FNCE90056:
Investment Management

Week 6 - Lecture 6: Fixed Income

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About myself...

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Academic background

- Ph.D. (Finance) and M.Sc (Finance), Kellogg School of Management, Northwestern University (USA)
- BCom and M.A. (Economics), Victoria University of Wellington (NZ)

Research interests

- Empirical asset pricing, financial market frictions, international finance

I am the Subject Coordinator and I will be teaching Week 6-8 and 10-12.

Agenda today

- Introduction: fixed income markets
- Government debt markets
- Discount factors
- The money market

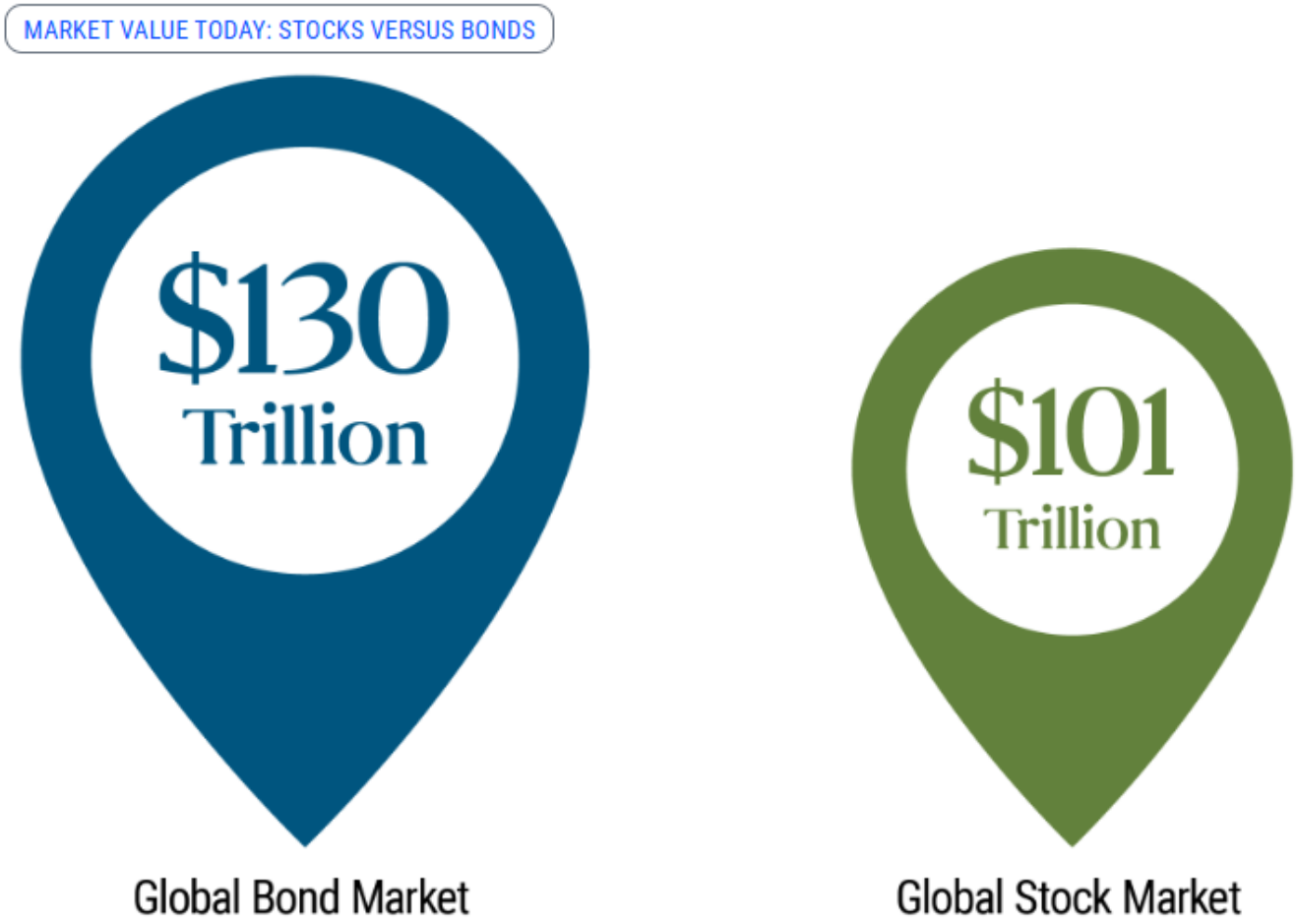
Introduction

Today

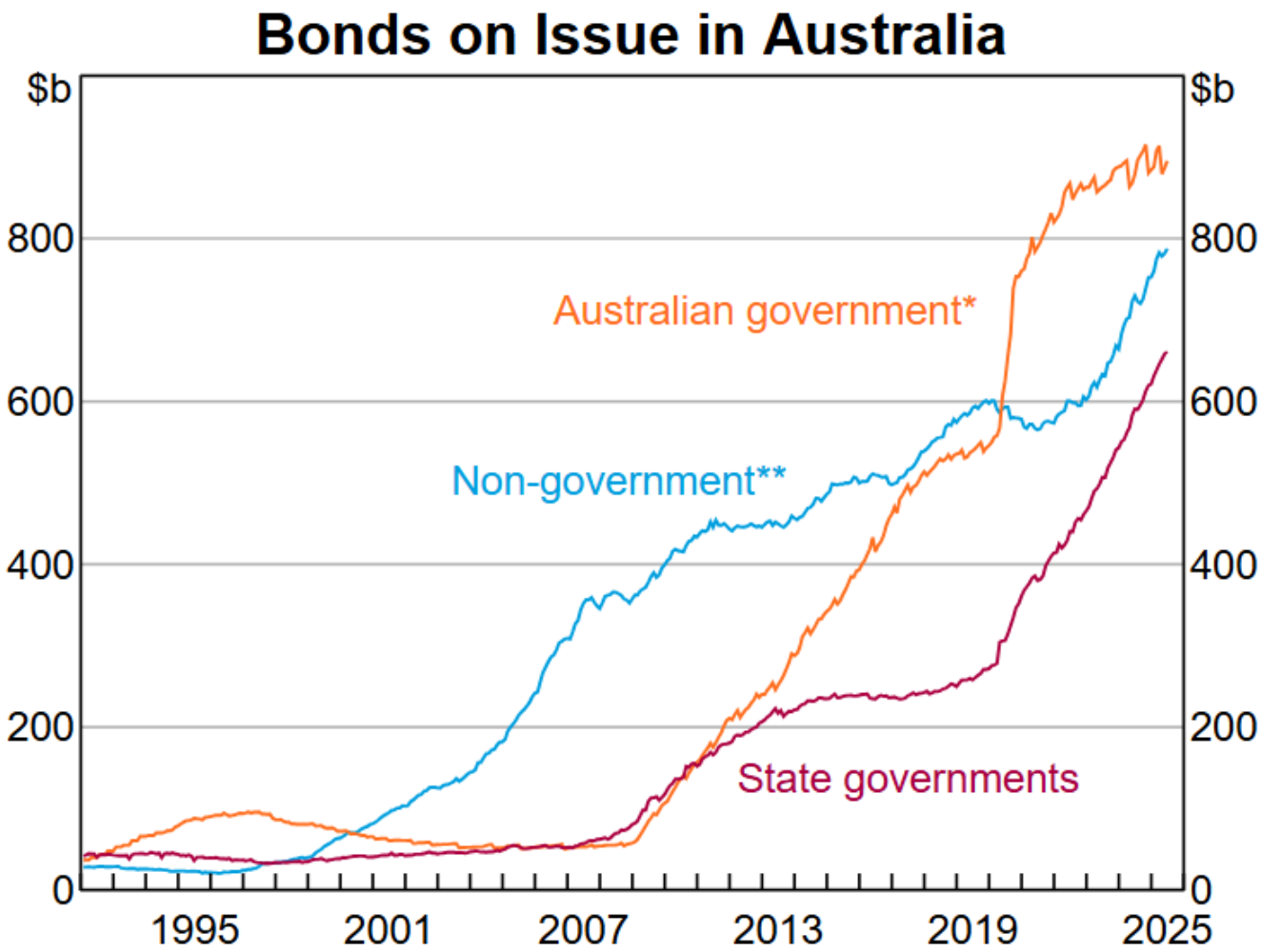
The Bank of England was founded in 1694 to issue some of the earliest government bonds. After England's naval defeat by the French at the Battle of Beachy Head, William III's government undertook borrowing 1.2 million pounds to rebuild the navy. Unable to borrow the money directly at an 8% interest rate, the Bank of England was founded to induce investors to provide the funds. The Bank was given exclusive right to be the banker to the government including being allowed to issue bank notes. Pictured above is a metalwork panel at the Bank of England.

- Today we will introduce several different segments of the fixed income market.

Bond market is big!



Bonds issued to finance projects



* Excludes bonds purchased by the Australian Government.

** Excludes ADIs' self-securitisations, includes government-guaranteed bonds.

Sources: ABS; AOFM; Bloomberg; KangaNews; Private Placement Monitor;

- This Bloomberg screen demonstrates the complexity of the fixed income market as multiple securities are presented on one page.

Securities on the Bloomberg Terminal Market Monitor

The screenshot on the previous slide gave summary information about a number of securities:

- Federal funds rate quotes
- U.S. Treasury bill prices and yields
- Eurodollar deposit rates
