Foundations of Finance

Interest Rate Risk and the Yield Curve

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Partial Review of the Last Class

- A 3-year zero yielding 5% costs $863.84. One year later the yield is 7% and you sell. What did you earn?
- Why is that not 5%?

- A bond pays semi-annual coupons and is quoted at a yield of 6%. What rate do you discount with, and over how many periods?
- What is that bond's effective annual yield, and why is it not 6%?

Today

- Interest rates and inflation: what a quoted rate is made of
- Who sets the short end: the Fed and the ECB
- The yield curve: its shapes, and the curve in motion
- The euro-area curve: Tesoro, Bund and the prima de riesgo
- Rolling over versus locking in
- The expectations hypothesis and the forward rate
- Interest rate risk as a maturity mismatch: the S&Ls and SVB

Interest Rates and Inflation

- Every yield we have computed so far is a nominal rate. It pays for three things:
  - the real return the lender wants for waiting
  - the inflation expected over the life of the loan
  - the risk that the borrower does not pay
- **(1 + nominal) = (1 + real) × (1 + expected inflation)**
  - real 1% and expected inflation 2% give a nominal rate of about 3%
- Discount nominal cash flows at a nominal rate, real cash flows at a real rate — the answer is the same as long as you are consistent
- So the curve can move on expected inflation alone, with no central bank involved

Who Sets the Short Rate: the Fed and the ECB

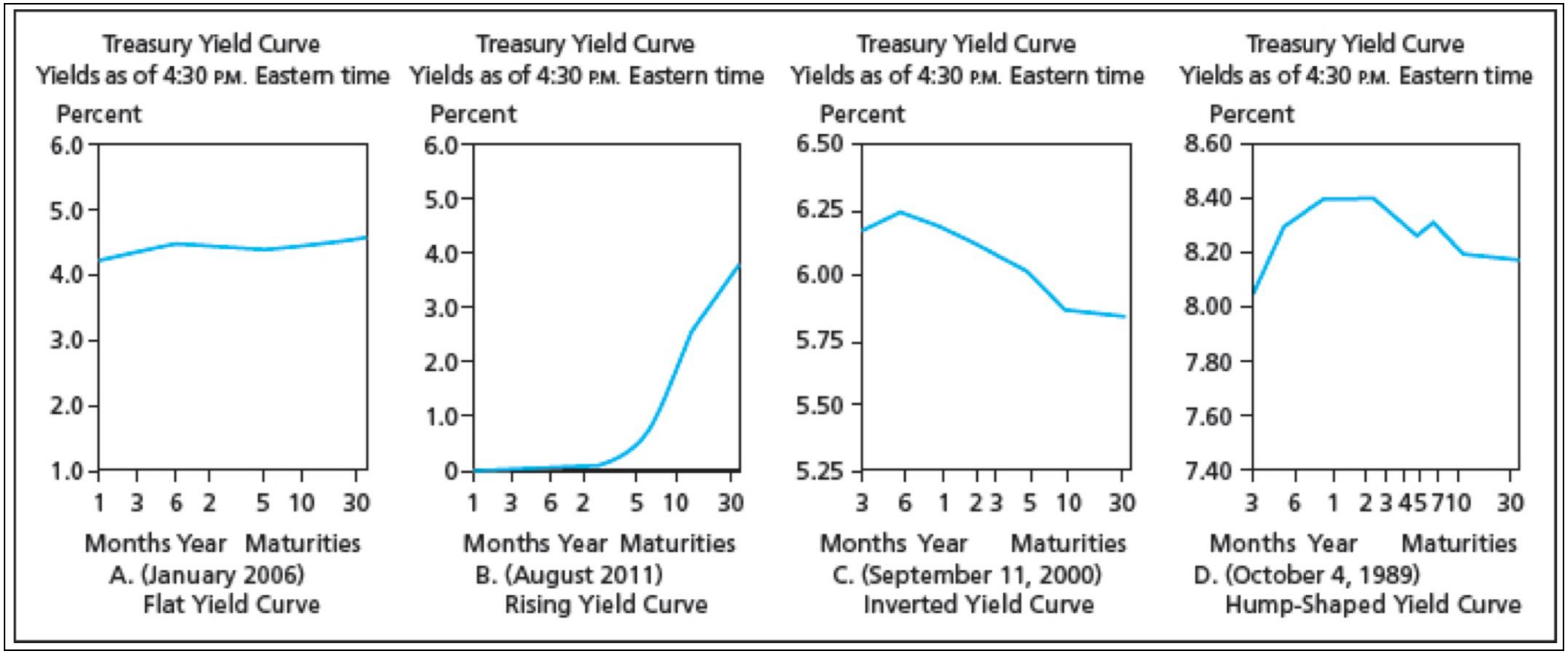
- A central bank sets the short end of the curve. The market sets the rest
  - United States — the Federal Reserve: price stability and maximum employment
  - Euro area — the European Central Bank: price stability first
    - one policy rate, and as many sovereign curves as there are member states
- Both are independent of the governments that appoint them — the point from Session 1
- **So a central bank can cut the overnight rate and watch the 10-year yield rise the same afternoon**

