Bond Pricing and Interest Rates

- Government bond prices represent the time value of money
  - In the US, pictures of George Washington
  - No (or very small) default risk
  - Simple application of NPV analysis
  - Nominal interest rates
    - Real interest rates + expected inflation

Coupon Bonds & "Zeroes"

- Zero coupon bonds are pure discount securities
  - All US Treasury bills (with maturities at issue less than 1 year) are pure discount bonds
  - The only payoff is the $10,000 (or multiples) paid at the maturity date

$$P = \$10{,}000 / (1 + r)^k$$

  - P = price of bill
  - r = effective annual interest rate
  - k = number of years to maturity
    - (e.g., l = ½ for a six month bill)

Coupon Bonds & "Zeroes"

- <u>Example:</u>
  - – Six month Tbill selling at $9,900

$$9{,}900 = \$10{,}000 / (1 + r)^{1/2}$$

$$1 + r = [10{,}000/9{,}900]^2$$

So r = 0.0203 (or 2.03% effective annual rate)

Coupon Bonds & "Zeroes"

- Coupon bonds pay cash (coupon) payments every six months until maturity, plus the principal repayment at maturity
  - You can think of it as a portfolio of zero coupon bonds maturing every six months to maturity (with equal face value) plus a larger face value discount bond with a payoff at the maturity date
  - The weighted average maturity is shorter than for a zero coupon bond with the same maturity date
    - This is called Macaulay's <u>duration</u> measure

Coupon Bonds & “Zeroes”

- Example:
  - Suppose you had a Treasury note maturing in March 2018 with a coupon rate of 2.875% per year
    - Current price (average of bid and ask prices from 4/24/2017 WSJ) is 101.6563
  - You also have Treasury bills maturing in September 2017 and March 2018 with yields of:
    - 9/28/2017: r = 0.873
      - Price = $100/(1+r)^{[157/365]}$ = 99.62682
    - 3/29/2018: r = 1.003
      - Price = $100/(1+r)^{[339/365]}$ = 99.07737

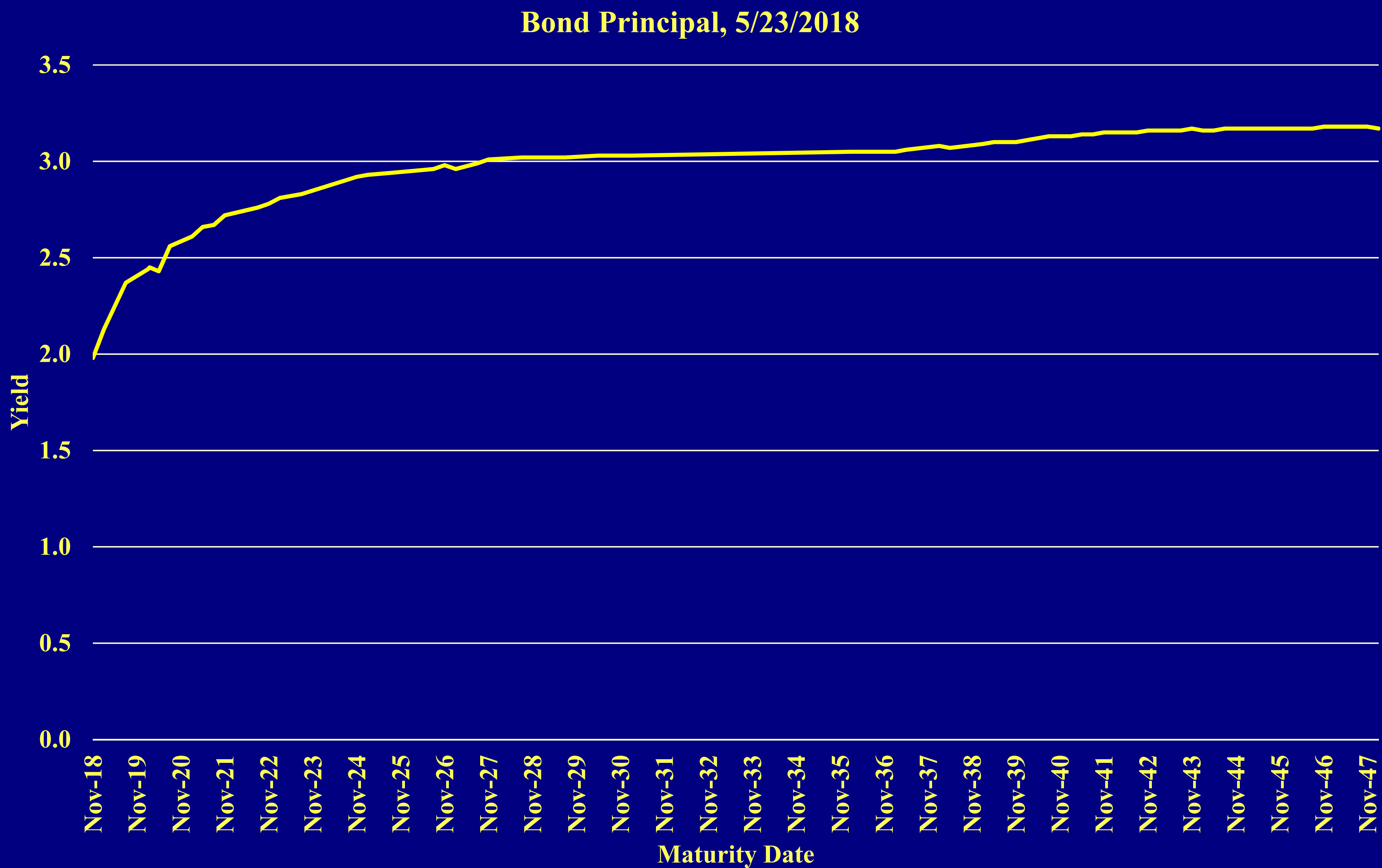
Coupon Bonds & “Zeroes”