- Repo and reverse repo rates
- U.S. Treasury bond yields and prices
- Commercial paper quotes
- 90-day Eurodollar futures
- Federal funds futures
- LIBOR
- Foreign exchange rates
- 30-year mortgage-backed securities
- 10-year Treasury note futures
- Swap rates
- Other key rates, including the prime rate

Terminology

A **bond** is essentially an IOU: the issuer (borrower) promises to repay the investor (lender) the amount borrowed plus interest over some specified period of time.

- A **coupon bond** promises a periodic interest payment (e.g. every 6 months or every year) and repayment of the face value (principal) of the bond at thematurity date.
  - The periodic interest payment is also known as the coupon and the interest rate that the issuer agrees to pay annually on the face value is called the coupon rate.
- In the case of a **zero-coupon bond** (ZCBs) there are no periodic coupon payments and both principal and interest are paid together at the maturity date.
  - ZCBs are the building block securities in the fixed income market.
  - A general bond, with many future payments, can be thought of as a bundle of ZCBs corresponding to each individual payment.

No-arbitrage

An **arbitrage** opportunity is a feasible trading strategy involving 2 or more securities with either of the following characteristics:

1. It has a price of zero, non-negative payoffs, and it generates at least one positive payoff with a positive probability
2. It has a negative price, and non-negative payoffs

The **law of one price** establishes that securities with identical payoffs should have the same price.

Much pricing is done by **replicating** a security's cash flows and then applying the law of one price.

No-arbitrage

- The principle of no-arbitrage is incredibly important here.
- The **no-arbitrage** condition requires that arbitrage opportunities do not exist.
- Fixed income markets are tightly linked and organised around no-arbitrage relationships.
- The whole market relies on relative valuation to function.

