# Monetary Economics
# Fixed-Income Securities
## Money and Bond Markets

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# Readings this Material

- Cuthbertson and Nitzsche, Chapters 19 and 20

# Readings Next Set of Slides

- Cuthbertson and Nitzsche, Chapters 21 and 22
- Skipping Sections 22.3 and 22.4

# Outline

- Bond Market Overview
- Different Ways to Compute “Interest Rates”
- Bonds and Term to Maturity
- Term Structure and Rates Computed
- Additional Aspects of Bonds and Bond Trading
- Summary

# Fixed-Income Securities

- Money Markets
- Bond Markets
- Term Structure of Interest Rates
- Duration, Convexity and Immunization

# Fixed-Income Securities

- Money Markets
  - Instruments
  - Alternative ways of calculating return
- Bond Markets
  - What is return on a bond?
  - How estimate the price of a bond?

# Money Markets

- A misnomer, but widespread
- Short-term fixed-income securities
  - Securities promise to make certain payments

# Securities in Money Market United States

- All, or virtually all involve a payment today to the buyer and receipt of one payment in a year or less
- Treasury bills
  - Issued by U.S. Treasury
- Commercial paper
  - Issued by corporations
  - 90 days or less can be used as collateral at the Federal Reserve
  - Less than 270 days, a bearer instrument
  - 270 days or more, registered with the SEC

# Securities in Money Market United States

- Certificates of deposit (CD)
  - Negotiable or non-negotiable
  - Normal CDs versus term CDs
    - Normal CDs pay interest at maturity
    - Term CDs pay interest semi-annually
  - Eurodollar CDs
    - Issued outside the U.S. in dollars
  - Yankee CDs
    - Issued by a non-U.S. bank with a U.S. branch and denominated in dollars

# Securities in Money Market United Kingdom

- U.K. Interbank market
  - London Interbank Offer Rate (LIBOR)
    - Bank able to borrow at that rate
    - Denominated in dollars
  - London Interbank Bid Rate (LIBID)
    - Banks bid that rate for deposits
    - Denominated in different currencies
  - London Euro Interbank Offer Rate (EURIBOR)
    - Bank able to borrow at that rate
    - Denominated in Euro

# Securities in Money Market
# United Kingdom

- Certificates of deposit
  - Negotiable or non-negotiable
  - Bearer instrument
  - Interest may be accrued at maturity or periodically
- Sterling floating-rate notes (FRN)
  - Interest rate floats
    - A fixed premium over LIBOR
  - Bearer instruments
  - Interest payable at three-month intervals

# Securities in Money Market
# United Kingdom

- Bill of Exchange
  - Customer of a firm promises to make payment for goods at a later day
  - Both seller of good and customer sign paper
  - Seller of good can take paper to bank and receive funds or can sell it to another party
  - At maturity, the holder of the bill of exchange goes to the firm's customer to get payment
- Certificate of deposit
  - Bearer instrument
  - Interest may be accrued at maturity or periodically

# Markets Related to Monetary Policy

- Fed Funds market
  - Banks borrow and lend reserves at the Federal Reserve to each other
  - Federal Reserve used to target this rate
  - Fed still announces a target range

# Markets Related to Monetary Policy

- Repo market
  - Fed implements monetary policy by buying and selling government securities in the repo market
  - Repo (Sale and repurchase agreement)
    - Sell a security today and promise to buy it back at a fixed price tomorrow or in a few days generally
    - Repo seller
  - Reverse repo
    - Buy a security today and promise to sell it back at a fixed price tomorrow or in a few days generally
    - Repo buyer
    - Fed is using this term to denote their sales of securities with promise to buy back
  - Repo rate is difference between purchase price and later sale price as a percentage

# Characteristics of Short-term Securities

- Term – a year or less usually meant
  - Can range from one day to one year
- Currency in which denominated
- Negotiable or not
- Fixed or floating rate
- Collateralized or not
- Rates are quoted in different, somewhat inconsistent ways