- Present value of coupons:
  - 9/28/2017: $1.432 = .9962682 * $2.875/2 per $100 face value
  - 3/29/2018: $1.424 = .9907737 * $2.875/2 per $100 face value
- Present value of principal:
  - 3/29/2018: $99.077 = .9907737 * $100 per $100 face value
- Total value of coupon bond:
  - 3/29/2018: $101.934 = $99.077 +1.432 + 1.424 per $100 face value
  - Compared to ask price of $101.6641
    - Note that the quoted yield on the note is 1.075%, which is a weighted average of the yields on the coupon and principal cash flows

Term Structure of Interest Rates

- Term structure refers to the shape of the plot of yields to maturity as a function of the maturity date
  - Discount term structure reflects yields on Tbills and zero coupon (strip) bonds
    - This is the price of receiving $1 at some time in the future
  - Coupon term structure reflects yields on coupon bonds
    - These are each weighted averages of the yields associated with the intermediate and final cash flows (i.e., pretty meaningless)

Term Structure of Interest Rates



Term Structure and Forward Rates

- Think of the yield on a 2-period bond in terms of the yield on the 1-period bond and the forward rate of interest from period 1 to period 2

$$(1 + y_2)^2 = (1 + y_1)(1 + r_2)$$

where y_1 is the yield to maturity on a 1-period strip and r_2 is the forward rate for period 2

Term Structure and Forward Rates

- In general:

$$(1 + y_k)^k = (1 + y_{k-1})^{k-1} (1 + r_k)$$

where y_k is the yield to maturity on a k-period strip and r_k is the forward rate for period k (note: $r_1 = y_1$)

$$(1 + y_k)^k = (1 + r_1)(1 + r_2)(1 + r_3) \ . \ . \ . \ (1 + r_k)$$

So the yield to maturity is simply a geometric average of the forward rates

Term Structure and Forward Rates

- If the term structure is rising, then the forward rate is above the spot rate

  $r_k > y_k$

  and vice versa

- Holding period returns from period to period depend on movements of the term structure
  - Increases in interest rates cause bond prices to fall
    - Shift in the term structure
  - Movements along the term structure (no shifts) cause returns to equal forward rates

Term Structure and Forward Rates

- Note that forward rates are not just a theoretical concept
- You can invest in a forward contract, buying a k-period strip and short selling a (k-1) period strip
  - You receive the interest rate r during period k
- We will see this concept again when we get to a discussion of futures contracts