Pricing

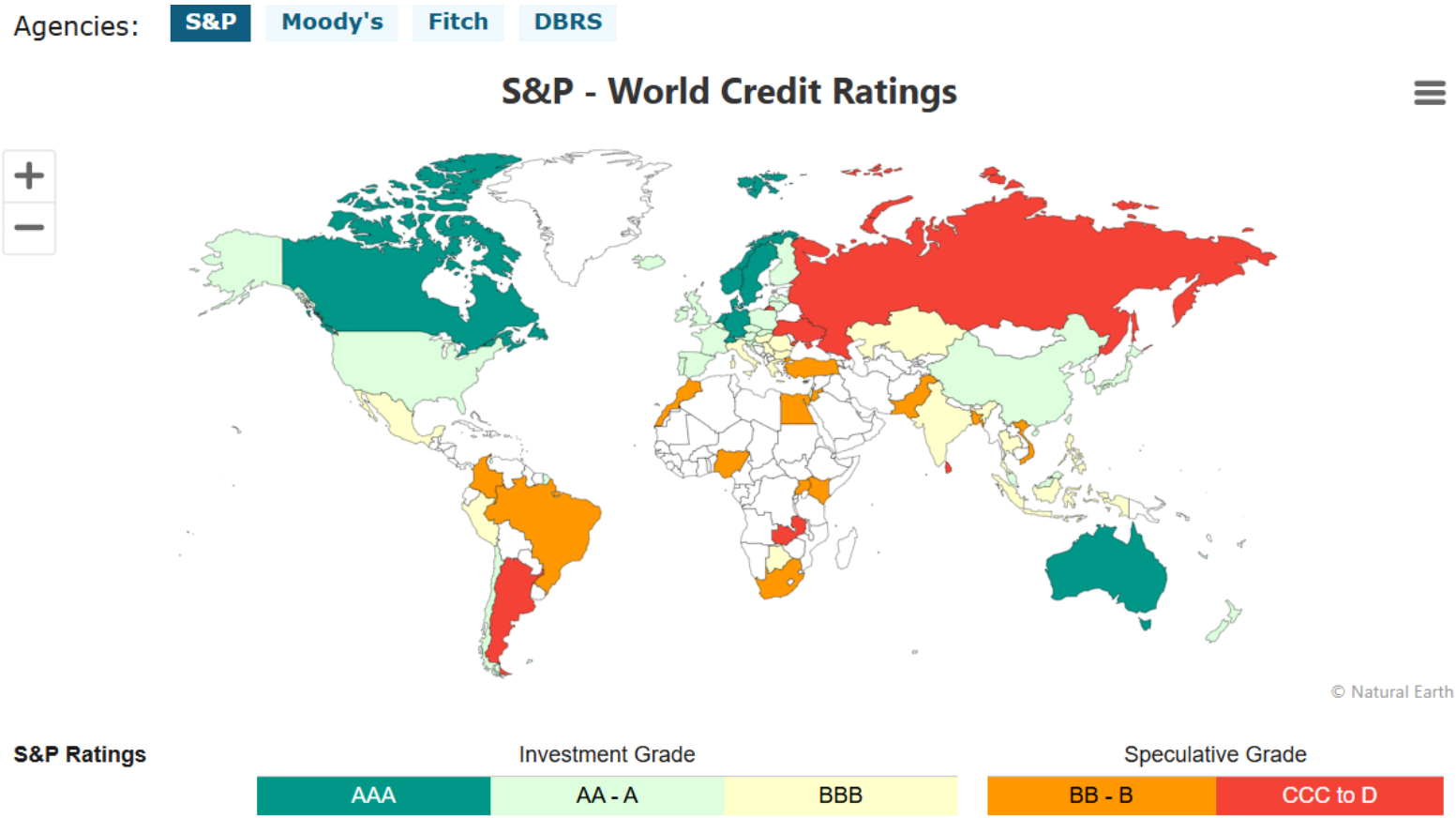
- **Applying no-arbitrage to bonds:**
  - Bond A has a specified set of future cash flows.
  - The portfolio consisting of bonds B and C has the same cash flows as bond A.
  - Then bond A must have the same price as the portfolio of bonds B and C.
  - Future interest rate changes will affect both "portfolios" identically.
- The amazing thing about the fixed income market is that so many securities can be priced (and hedged) without needing to worry about future interest rate changes.
- The success of the fixed income market is rooted in the fact that so many securities can be replicated.
- If something can be replicated it can also be hedged (by doing the opposite).

Credit Risk

Credit risk, or default risk, is the probability that the borrower will fail to pay (default on) some of the coupons or principal.

- Bonds with low credit risk are called **investment grade** bonds, those with high credit risk are called **high yield** or **junk bonds**.
- Government bonds typically have low credit risk.
  - Bonds issued by different governments may have different levels of credit risks: Australian and US government bonds have very low default risk; but Brazilian and Argentinian government bonds have much higher default risk.
- Credit rating agencies (S&P, Moody's, Fitch) issue credit ratings, e.g. Australian government bonds are rated AAA. Argentina government bonds are rated CCC.