The Yield Curve

- The collection of YTM of zero-coupon bonds has many names:
  - The term structure of zero-coupon bond yields
  - The term structure of (spot) interest rates
  - The yield curve

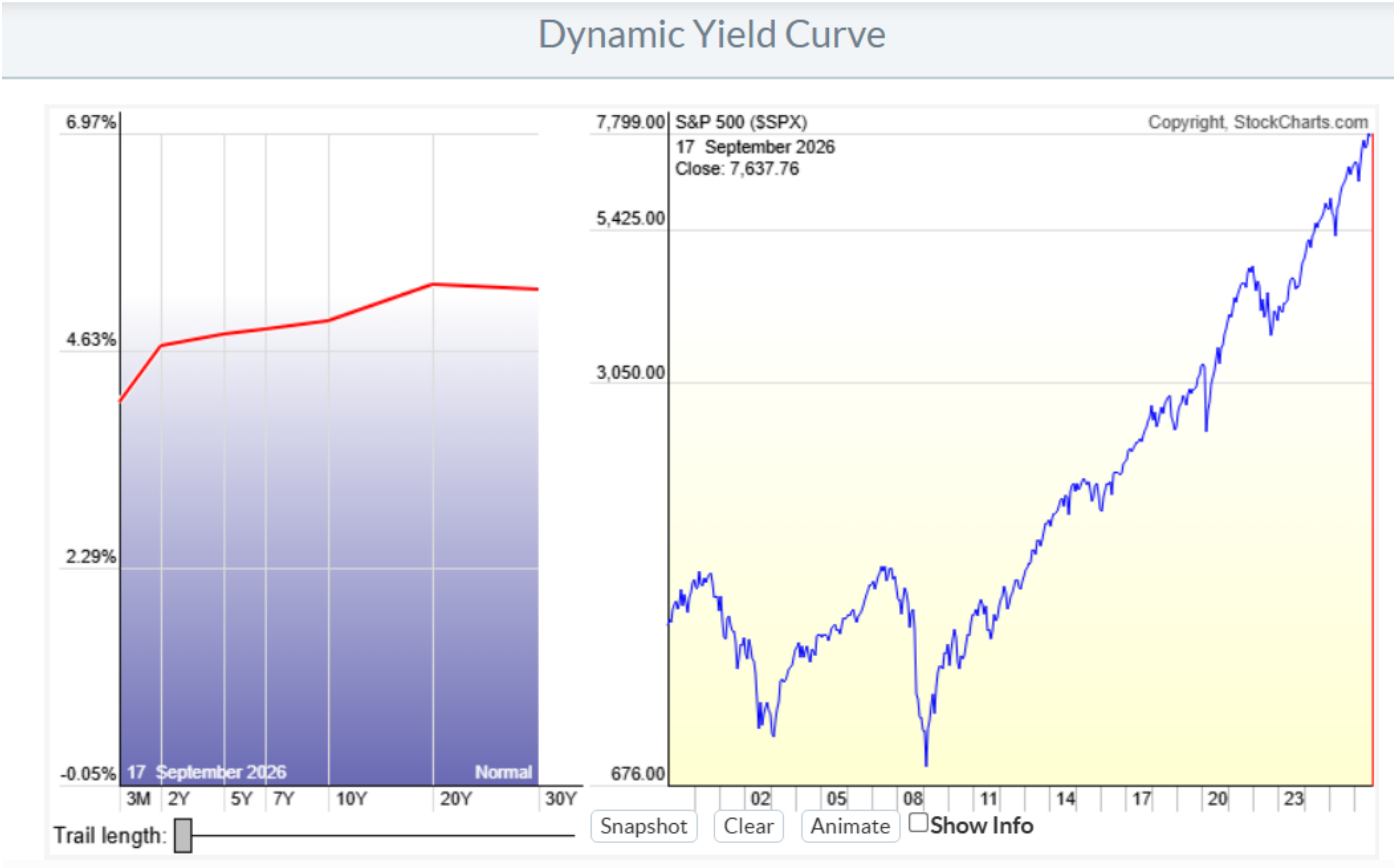
- Typical shapes of the term structure of interest:
  - Upward sloping (most common)
  - Downward sloping
  - Flat
  - Hump-shaped

