without a Clearinghouse. Panel B, Trading with a Clearinghouse



Margin and Trading Arrangements

Initial Margin - funds deposited to provide capital to absorb losses

Marking to Market - each day the profits or losses from the new futures price are reflected in the account

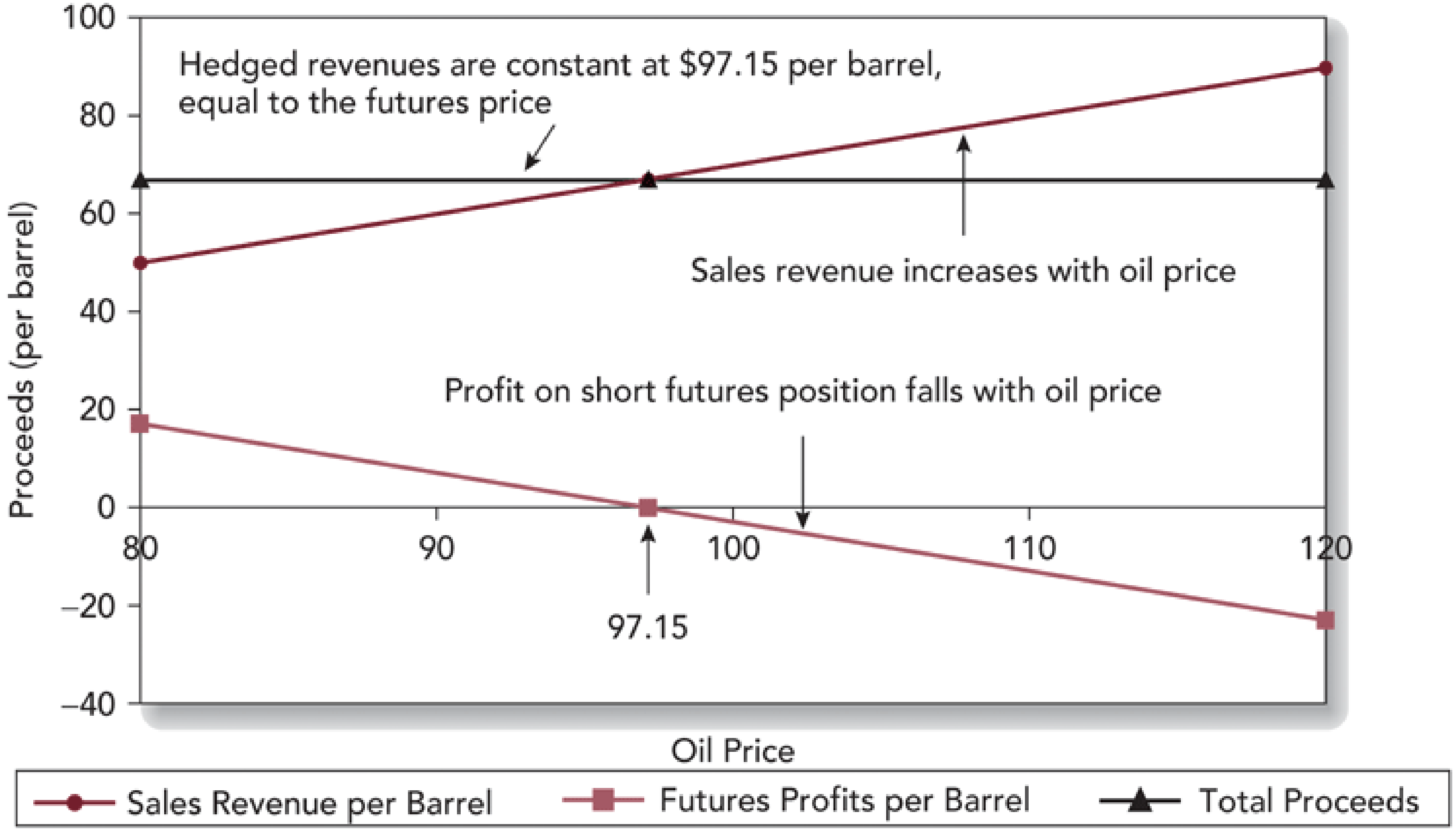
Delivery - Actual commodity of a certain grade with a delivery location or for some contracts cash settlement

Cash Settlement – some contracts are settled in cash rather than delivery of the underlying assets

Trading Strategies

- Speculation -
  - short - believe price will fall
  - long - believe price will rise
- Hedging -
  - long hedge - protecting against a rise in price
  - short hedge - protecting against a fall in price