Credit Risk of Government Bonds Around the World



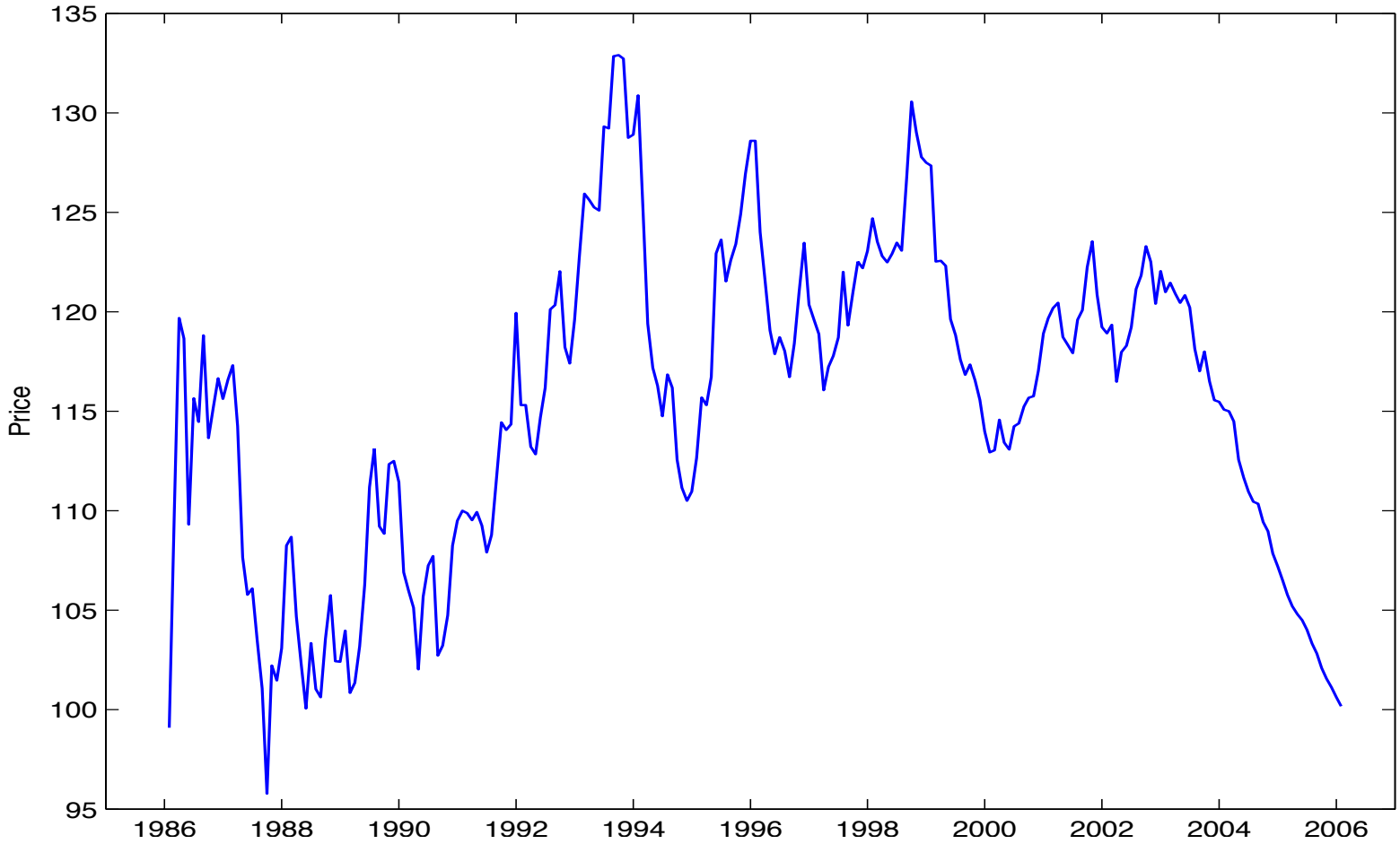
Source: World Government Bonds
https://www.worldgovernmentbonds.com/world-credit-ratings/

Government Debt Markets

Government debt

- Essentially all countries issue debt to finance their operations.
- U.S. government debt has always occupied a special place in fixed income markets, mainly because it is perceived to have an extremely low probability of default.
- The rationale behind its safety from default is that these bonds are backed by the ability of the U.S. government to levy taxes on its citizens in the future to pay the debt back.
- However, an investment in a U.S. Treasury bond may not be predictable in terms of its return on investment over a short period of time (i.e. prior to the maturity date).