The Four Shapes of the Yield Curve



Source: www.treasury.gov

The Yield Curve, Live



https://stockcharts.com/freecharts/yieldcurve.php — drag the trail to replay the curve

The Euro-Area Curve: Tesoro, Bund and the Prima de Riesgo

- Spain has a curve of its own, quoted every day by the Tesoro Público:
  - Letras del Tesoro — up to 12 months, issued as zeros
  - Bonos del Estado — 3 and 5 years, with coupons
  - Obligaciones del Estado — 10 years and beyond
- The German Bund curve is the euro-area benchmark: the closest thing to a risk-free curve in euros
- **The prima de riesgo is one number off two curves: the Spanish 10-year yield minus the German 10-year**
  - a credit spread, not a term spread — Session 5's idea measured on Session 7's object
- So a Spanish yield moves because the Bund moved, or because the spread moved, or both

Rolling Over Short-Term Bonds

- Your company issues a 1-year zero-coupon bond with \$100 face value at a yield of 5%
- Next year it rolls the debt over into a new 1-year zero-coupon bond at a yield of 3%. What was the annualised cost of borrowing over the two years?
- What if the new bond's yield turned out to be 7% instead?
- What would the annualised cost have been if the company had issued a 2-year zero-coupon bond at 5% in the first place?

Rolling Over Short-Term Bonds — Answer

- Year 0: raise 100 / 1.05 = \$95.24. Year 1: repay \$100, raise \$100 again. Year 2: repay \$103
- **Annualised cost = (103 / 95.24)^(1/2) – 1 = (1.05 × 1.03)^(1/2) – 1 = 4.00%**
  - the geometric average of the two one-year rates — Session 6's annualised HPR from the issuer's side

- If the second year's yield is 7% instead: (1.05 × 1.07)^(1/2) – 1 = 6.00%

- The 2-year zero at 5% costs exactly 5%, whatever happens next year
- Rolling over is cheaper only if next year's rate turns out lower, and today you do not know