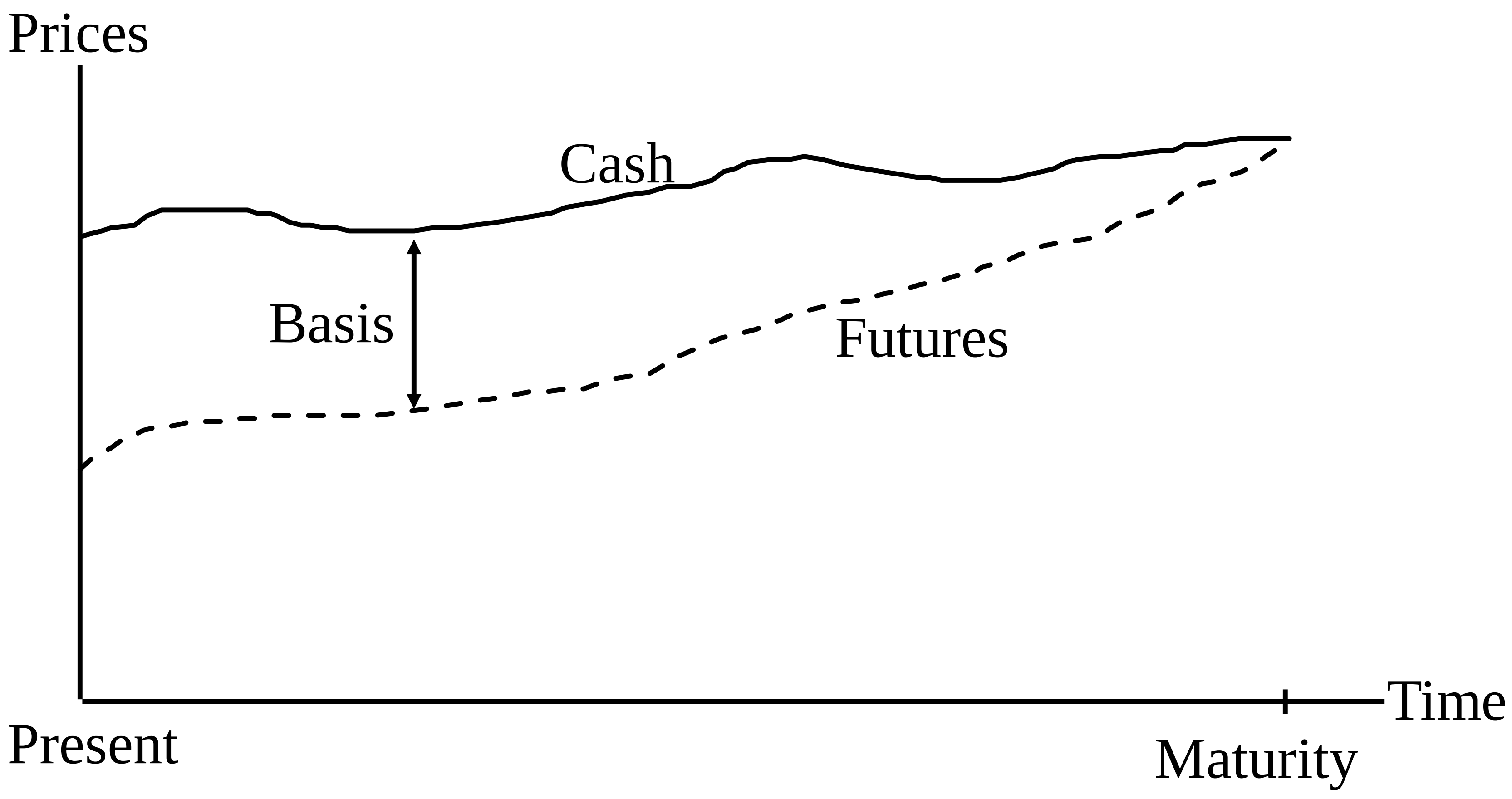
Hedging Revenues Using Futures, (Futures Price = $97.15)



Basis

- Basis - the difference between the futures price and the spot price (spot=price today)
  - over time the basis converges

Convergence of cash and futures price



Futures Pricing

Spot-futures parity theorem - two ways to acquire an asset for some date in the future

- Purchase it now and store it: assume this is free
- Take a long position in futures
- These two strategies must be equivalent

Example

- S&P 500 fund that has a current value equal to the index of $1,500
- Assume dividends of $25 will be paid on the index at the end of the year
- Interest rate is 5%
- If I buy the stock today, costs $1,500
- If I wait for one year, I pay F

$$\frac{F}{1.05} + \frac{25}{1.05} = 1,500$$

$$\therefore F = 1,550$$

General Spot-Futures Parity

$$F = S_0(1 + r_f)^T - D$$

- If there are no dividends, then the futures price should lie above the spot price