Price history of a 20-year U.S. bond



Source: Center for Research in Security Prices

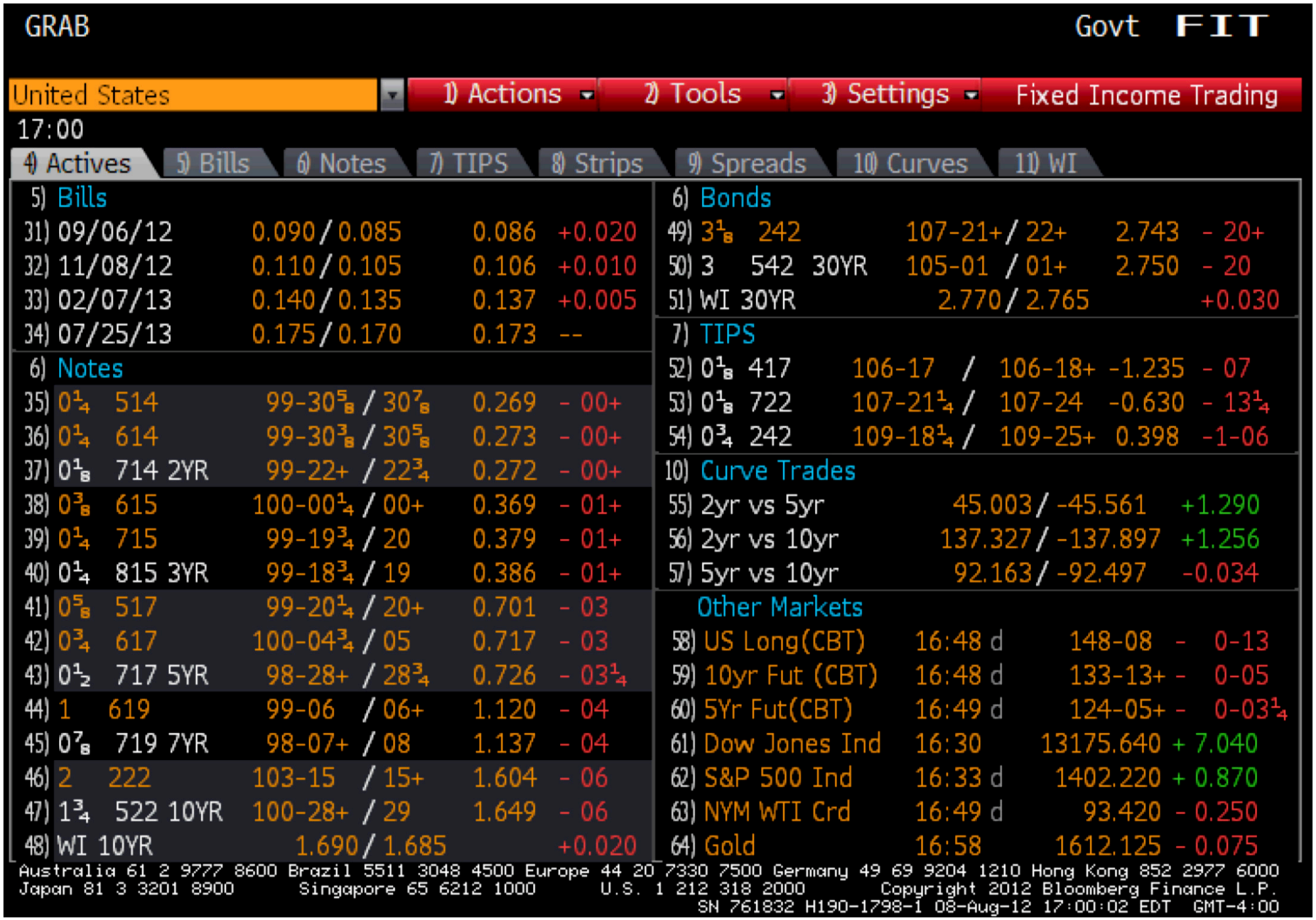
What drives the (substantial) price variation? (It's not credit/default risk.)

U.S. Treasury securities

Name	Maturity	Coupon	Principal
Treasury Bills	4, 13, 26 and 52 weeks	none	fixed
Treasury Notes	2, 5 and 10 years	fixed, semi-annual	fixed
Treasury Bonds	30 years	fixed, semi-annual	fixed
TIPS	5, 10 and 20 years	fixed, semi-annual	Adjusted for inflation

- **Treasury bills** are zero-coupon bonds (ZCBs).
- **Treasury notes** and **bonds** are coupon bonds with coupon (interest) payments every 6 months.
  - All coupon rates as annual rates with semi-annual compounding, by convention.
- The ZCBs corresponding to unbundled Treasury coupon bonds are called Treasury **STRIPS**. A coupon bond is basically a portfolio of zero-coupon bonds, one for each coupon or principal payment.
- In 1997 the U.S. government started issuing **Treasury Inflation Protected Securities (TIPS)** - the principal (and thus coupon payments) increases with higher inflation.

US Treasury Bills/Notes/Bonds Quotation



How Treasury bills are quoted

US Treasury bills are quoted in terms of a *discount rate* (in percent), not of a price.

- If d is the quoted discount rate, T the maturity (in days) and F the face value, then:

$$P = F\left(1 - d\frac{T}{360}\right)$$

- If the quote for a 100-day T-bill with face value of $\$100,000$ is 8.75%, then:

$$P = \$100,000\left(1 - 0.0875\frac{100}{360}\right) = \$97,569.44$$

In Australia, there is a convention using *simple interest* (not compound interest).

- If the quoted simple interest rate is s per year, then:

$$P = \frac{F}{\left(1 + s\frac{T}{365}\right)}$$

- The price of a 100-day T-bill yielding 8.75% per year is

$$P = \$100,000 \div \left(1 + 0.0875\frac{100}{365}\right) = \$97,658.86$$

How Treasury notes and bonds are quoted

US Treasury coupon securities and Treasury STRIPS are quoted in terms of prices (in percent of face value), with the decimal part expressed in units of $^1/_{32}$ (since bond prices historically had increments of $\$^1/_{32}$).

- To facilitate tick sizes below $^1/_{32}$ the following additional modifications are made to the bond's price quote:
  - If the quote ends in a "+", the bond's price is increased by $\$^1/_{64}$
  - If the quote ends with a third decimal digit, this signifies increasing the bond's price by eighths of 1/32. (This is less common, as increments of $^1/_{64}$ are typically sufficient.)
- For example, a quote of 92.143 indicates a price of

$$92 + \frac{14}{32} + \left(\frac{3}{8} \times \frac{1}{32}\right) = 92.449$$ for a security with a \$100 face value.

Discount Factors

Discount factor: motivating example

On 10 August 2006 the Treasury issued 182-day Treasury bills. The issuance market price was \$97.477 for \$100 of face value. That is, on 10th August 2006, investors were willing to pay \$97.477 for a government security that would pay \$100 on 8th February 2007.

- The Treasury would not make any coupon payments between the 2 dates.
- Thus, the ratio between purchase price and the payoff, $\$97.477/\$100 = 0.97477$, can be considered the market-wide discount factor between the two dates 10th August 2006 and 8th February 2007.
- Market participants were willing to exchange \$0.97477 on the first date for \$1 six months later.
- The quantity 0.97477 is simply a 6-month **discount factor** recovered from bond prices; the annual discount rate is 0.05026.