- **The 2-year rate is what the market charges you for not having to find out**

The Expectations Hypothesis

- Two ways to be invested for two years:
  - buy a 2-year zero at today's 2-year yield y_2
  - buy a 1-year zero at y_1 and reinvest next year at whatever the 1-year yield then is
- If investors care only about expected return, the two must be worth the same:
- $\mathbf{(1 + y_2)^2 = (1 + y_1) \times (1 + E[y_1 \text{ next year}])}$
- Turn it around and the curve tells you what the market expects:
- $\mathbf{f = (1 + y_2)^2 / (1 + y_1) - 1}$
  - f is the forward rate: the 1-year rate the curve implies for next year
- A long rate is a geometric average of expected short rates

The Expectations Hypothesis — Examples

- If the current yield on 1-year bonds is 2% and the current yield on 2-year bonds is 3%, what do investors expect the yield on 1-year bonds to be next year? Assume investors are risk neutral.

- If investors come to expect that the yield on 1-year bonds next year will be 5%, what will happen to the current yield on 2-year bonds?

The Expectations Hypothesis — Examples — Answer

- 1-year at 2%, 2-year at 3%. What does the market expect the 1-year rate to be next year?
- **$f = (1.03)^2 / 1.02 - 1 = 4.01\%$**
  - roughly $2 \times 3 - 2$: the long rate is an average, so the second year carries the difference

- Now investors come to expect 5% instead. What happens to today's 2-year yield?
- **$(1 + y_2)^2 = 1.02 \times 1.05 = 1.071 \rightarrow y_2 = 3.49\%$**
  - the 2-year yield rises, so the 2-year bond you already own falls in price

- **Nobody defaulted and no central bank met. An expectation changed, and that was enough**

Implications of the Expectations Hypothesis

- Assume the EH, and suppose the curve slopes upward: $y_2 > y_1$
- What does that imply about the future path of short-term interest rates?
- Will investors earn more on long-term bonds than on short-term bonds?
- Will a company pay more if it issues long-term rather than short-term debt?

Does the Expectations Hypothesis Hold?

- The expectations hypothesis implies the yield curve is:
  - upward sloping when short rates are expected to rise
  - downward sloping when they are expected to fall
  - flat on average
- The last prediction fails: on average the curve slopes up
  - the extra slope is a risk premium, not an expectation — expectations plus that premium is the liquidity preference hypothesis (LPH)
- A long bond held to maturity is perfectly safe in nominal terms — but nobody promised you would hold it to maturity
  - sell early and you carry price risk; short bonds are also easier to sell
- So read the curve as expectations plus a premium, and never as a forecast you can trade on for free

The Yield Curve and Recessions

- 10-year Treasury yield minus 3-month yield
- Falls below zero before virtually every recession

Who Is Exposed to Interest Rate Risk?

- Investors and financial institutions are subject to interest-rate risk, for instance:
  - Homeowner: mortgage payments (ARM)
  - Bank: short-term deposits and long-term loans
  - Pension fund: owns bonds and must pay retirees
- A change in the interest rate results in:
  - Price risk
  - Re-investment risk
- Want to construct a portfolio which is insensitive to interest-rate changes

Interest Rate Risk Is a Mismatch

- You are exposed when the timing of your cash flows does not match your horizon:
  - a short-term investor holding long-term assets loses when rates rise
  - a long-term investor holding short-term assets loses when rates fall
- Two faces of the same problem, both from Session 6:
  - price risk — you have to sell before maturity
  - reinvestment risk — you have to put the coupons somewhere
- Match the timing to the horizon and both disappear together
- **Interest rate risk is not a property of the bond. It is a relationship between the bond and you**