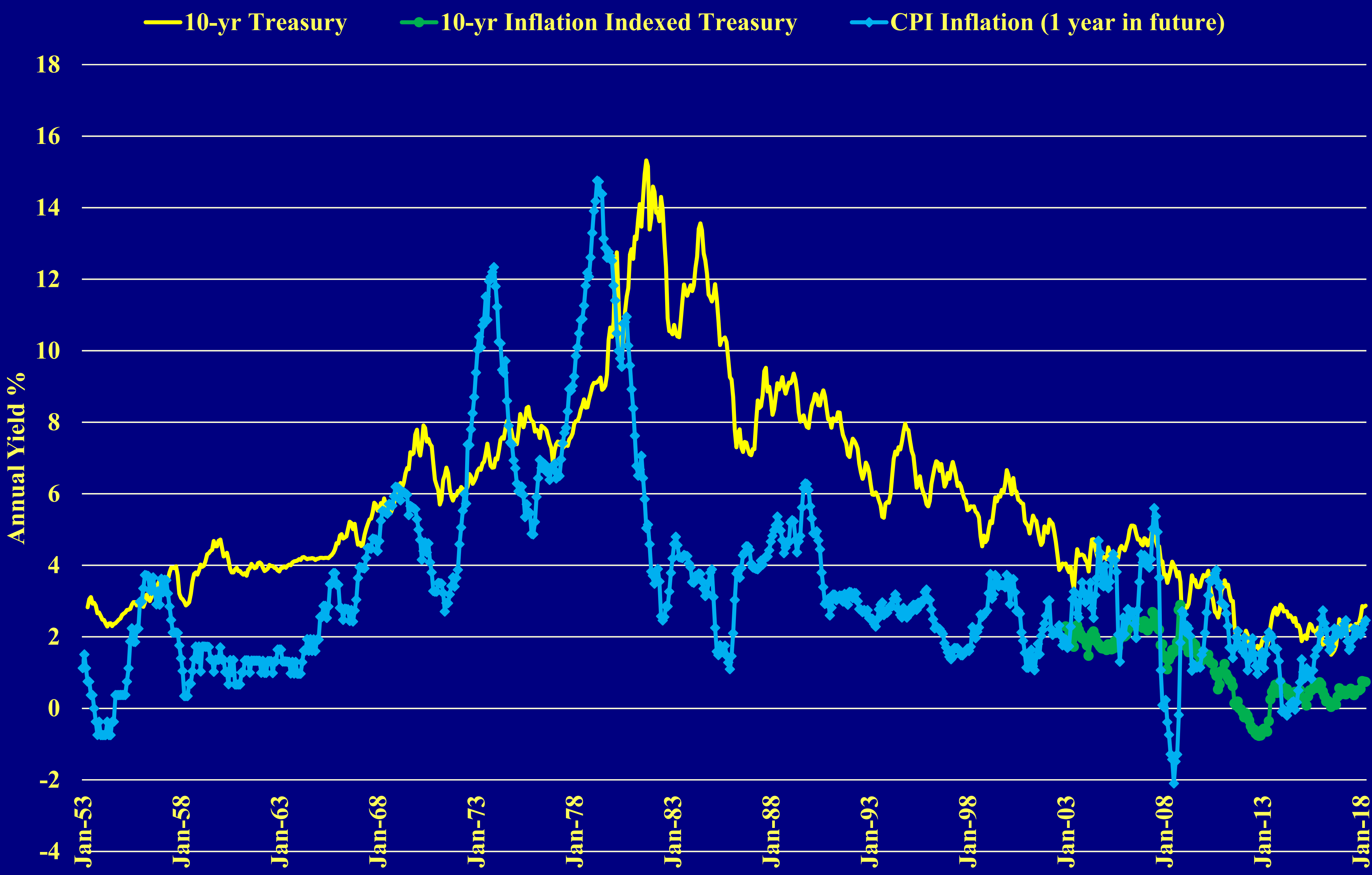
Interest Rates and Inflation

- One reason why nominal interest rates are different for different maturities (at the same point in time), and why nominal interest rates of the same maturity are different at different points in time is

EXPECTED INFLATION

real rates = nominal rates – expected inflation

Nominal and Real
10 Year Yields (Interest Rates)



Interest Rates and Inflation

- Graph shows that nominal yields tracked future inflation pretty well until the early 1980s
- Reagan and Volcker changed fiscal and monetary policy so that inflation came down substantially and has stayed low since
- The bond market took a while to become convinced that this was a new "normal" so yields came down to reflect the new inflation regime
- Larry Summers (as Clinton's Treasury Secretary) argued for and got permission for the US government to sell inflation-indexed Treasury securities for the first time
  - So investors could hedge against inflation by buying TIPS