Discount factor: definition

The **discount factor** between two dates t and T, denoted by $\text{DF}(t, T)$, provides the terms of exchange between a given amount of money at date t versus a (certain, or risk-free) amount of money at a later date T.

- The discount factor is unambiguous since it always represents a price of transferring \$1 between 2 points in time, t and T.
  (In contrast, an interest rate is ambiguous, as it depends on compounding frequency, for instance.)
- For simplicity, when $t = 0$, we just write DF_T instead of $\text{DF}(0, T)$.

By no-arbitrage, discount factors decline with maturity (i.e. positive time value of money).

$$\text{If } T_1 < T_2, \text{ then } 1 \geq \text{DF}(t, T_1) \geq \text{DF}(t, T_2).$$

- Caveat: in several countries, interest rates are actually negative, so discount factors may be slightly higher than 1.

Identify the arbitrage

The government issues zero-coupon bonds that pay \$100 at maturity according to the table below.

Bond	Price	Maturity (years)
A	104	1
B	80	2
C	90	3

Question: How can an arbitrage trade be constructed?

Hint: what are the DF_T, for times 1, 2, and 3?

Relating discount factors and interest rates

Letting

$$\mathrm{DF}_t = \frac{1}{(1+r_t)^t} \tag{1}$$

we can write the present value formula as

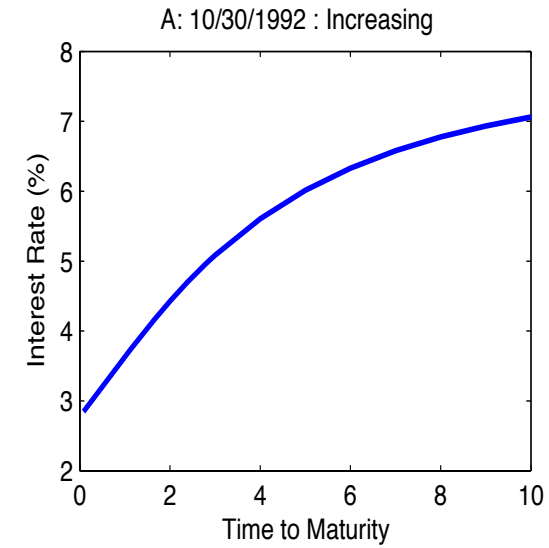
$$\mathrm{PV} = C_1 \times \mathrm{DF}_1 + C_2 \times \mathrm{DF}_2 + \cdots + C_T \times \mathrm{DF}_T = \sum_{t=1}^{T} (C_t \times \mathrm{DF}_t) \tag{2}$$

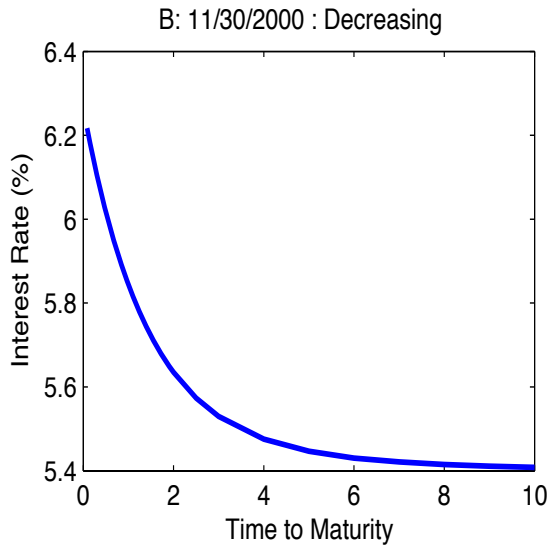
- DF_t is the t-period discount factor, since multiplication by DF_t converts a cash flow C_t in t years into its present value.
- Notice that if $r_t \geq 0$, $DF_t \leq 1$: a dollar tomorrow is worth less than a dollar today.
- Generalising our earlier claim, we must have $1 > DF_1 > DF_2 > \cdots > DF_T$. IF that is the case, then we will be able to say that there are no arbitrage opportunities.