General Spot-Futures Parity

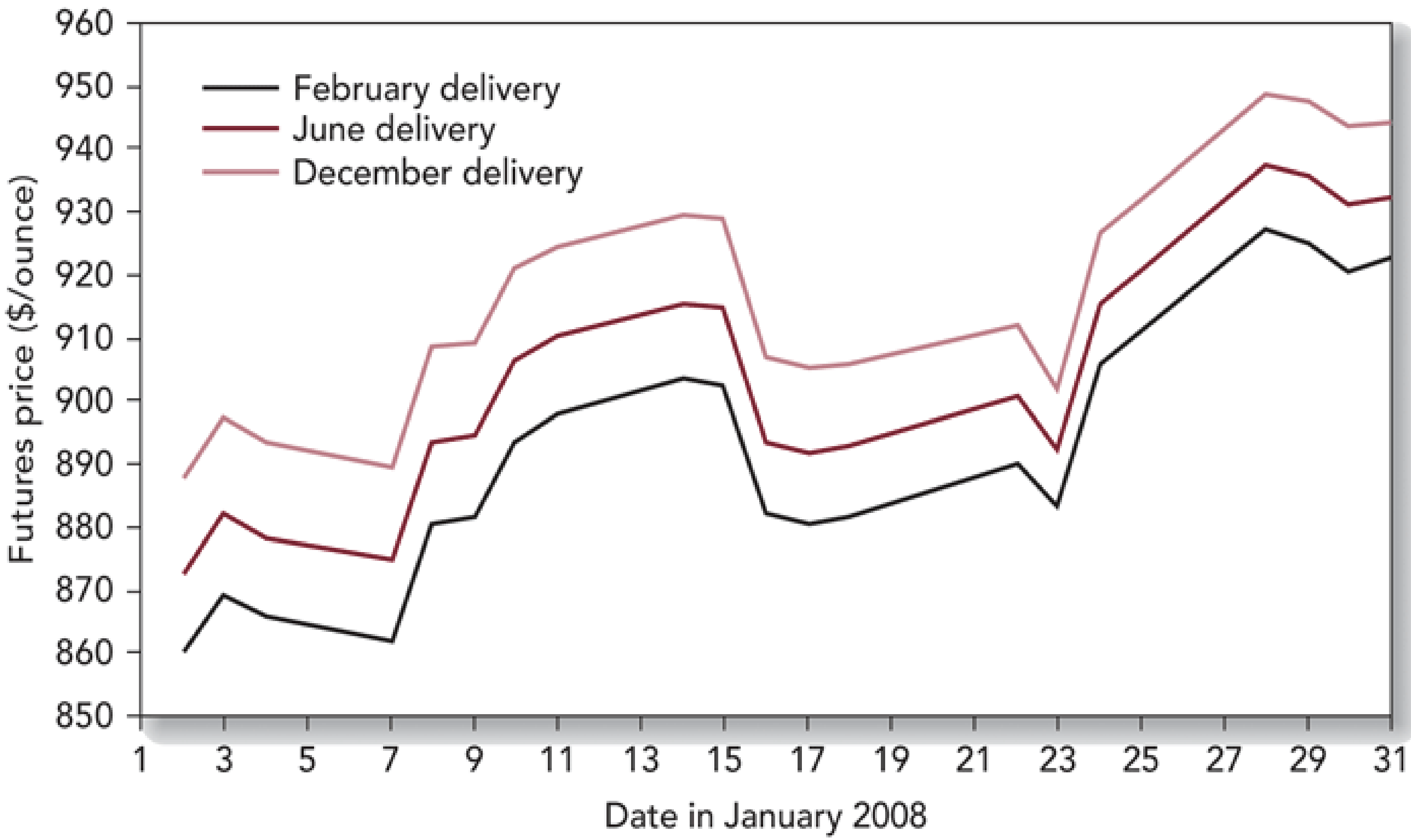
$$F_1 = F_0(1 + r_f)^T - D$$

- F1 and F0 are prices on two futures contracts maturing T periods apart

Arbitrage Possibilities

- If spot-futures parity is not observed, then arbitrage is possible
- If the futures price is too high, short the futures and acquire the stock by borrowing the money at the risk free rate
- If the futures price is too low, go long futures, short the stock and invest the proceeds at the risk free rate

Gold Futures Prices



Storage costs

- Relationship between futures, spot price and interest rates applies in the absence of storage costs
- Storing oil is possible, but expensive
- If the futures curve slopes down, this is called normal Backwardation
- If it slopes up, it is called Contango

What determines the slope of the futures curve?

- Expectations
- Storage Costs
- Hedging demand
  - Oldest story: Producers sell into futures markets to lock in prices creating normal backwardation
- Portfolio theory (e.g. correlation with market returns)

Interest Rate Futures

- Two main interest rate futures
  - Treasury bond
  - Eurodollar

Eurodollar Futures

- The Eurodollar futures contract is the most widely traded short-term interest rate futures.
- It is based upon a 90-day $1 million Eurodollar time deposit.
- It is settled in cash.
- Contracts mature in March, June, Sep, December
- At expiration, the settlement price is 100-LIBOR
- At expiration if the settlement price is S and the futures price is F, then the short side pays the long side **$2,500*(S-F)** per contract.

Eurodollar Futures Example

- In February you buy a March Eurodollar futures contract. The quoted futures price at the time you enter into the contract is 94.86.
- Q. If the 90-day LIBOR rate at the end of March turns out to be 4.14% p.a., what is the payoff on your futures contract?
- A. Settlement price: 95.86. So you receive a payoff of $2,500*(95.86-94.86)=$2,500.

Hedging with a Eurodollar Futures Contract

- Suppose a firm knows that it must borrow $1million for three months in the future.
- **Sell** a Eurodollar futures contract.
- Suppose the current futures rate is 94.86. This implies a LIBOR rate of 5.14%.
- Now consider three scenarios:

Borrowing Rate	5.14	6.14	4.14
Eurodollar Payoff	0	$2,500	-$2,500
Borrowing Cost	$12,850	$15,350	$10,350
Total Expense	$12,850	$12,850	$12,850

Foreign Exchange

- 1 Unit of currency A = X units of currency B
- Quoting conventions differ by currency pair
- Euro-Dollar: 1 Euro = X Dollars
- Dollar- Yen: 1 Dollar = X Yen
- Enormous liquid market

Trilemma

- Trilemma is principle that a country can have any two of:
  - Fixed exchange rate
  - Independent monetary policy
  - Absence of capital restrictions
- Broadly, 3 alternatives:
  - Fixed exchange rate, independent monetary policy, capital controls
    - Bretton Woods system
  - Fixed exchange rate, no capital controls, follow foreign monetary policy
    - Denmark
  - Floating exchange rate, independent monetary policy, no capital controls
    - Canada