Interest Rates and Inflation

- Note that the Inflation Indexed Treasury yield has been between -0.5 and 3 percent since these bonds started trading in 2003
  - A negative real yield just means that inflation is expected to be higher than the nominal interest rate over the life of the bond
  - Treasury Inflation-Protected Securities, or TIPS, provide protection against inflation. The principal of a TIPS increases with inflation and decreases with deflation, as measured by the Consumer Price Index. When a TIPS matures, you are paid the adjusted principal or original principal, whichever is greater. TIPS pay interest twice a year, at a fixed rate. The rate is applied to the adjusted principal; so, like the principal, interest payments rise with inflation and fall with deflation.
    - https://www.treasurydirect.gov/indiv/products/prod_tips_glance.htm

Term Structure and Profit Opportunities

- Term structure may be the best example of an efficient market
  - Lots of traders
  - Information is widely available and no one has cheap access to better information about the macroeconomy
  - Transaction costs are very low
  - Scope of uncertainty is limited
    - Set of possible outcomes is small
    - Unlike future events that affect the value of corporate securities
- This implies that "profit opportunities" should be scarce

Term Structure and Profit Opportunities

- Means that it should not pay to “play” the term structure
  - buy long-term bonds because they have higher yields?
  - **Why Not?**
    - If rates rise in the future, bond prices will fall, so returns will be lower than implied by forward rates
    - Also, rising forward rates may imply that inflation or real interest rates will be much higher in the future than they are today

Term Structure and Profit Opportunities

- Humorous example (sort of):
  - Original Bill Clinton Budget Plan:
    - Largest single source of “budget cuts” was from borrowing at the short end of the term structure!
    - Is this an “expenditure cut”?
      - In the short-run, less cash flows leave the Treasury
      - In the longer run, if the upward sloping term structure correctly implies that short-term rates will rise, the cost of short-term borrowing will rise
      - Future administrations would have to pay for the decision to borrow short today
      - No free lunch (just put it on someone else’s bill . . .)

Corporate Bonds and Default Risk

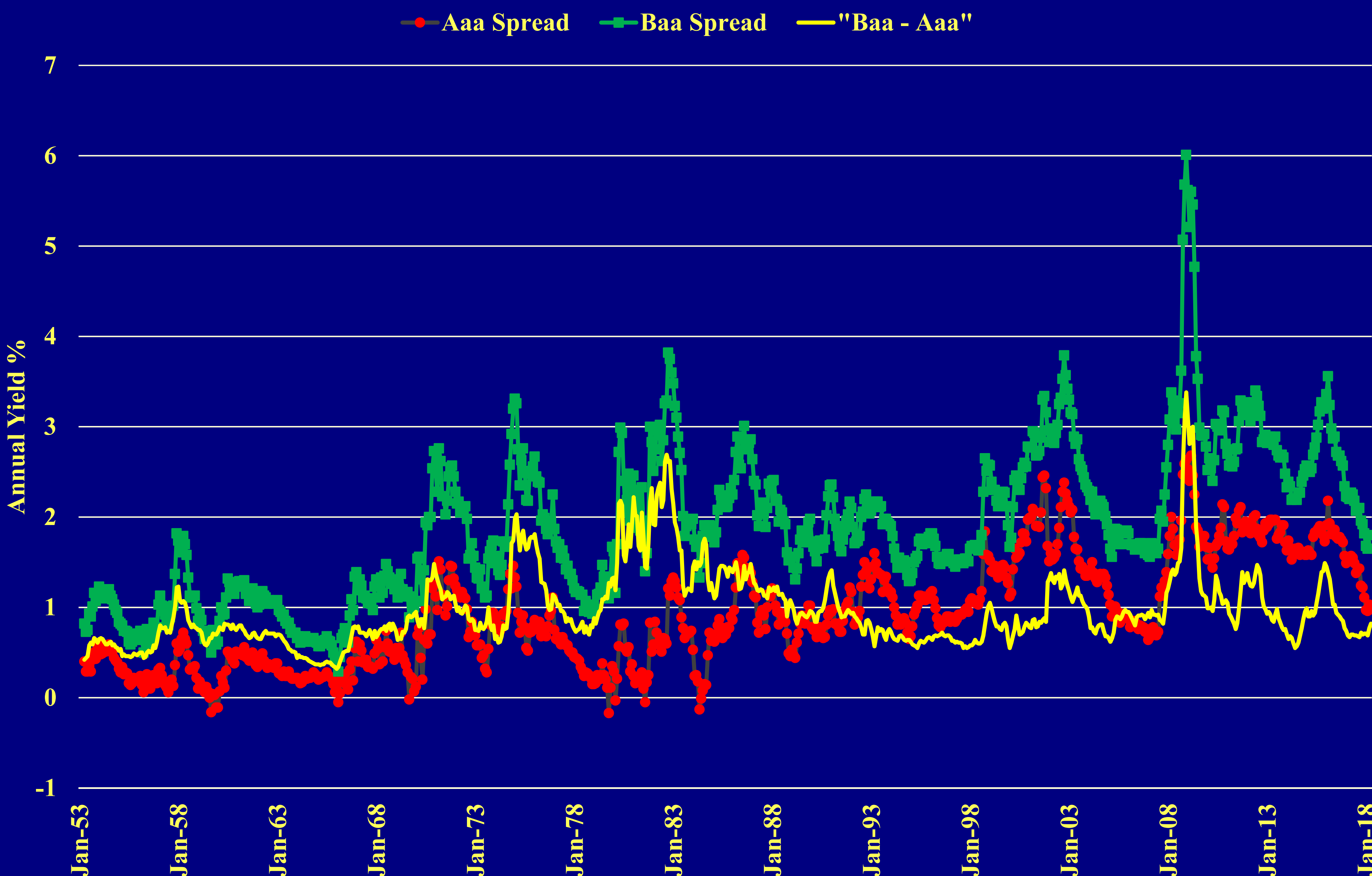
- Rating agencies (Moody's S&P, Fitch, etc.) publish ratings for corporate, municipal and structured finance debt
  - Intended to reflect default risk (and losses given default)
  - Aaa is highest Moody's rating
  - Baa is lowest "investment grade" bond
    - Eligible for purchase by most banks, insurance companies, etc.
  - Below Baa are "junk" (high yield) bonds
    - Somewhat like equity since their payoffs are strongly linked to the health of the issuer
    - Yields are higher (and prices lower) to reflect more default risk