# Quoting of Rates

- Interest rate on security with a current value *P*, a final value *FV*

$$R = \frac{FV - P}{P}$$

  - Called a "yield basis" in fixed-income markets
- This is simple conceptually but not so simple arithmetically
  - Treasury bill with a price of $9900 and a face value of $10,000

# Quoting of Rates

- Interest rate on security with a current value *P*, a final value *FV*

$$R = \frac{FV - P}{P}$$

- This is simple conceptually but not so simple arithmetically
  - Treasury bill with a price of $9900 and a face value of $10,000
  - Interest rate $100/$9800 = 1.02%
  - High or low?
    - Suppose interest rates on Treasury bills are 3 percent per year

# Quoting of Rates

- Two issues with

$$R = \frac{FV - P}{P}$$

  - Dividing by price
    - Face values often nice round numbers
    - Prices are not
  - What is term to maturity and how to make them comparable?

# Quote Discount Rate

- Discount basis
  - Instead of $$R = \frac{FV - P}{P}$$
  - Use the discount rate $$d = \frac{FV - P}{FV}$$
  - FV of $10000 and P of $9900
    - d is 1 percent
    - R is 1.02 percent

# Term to Maturity

- Data from the Federal Reserve on Treasury bill rates in September are

| DATE | 4-week | 3-month | 6-month | 1-year |
|---|---|---|---|---|
| 2014-10-17 | 0.03 | 0.02 | 0.05 | 0.10 |

- Percentage terms
  - .03 percent on 4-week Treasury bills
  - 3 basis points on 4-week Treasury bills
- Annualized
  - .03 basis points per year, not for 4 weeks
  - How annualized?

# Treasury Bill Rates

- Board of Governors of Federal Reserve System
  - http://www.federalreserve.gov/releases/h15/update/
  - October 17, 2014 – percent per year

| Treasury bills (secondary market) 3 4 | |
|---|---|
| 4-week | 0.03 |
| 3-month | 0.02 |
| 6-month | 0.05 |
| 1-year | 0.10 |

- Footnotes – “On a discount basis” and Annualized using a 360-day year”

# How Annualized?

- Using relatively simple arithmetic
  - Simple interest
- Suppose FV of $10000 and price of $9900 on 3-month Treasury bill
  - Number of days depends on exact months
  - Avoid confusion by supposing 1/4 of a year
  - 1/4 is simple if there are 360 days in the year
  - Annualize discount rate by multiplying term from 90 days to 360
  - Suppose original discount rate is 1 percent for three months
  - Will receive this for one-quarter of year (90/360)
  - Gross up interest rate by multiplying by 4=360/90
  - Annual discount rate 4 percent per year

# Annualizing Using Simple Interest

- Annualized simple interest rate on a discount basis in percent per year

$$d = \frac{FV - P}{FV} \frac{a}{m} 100$$

  - Multiplying by the number of days in a year, *a*, divided by the number of days to maturity, *m*, annualizes the return
  - Multiplying by 100 results in interest rate in percent

# Back to 4-week Rate

- From Board's site for October 17, 2014

| DATE | 4-week | 3-month | 6-month | 1-year |
|---|---|---|---|---|
| 2014-10-17 | 0.03 | 0.02 | 0.05 | 0.10 |

- Looks like noticeable increase for longer term
  - Basis points (bps): 3 to 10
  - Annualized
- What are actual discount rates on these Bills?
  - Suppose 4 weeks is 30 days to simplify arithmetic
  - Annualization is 360/30=12, 360/90, 360/180 and 360/360
  - Convert back to real number of weeks by multiplying discount rate by 1/12 in basis points

# Back to 4-week Rate

- From Board's site for October 17, 2014

| DATE | 4-week | 3-month | 6-month | 1-year |
|---|---|---|---|---|
| 2014-10-17 | 0.03 | 0.02 | 0.05 | 0.10 |

  - One month is .03/12 = .0025 percent per month
  - Three month is .02/4 = .005 percent per 3 months
  - Six month is .05/2 = .025 percent per 6 months
  - Twelve month is 0.10/1 = 0.10 percent per year
- These are the actual discount returns received over the term of the bills