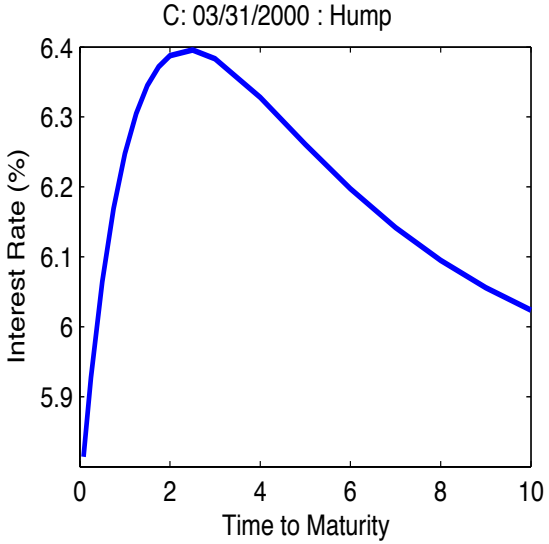
Term structure of interest rates

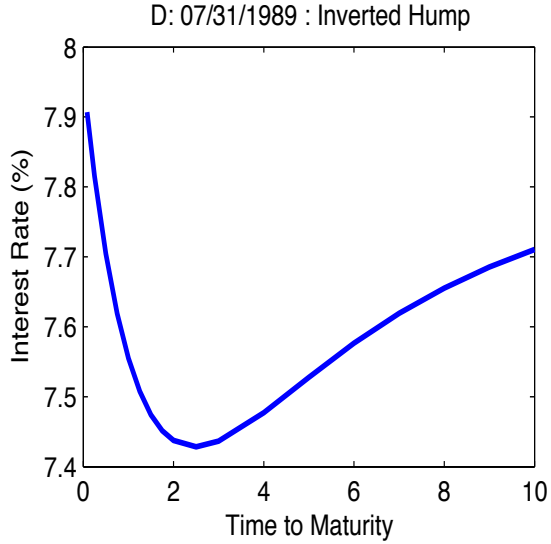
- While discount factors are easier to use for bond calculations, interest rates have a big advantage in that they are easier to use when assessing the cost of borrowing or lending capital as maturity is adjusted.
- In particular, we can use the **term structure of interest rates** to see immediately how the borrowing or lending costs behave relative to maturity.
  - The **term structure of interest rates**, or **spot curve**, or **yield curve**, at date t defines the relation between the level of interest rates and their time to maturity T.
  - Note that the term structure of interest rates is a snapshot of today's borrowing/lending rates. Here we can construct a **zero curve**, or a curve giving the interest rates for zero-coupon bonds of different maturities (zero rates).
  - The **term spread**, or **slope**, is the difference between long-term interest rates (e.g. 10-year rate) and the short-term interest rates (e.g. 3-month rate).

Term structure shapes









Data Source: Center for Research in Security Prices

The Money Market

Money market: definition

- The **money market** is the market for short-term borrowing and lending.
- Banks and financial institutions have various means of borrowing and lending at any point in time, e.g.
  - Federal Funds Rate
  - Eurodollar Rate
  - LIBOR Rate
  - Commercial Paper Rate

Interest Rates set by Central Banks

Central banks are usually independent of government, to avoid conflicts of interest:

- e.g. Reserve Bank of Australia (AU), Federal Reserve Board (US), European Central Bank (EU), Bank of England (UK)

Typical objectives:

- Currency stability, control inflation (target 2-3% per year)
- Economic prosperity, including maximising employment
- Financial stability

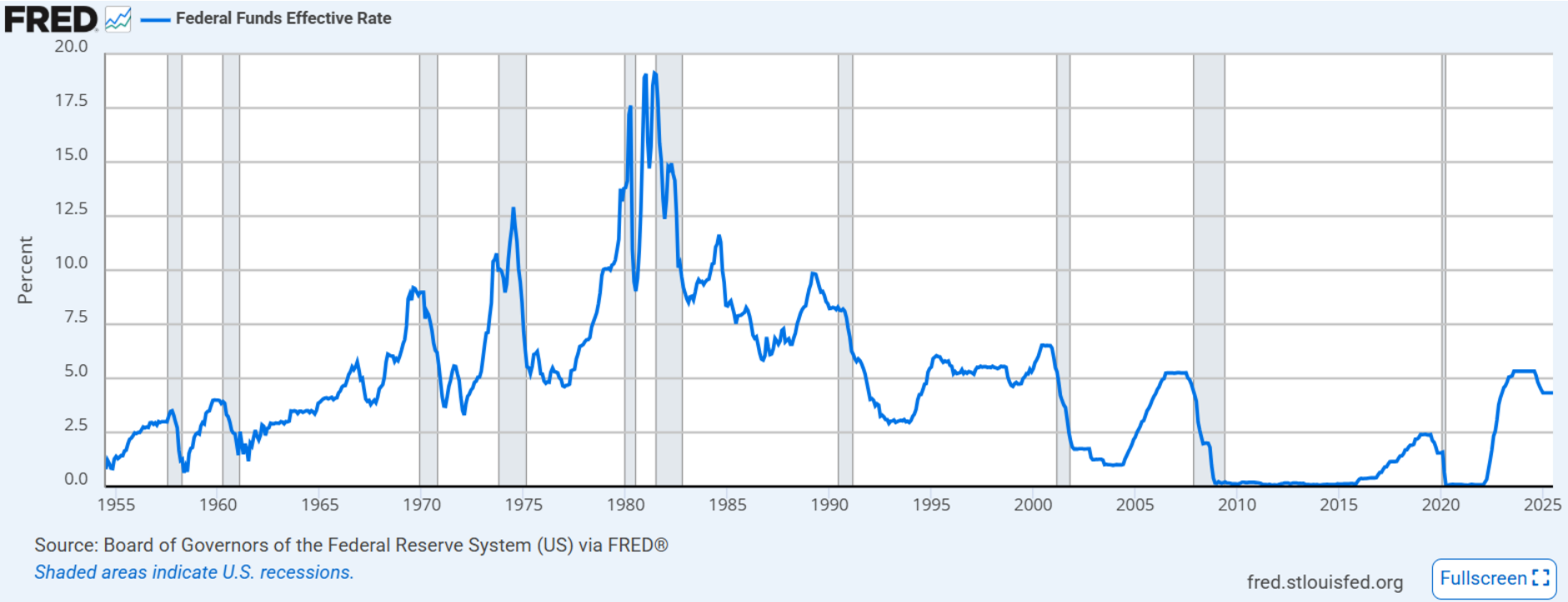
Interest rates:

- Central bank sets interest rates at which it lends to banks at a short (overnight) horizon and also the target interest rate at which banks lend to each other.
- Tension: lower interest rates stimulate economic growth, higher interest rates lower inflation

US Federal Funds Rate

- U.S. banks and other financial institutions must keep some amount of capital within the Federal Reserve. Balances at the Federal Reserve yield a small rate of return, which was in fact zero until September 2008. It is in the interest of banks to maintain their reserves as close to the limit as possible.
- Banks with a reserve surplus may then lend some of their reserves to banks with a reserve deficit. The **federal funds rate** is the average realised rate of interest that banks charge to each other to lend or borrow reserves.
  - This market clears every other Wednesday, when banks are asked to prove they have sufficient reserves.
- The Federal Reserve implements monetary policy largely by targeting the federal funds rate. Given this rate is actually determined by the market and is not explicitly set, the Fed tries to align the effective federal funds rate with the targeted rate by adding or subtracting from the money supply through open market operations (buying/selling government bonds).