Arbitrage relationships in FX

- Locational arbitrage
- Triangular arbitrage
- Covered Interest Parity (Next)

Foreign Currency Futures and Forward Rates

- Currency futures are an agreement to buy a foreign currency at a point in the future
  - Currency forwards are more common
- Covered Interest Parity

$$S_t(1+R_t)^T = F_t(1+R_t^*)^T$$

where

S_t : Exchange Rate (US$/Foreign Currency)

F_t : Forward Exchange Rate

R_t : $ Interest Rate

R_t^* : Foreign Interest Rate

Covered Interest Parity Example 1

- Suppose that the exchange rate today is 1 Euro=$1.10
- Interest rate is 2% in the US
- Interest rate is -0.25% in the euro zone
- Covered interest parity says that the one year forward rate must satisfy

$$1.1*1.02=F_t*0.9975$$

- The forward rate is 1 Euro=$1.125

Covered Interest Parity Example 1

- In the example on the last slide, suppose instead that the forward rate was 1 Euro=$1.14.
- What could I do?

Borrow $1, Convert it to Euro.

Receive: Euro 0.9091.

Invest it at -0.25% interest. In one year I have Euro 0.9068.

Convert this back to dollars to receive $1.034

Pay off the loan for $1.02

Profit of 1.4 cents

Covered Interest Parity Example 2

- Suppose that the spot exchange rate in 2005 was \$1=100 Yen.
- Interest rate was 0 in Japan
- One year forward rate was \$1=95 Yen.
- Q. What must US\$ interest rate have been?

Spot: 1 Yen=\$0.01.   Forward 1 Yen=\$0.0105

$0.01*(1+R_t)=0.0105$

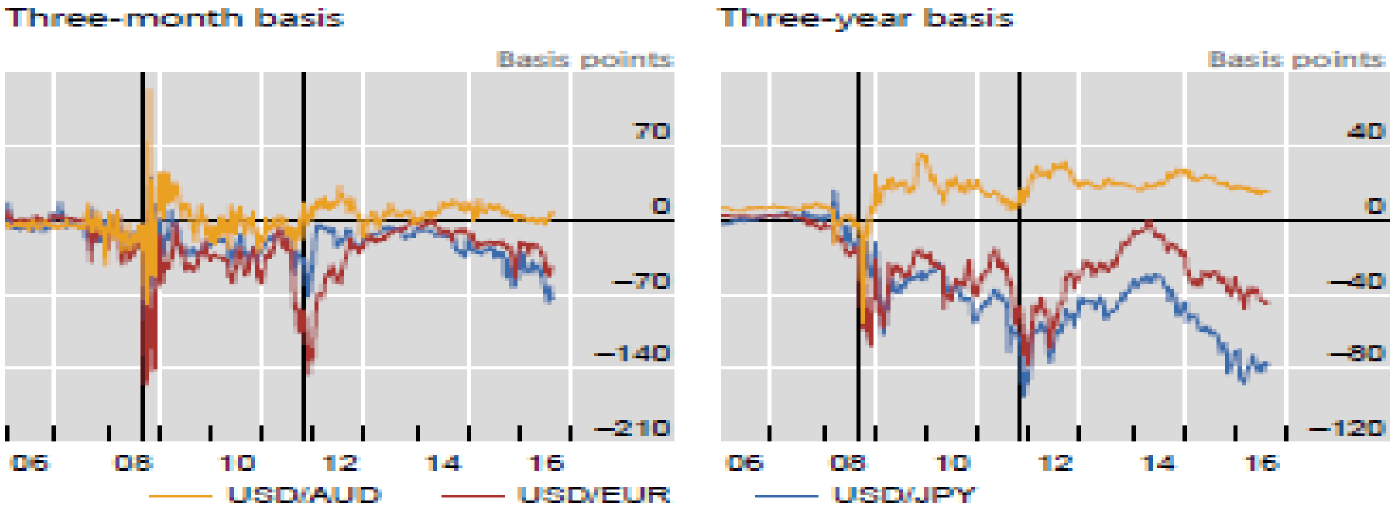
- US interest rate is 5 percent.

Foreign currency swaps

- A swap is a combination of a spot and forward rate
- Party A buys dollars for euros today
- Agrees to sell the dollars back in the future at a rate agreed today
- Covered interest parity says that the difference in the exchange rates should be determined by relative interest rates
- Makes up a lot of FX trading

Covered Interest Parity

- A violation of covered interest parity is an arbitrage opportunity
- Violations used to be rare and small
- Since 2008, there have been violations
- Banks need to use swaps market to borrow dollars
  - Cross-currency basis: negative means more expensive to borrow dollars via swaps than to do so directly



Central bank foreign currency swaps

- Fed developed facilities with other major central banks in 2008 which are still there
- ECB asks for dollars from Fed in exchange for euros
- ECB pays interest and fee on the dollars and lends them on to European banks without taking a profit
- Fed pays no interest on the euros that it has received
- After the term, the money is returned
- ECB is responsible for returning funds even if European banks default

Central bank foreign currency swaps

- Why did the Fed do this?
  - Fed makes a profit
  - Alternative is that European banks would have to sell their US assets quickly which is bad for the US.