# Back to 4-week Rate

- Dollar magnitudes on a million dollars are small
- How much difference does it make if one receives .02 percent per year for three months or receives .03 percent pear year for three months?
  - Assume you have $1 million
- Do yourself

# Yield and Discount Basis

- Yield basis with simple interest

$$R = \frac{FV - P}{P} \frac{a}{m}$$

- Discount basis with simple interest

$$d = \frac{FV - P}{FV} \frac{a}{m}$$

# Which Instruments Are Which?

## In the United States

- Treasury Bills and commercial paper are the most commonly encountered securities quoted on a discount basis
- CDs are quoted on a yield basis
- Some securities use a 365-day year and not a 360-day year
- In comparing rates on different securities, must have them on the same basis
- As a consumer, often quoted compounded rates

# Simple Interest Rate

- Start with $10,000 and consider 6-month CD paying 1 percent per year

$$R = \frac{FV - P}{P} \frac{a}{m}$$

  - 0.01 in proportional terms per year
  - Over a six-month period, receive 0.005 percent for six months (discount basis)
  - Will receive $10,000 * (1+.005)=$10,050
  - Simple interest for a year
    - $10,000 * (1+.0100)=$10,100
    - Receive $50 in middle of year and apparently no interest on that $50

# Compounded Interest Rate

- Saw simple interest for a year

$$R = \frac{FV - P}{P} \frac{a}{m}$$

  - Suggests get twice as big an interest payment for a year as for six months
  - Have $50 for six months – no interest on that
- Compound interest
  - Receive interest on the $50 interest payment

# Example of Compounded Interest Rate

- Have $10,000
- Six-month interest rate is 1/2 percent
- Receive $10,050 at end of six months
- Suppose get same interest rate for rest of year
- $10,050 * 1.005 = $10,100.25
  - More than $10,100 – one-half percent interest on interest payment of $50
- Rate allowing for compounding is

  $10,000 * (1+.005) * (1+.005) =

  $10,000 * $(1+.005)^2$=$10,100.25

# Compound Interest

- We see that compounding results in

  $10,000 * (1+.005) * (1+.005) = $10,000 * $(1+.005)^2$=$10,100.25

- With compounding, the semi-annual interest rate *rh* is an annual interest rate *r* of

$$r = (1+rh)^2 - 1$$

- If *rh* is 0.5 percent per half year, then annualized interest rate with compounding is 1.0025 percent per year, not 1 percent per year
- Can see this from

$$r = 2rh + rh^2$$

# Compound Interest

- Compound interest seems unimportant here
- We see that compounding results in

  $\$10,000 * (1+.005) * (1+.005) = \$10,000 * (1+.005)^2 = \$10,100.25$
- Suppose that interest rate is 5 percent per six months

  $\$10,000 * (1+.05) * (1+.05) = \$10,000 * (1+.05)^2 = \$11,025$
- Without compounding

  $\$10,000 (1+.1) = \$11,000$

# Compound Interest

- For a six-month security, see that

$$r = (1+rh)^2 - 1$$

- More generally, for a security that
  - Matures in *m* days
  - A payment only at maturity
  - With a year of *a* days
  - An interest rate to maturity of *rm*

  – The annualized compound interest rate is

$$r = (1+rm)^{a/m} - 1$$

# Bond Rates

- Yield basis – uses compounding
- Zero-coupon bond
  - Often formed as strips of more conventional bonds
  - Payment at maturity only
  - *P* is current price and *M* is the payment at maturity *n*

$$P = \frac{M}{(1+r)^n}$$

  - *r* is the spot yield for maturity of *n*
  - Price is determined by demand and supply
  - Price and spot yield are inversely related

# Bonds

- Bonds typically have coupon payments in addition to a final payment
- Two-year bond
  - Pays $500 (C) per year and has a final payment (M) of $10,000
- What is “interest rate”?
  - “Coupon rate” is 5 percent per year on this bond
  - Ignores current price
- Internal rate of return is better measure