Riskless and Risky
10 Year Yields (Interest Rates)

Corporate Bonds and Default Risk

- Note that most of the movement in the yields is driven by the same factors that influence "riskless" government bonds
- Aaa yields are higher, and Baa yields are even higher, but all move together

Credit Risk
10 Year Yield Spreads



Credit Risk and Default Spreads

- Spreads between Aaa corporates versus the Treasury yield tend to be between 0 and 2 %
- Spreads between Baa corporates versus the Treasury yield tend to be between 0 and 6 %
- Spreads between Baa and Aaa yields have been between 0.3 and 3.4%
  - Highest in periods of financial distress
    - 1974-76 (OPEC I)
    - 1979-82 (OPEC II, Carter "stagflation," Iran hostage crisis)
    - 2008-09 (financial crisis)

Managing Interest Rate Risk

- If you have predictable cash outflows in the future, match the payments from bonds to the timing of the outflows
  - "cash flow matching"
- E.g., if you have a lump sum payment to make in 12 months (to pay a contractor for finishing a construction project), you can buy enough 12 month Treasury bills to deliver exactly the amount of cash you need 12 months from now
  - Even if interest rates change during the year, you are guaranteed to have the cash necessary to make the payment

Managing Interest Rate Risk

- If you have a more complicated set of cash flows to deliver in future periods, rather than purchasing securities to match each projects demand for future cash, you can use an approximation to buy a set of securities that should have little interest rate risk

- "duration matching"
  - The modified duration of a bond (D*) is the negative percent change in the price P divided by the change in the yield y

    $$D^* = -[\Delta P/P]/\Delta y$$

  - So this tells you the bond's exposure to changes in interest rates

Managing Interest Rate Risk

- "duration matching" amounts to buying a set of riskless securities that has the same duration as your anticipated cash demands
  - This rule is only approximate and works exactly only when all movements in interest rates are small
  - For larger changes in rates, the curvature of the relation between yields and prices means that price changes will be greater than predicted by modified duration for either large increases or large decreases in yields
    - This is called "convexity"

Return to BRN 481 Home Page

Data used for these slides can be accessed at:

http:\\schwert.ssb.rochester.edu\brn481\brn481bond.xlsx

http:\\schwert.ssb.rochester.edu\brn481\brn481bond.zip

<u>Home Page:</u>

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