Hedging with Foreign Currency Futures

- A firms profits go down by $200,000 for every 5 cent rise in the pound/dollar exchange rate
- Each pound contract calls for the delivery of 62,500 pounds
- Q. How should this firm hedge exchange rate risk?
- A. Enters a long position on pound futures

1 contract goes up 0.05*62,500 when the pound appreciates by 5 cents

The firm needs 200,000/(0.05*62,500)=64 contracts

Uncovered interest parity

- Suppose I borrow dollars today, invest it in a foreign currency and plan to buy it back tomorrow.
- No forward/futures contract
- Profit will be

$$\frac{S_{t+T}(1+R_t^*)^T}{S_t} - (1+R_t)^T$$

- But there is no arbitrage strategy

Uncovered interest parity

- Uncovered interest parity says that

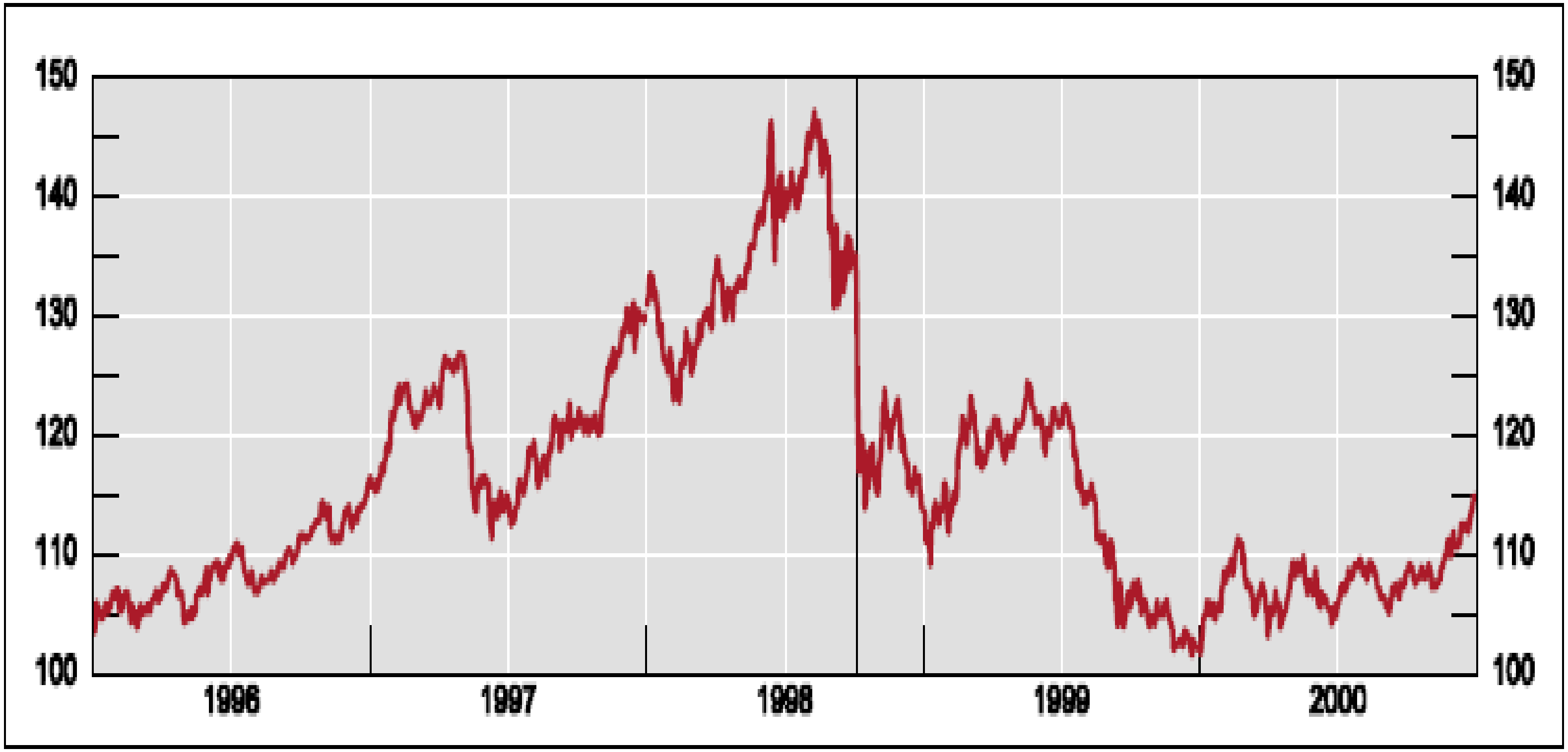
$$E_t(S_{t+T})(1+R_t^*)^T = S_t(1+R_t)^T$$

- For example, if exchange rate today is AUD 1=$0.80
- One year interest rate is 2 percent in US
- One year interest rate is 4.25 percent in Australia
- Expected exchange rate in one year is AUD=$0.783
- Currency with the higher interest rate is expected to depreciate