# Bond Yield to Maturity

- Internal rate of return, *y,* on a two-year bond

$$P = \frac{C_1}{1+y} + \frac{C_2}{(1+y)^2} + \frac{M}{(1+y)^2}$$

- If coupons are $500 and final payment is $10,000, yield depends on price
  - If price is $10,000, then yield to maturity *y* is 5 percent per year
  - If price is $9,000, then yield to maturity is 7.28%
  - If price is $10,500, then yield to maturity is 1.64%

# Bond Yield to Maturity with Semi-annual Payments

- For a two-year bond with semi-annual payments, formula is

$$P = \frac{C_1}{(1+y/2)} + \frac{C_2}{(1+y/2)^2} + \frac{C_3}{(1+y/2)^3} + \frac{C_4}{(1+y/2)^4} + \frac{M}{(1+y/2)^4}$$

- If didn't divide by two, would be computing yield to maturity per half year
- Equivalently, compute

$$P = \frac{C_1}{(1+y^*)} + \frac{C_2}{(1+y^*)^2} + \frac{C_3}{(1+y^*)^3} + \frac{C_4}{(1+y/2)^4} + \frac{M}{(1+y^*)^4}$$

  - And then compute $y$ = 2 times $y^*$

# Holding Period Return

- After the fact, can compute holding period return
- If hold for a year and received a price at the end of *TV*, then

$$hpr = \frac{TV - P}{P}$$

- Future holding period return, just use expected receipts at end of period

# Importance of Spot Rates

- In the market, when estimating a price for a bond, participants use spot rates, not yield to maturity

$$P = \frac{C}{(1+r_1)} + \frac{C}{(1+r_2)^2} + \frac{C}{(1+r_3)^3} + \ldots + \frac{C+M}{(1+r_n)^n}$$

- Possibly different rates for each maturity
- If don't use these rates, there are possible arbitrage profits from stripping out the underlying payments into different securities

# How Compute Spot Rates?

- Suppose a two-year bond with annual payments

$$P = \frac{C_1}{(1+r_1)} + \frac{C_2 + M}{(1+r_2)^2}$$

- How compute $r_2$ ?
  - Know T-bill rate for one year and therefore know $r_1$
  - Know price and coupon payments and final payment
  - Just have to compute $r_2$
  - With semi-annual payments, it's only a bit more complicated
  - Called "bootstrapping spot rates"

# Market Structure

- Bonds are traded over the counter, not on an organized exchange
  - Tends to be thin, i.e. relatively infrequent trading of particular securities
  - Newly issued Treasuries are the most commonly traded fixed-income securities with a term over one year
    - These are called “on-the-run” securities

# Additional Aspects of Bonds

- There are important details which affect observed bond prices
  - Accrued interest for part of period
  - Provisions besides payments
    - Options to call bonds
    - Collateral
    - Credit risk on corporate bonds

# Summary

- Money markets are markets for short-term funds
- Treasury Bills, Commercial paper and Certificates of Deposit are the most prominent in the United States
- T-bills and commercial paper are quoted on a discount basis
  - Convenient but not the same as bond-yield equivalent rates
  - Not hard to go from one to the other

# Summary

- Rates received on securities less than a year typically are annualized by computing simple interest rates
  - Multiplying them up by the number of days in a year divided by the number of days to maturity ($a/m$)
  - Ignores compounding

# Summary

- Compounded interest rates assume that all funds receive the same return over the life of the security
  - Raising one plus rate to power $a/m$
- Yield to maturity is a common way to quoting the return from owning a bond to maturity
  - Reflects compounding
  - Assumes all funds can be reinvested at the yield to maturity
  - Same as internal rate of return on a bond

# Summary

- If a bond is not held to maturity, the holding period return is the best measure of the return
  - Issues of intermediate payments and annualization arise here too
- Spot interest rates on bonds are the interest rates today for each payment made, with all of the rates possibly being different
- Spot interest rates can be computed by “bootstrapping” them
  - First rate is the one-period rate and the rest are bootstrapped from that one

# Summary

- Bonds are traded over the counter
- Markets for Treasury bills and recently issued longer-term Government securities are relatively liquid
- Corporate bonds are relatively illiquid
  - Different terms and different companies
  - Credit risk
  - Collateral has a unique value
  - Options to call bonds