The Savings and Loans Crisis

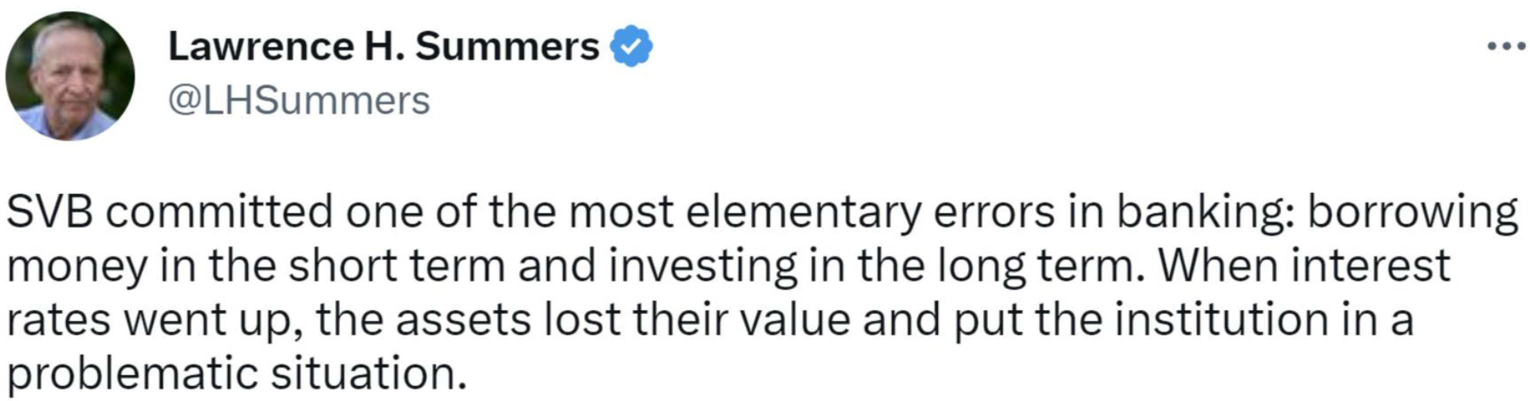
- The explicit purpose of S&Ls was to provide residential mortgage finance for single-family home buyers and for multi-family construction and ownership.
- Until 1979 federally chartered S&Ls and most state charted S&Ls were explicitly prevented from originating adjustable-rate mortgages (ARMs).
- S&Ls were thus restricted largely to making fixed-rate long-term residential mortgage loans, while financing these loans with relatively short-term deposits: They were borrowing short and lending long.

The Savings and Loans Crisis

- This was a good business till interest rates started rising in the 1960s
- Michael Lewis in his book Liar's Poker described S&L members as part of the "3-6-3 club": Borrow money at 3 percent, lend it out at 6 percent, and be on the golf course every afternoon by three o'clock.
- William Poole, former president FRB St. Louis: "The decline of the savings institutions [in the 80s] was a consequence of rising nominal interest rates combined with **duration mismatch**."

Silicon Valley Bank

- Silicon Valley Bank (SVB) collapsed in 2023 when the depositors withdrew $42 billion in 48 hours!
- What happened?



Silicon Valley Bank

- SVB specialised in financing venture-capital-backed tech startups
- In 2020 its clients saw a large influx of cash
- SVB invested those deposits in long-dated bonds
- The Fed raised rates in 2022 and those bonds lost value
- In 2022–23 customers withdrew cash as the tech sector cooled and venture money dried up
- Negative spiral of fire sale and bank run

Managing a Balance Sheet

- Many institutions manage a balance sheet
  - Assets = Liabilities + Equity
  - Examples: banks, pension funds, homeowners

- If assets and liabilities change by a different amount when interest rates move, then equity has interest rate risk
  - Equity holders (owners) will gain or lose when interest rates move
- Interest rate risk management seeks to reduce these risks

Summary

- A quoted rate is nominal: real return, expected inflation, and credit
- The yield curve is the whole set of spot rates: the central bank sets its short end, the market sets the rest
- The expectations hypothesis reads a forward rate off the curve: $(1 + y_2)^2 = (1 + y_1)(1 + f)$
- On average the curve slopes up more than expectations alone explain — the rest is a risk premium
- Interest rate risk is a maturity mismatch: the S&Ls and SVB made the same mistake forty years apart

- **Next class: Equity Valuation I (BMAE 4.1–4.3) — Problem Set 1 is due at the start of class**