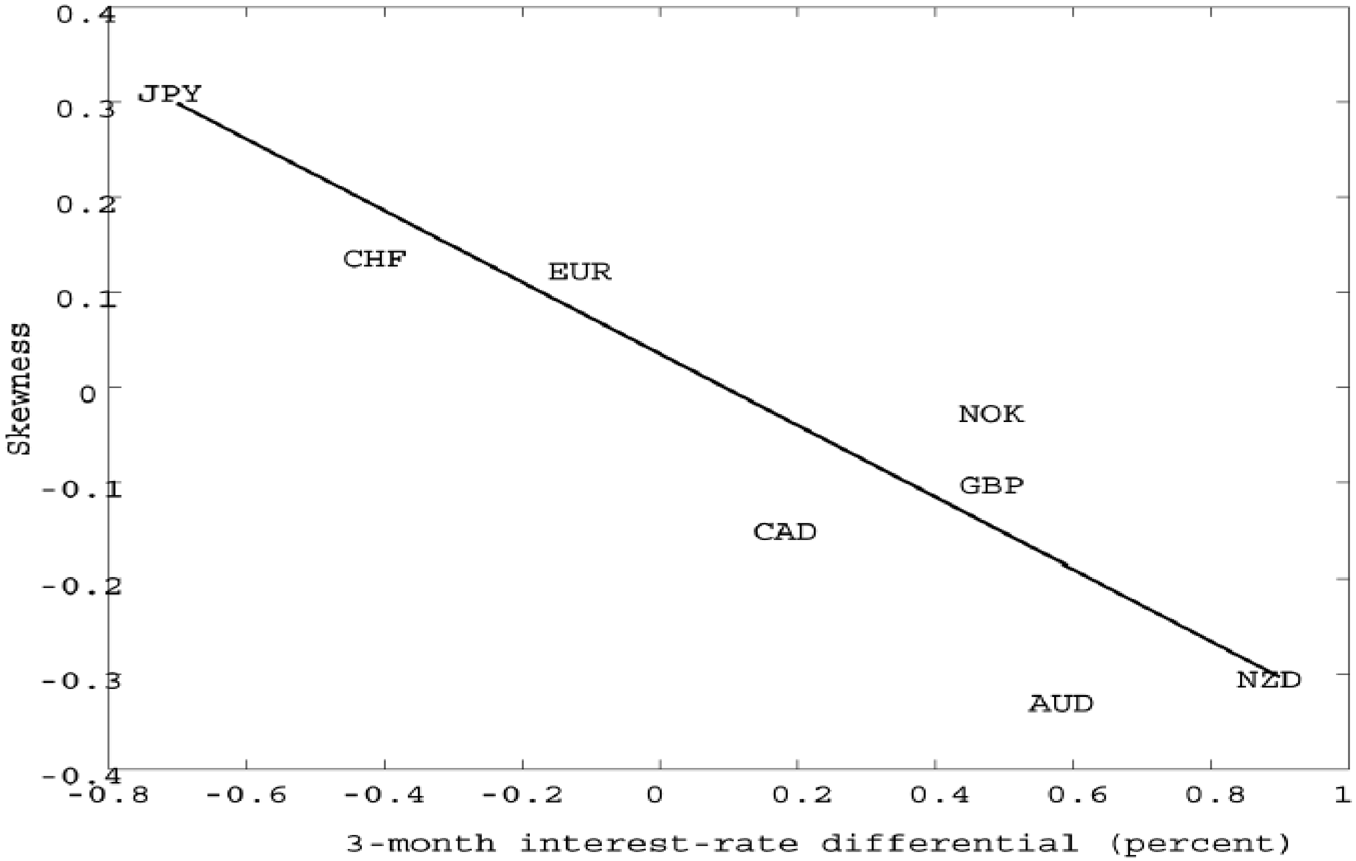
Uncovered interest parity
Empirical Evidence

- Evidence *for* covered interest parity fairly strong
- Evidence goes *against* uncovered interest parity
- If anything, the currency with the *higher* interest rate tends to *appreciate*
- Motivates the "carry trade"
  - Borrow in currency with low interest rate (*funding* currency)
  - Convert to the high interest currency and invest
  - Do NOT hedge the exchange rate risk
  - Convert back
- From 1990 till crisis, yen was the natural funding currency
  - From 2008 till 2015 dollar also a natural funding currency

AUD-JPY



Skewness and interest differentials



Risk Adjusted Performance: Sharpe

1) **Sharpe Index**

$$\frac{(\overline{r_P} - \overline{r_f})}{\sigma_P}$$

$\overline{r_p}$ = Average return on the portfolio

$\overline{r_f}$ = Average risk free rate

σ_p = Standard deviation of portfolio return

Risk Adjusted Performance: Treynor

2) Treynor Measure

$$\frac{(\overline{r_P} - \overline{r_f})}{\beta_P}$$

$\overline{r_p}$ = Average return on the portfolio

$\overline{r_f}$ = Average risk free rate

$ß_p$ = Weighted average beta for portfolio

Risk Adjusted Performance: Jensen

3) Jensen's Measure

$$\alpha_P = \overline{r_P} - \left[\overline{r_f} + \beta_P(\overline{r_M} - \overline{r_f})\right]$$

α_p = Alpha for the portfolio

$\overline{r_p}$ = Average return on the portfolio

β_p = Weighted average Beta

$\overline{r_f}$ = Average risk free rate

$\overline{r_m}$ = Average return on market index portfolio

M^2 Measure

- Developed by Modigliani and Modigliani
- Create an adjusted portfolio (P*)that has the same standard deviation as the market index.
- Because the market index and *P** have the same standard deviation, their returns are comparable:

$$M^2 = r_{P*} - r_M$$

M^2 Measure: Example

Managed Portfolio: return = 35% standard deviation = 42%

Market Portfolio: return = 28% standard deviation = 30%

T-bill return = 6%

P* Portfolio:

30/42 = .714 in P and (1-.714) or .286 in T-bills

The return on P* is (.714) (.35) + (.286) (.06) = 26.7%

Since this return is less than the market, the managed portfolio underperformed.

Style Analysis

- Introduced by William Sharpe
- Regress fund returns on indexes representing a range of asset classes.
- The regression coefficient on each index measures the fund's implicit allocation to that "style."
- R –square measures return variability due to style or asset allocation.
- The remainder is due either to security selection or to market timing.

Style Analysis for Fidelity's Magellan Fund

Style Portfolio	Regression Coefficient
T-Bill	0
Small Cap	0
Medium Cap	35
Large Cap	61
High P/E (growth)	5
Medium P/E	0
Low P/E (value)	0
Total	100
R-square	97.5

Source: Authors' calculations. Return data for Magellan obtained from **finance.yahoo.com/funds** and return data for style portfolios obtained from the Web page of Professor Kenneth French: **mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html**.

Table 24.5

Style analysis for Fidelity's Magellan Fund

Style Analysis for Hedge Funds

- *The equity market-neutral funds*
  - Have low and insignificant betas
- *Dedicated short bias funds*
  - Have substantial negative betas on the S&P index
- *Distressed-firm funds*
  - Have significant exposure to credit conditions
- *Global macro funds*
  - Show negative exposure to a stronger U.S. dollar

Performance Measurement for Hedge Funds

- Possible sources of superior performance
  - Skilled managers
  - Exposure to omitted risk factors with positive risk premiums
    - Liquidity
    - Survivorship bias
    - Tail events

Hedge Funds with Higher Serial Correlation in Returns (Proxy for Illiquid Investment)

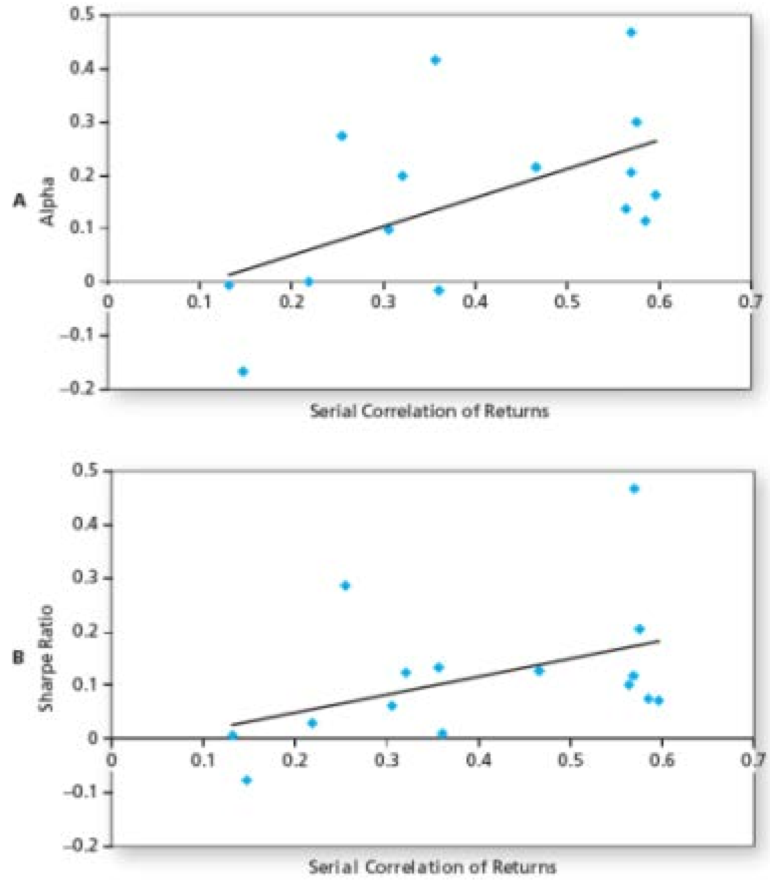
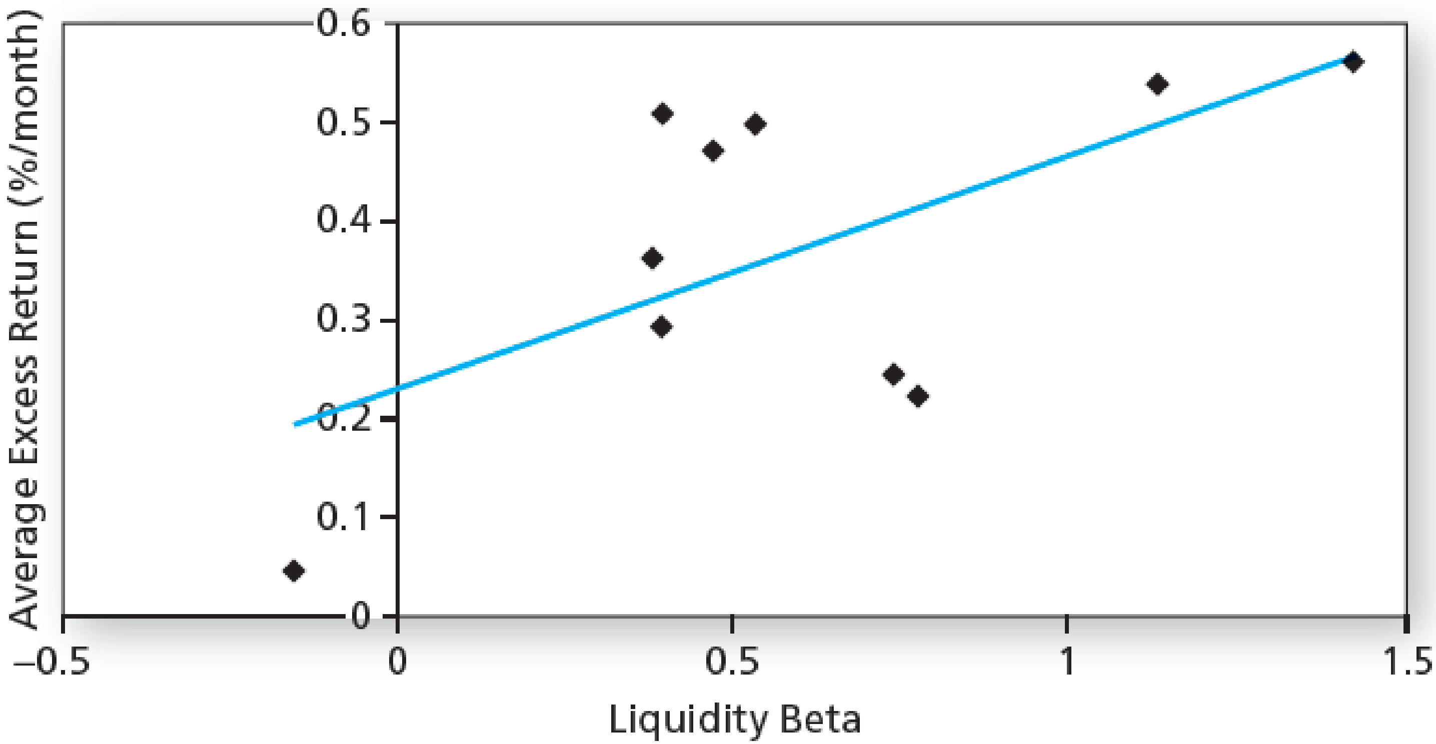
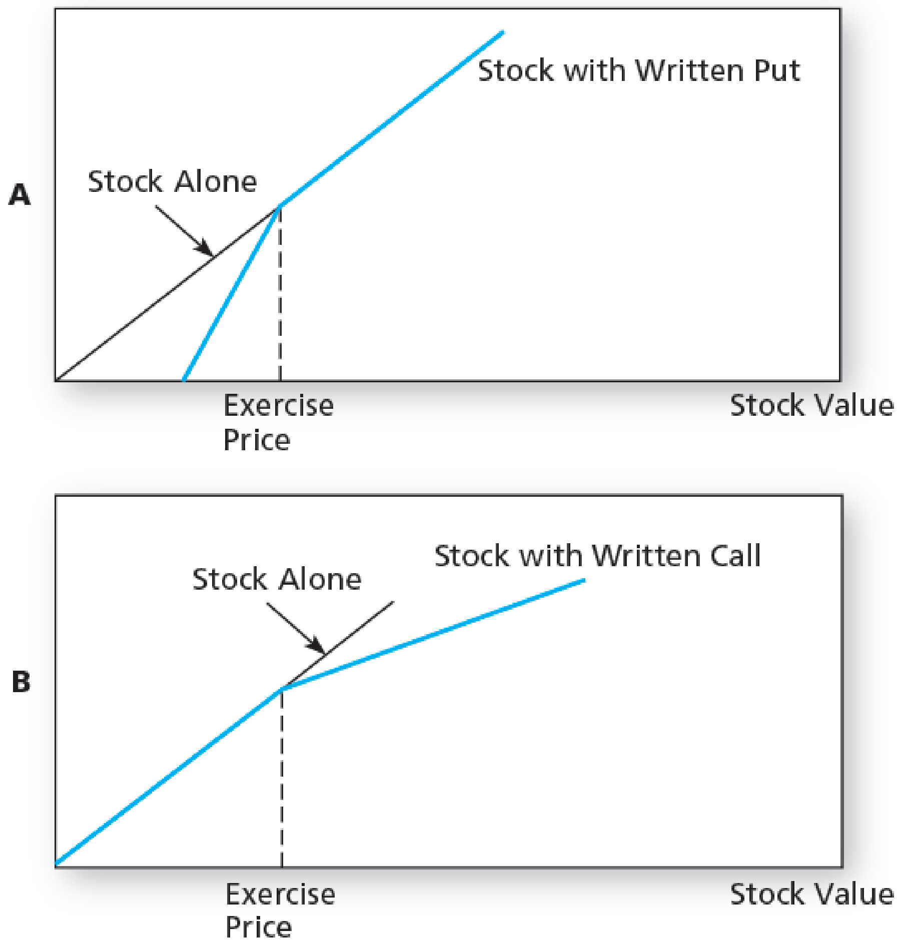


Figure 26.3 Average Hedge Fund Returns as a Function of Liquidity Risk



Characteristic Lines of Stock Portfolio with Written Options



Monthly Return on Hedge Fund Indexes versus Return on the S&P 500