Historical federal funds rate



BBC

Fed chair Powell raises hopes of US rate cut

Jerome Powell appeared to back a cut to borrowing rates and played down long term inflation risks in his annual speech at Jackson Hole.

1 week ago

Eurodollar rate

The **Eurodollar rate** is the rate of interest on a US Dollar deposit in a non-US bank.

- These are short-term deposits, ranging from 3 months to 1 year.
- In particular, the 90-day Eurodollar rate has become a standard reference to gauge the conditions of the interbank market.
- The market for Eurodollar futures and options (financial derivatives traded at the Chicago Mercantile Exchange that allow financial institutions to bet on, or hedge against, the future evolution of the Eurodollar rate) is among the largest and most liquid derivative markets in the world.
- In similar fashion, there are euroyen rates representing the interest earned on Japanese yen deposits in banks outside of Japan.

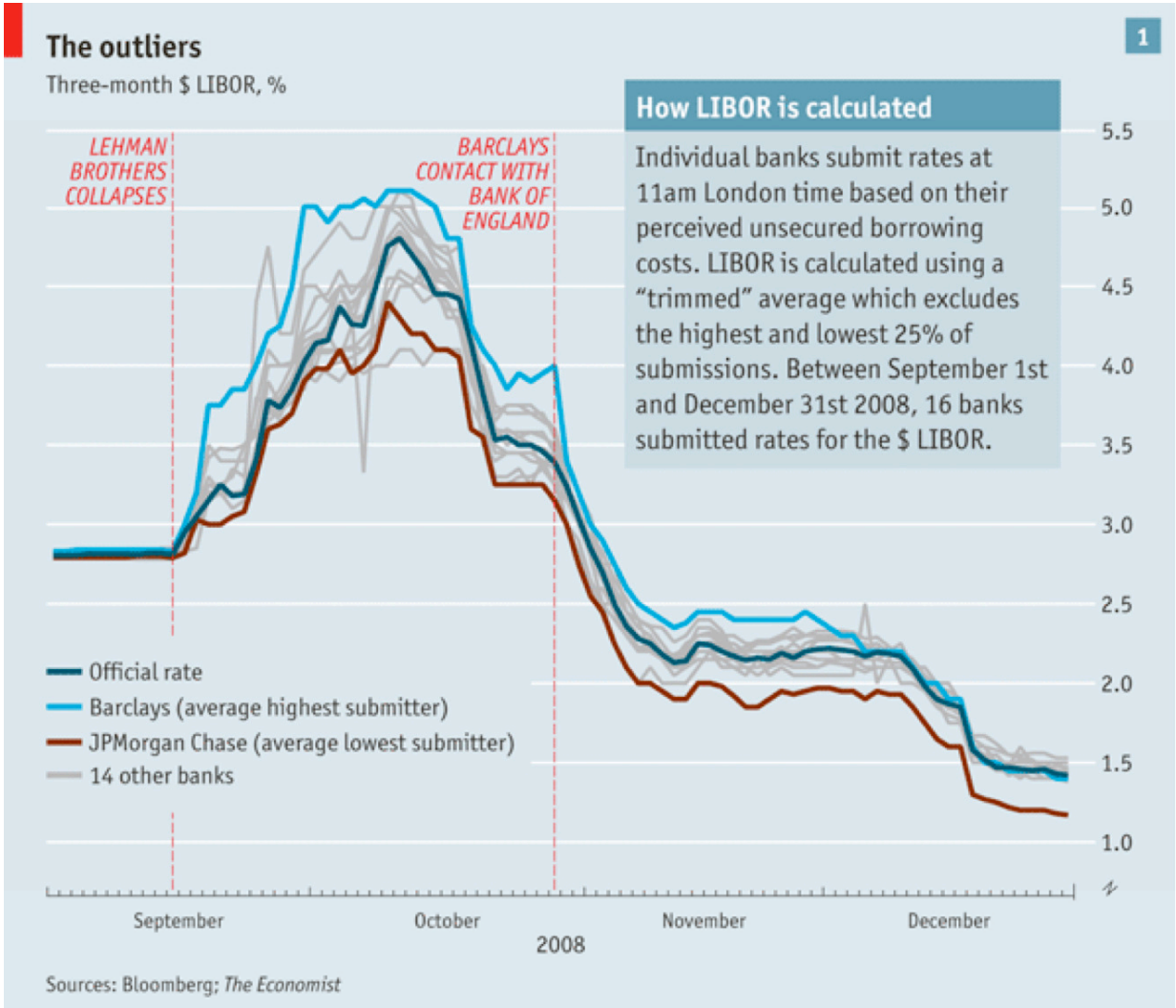
LIBOR

LIBOR stands for London Interbank Offer Rate.

- These rates correspond to the average interest rate at which leading banks report that they would borrow from each other for short-term uncollateralised contracts in the London market (The rates are typically similar to the Eurodollar rates.)
- LIBOR is one of the most important benchmark rates, used often as the reference index for many financial instruments including adjustable-rate loans, mortgages, asset-backed securities, and over-the-counter derivatives (including interest rate swaps, the single largest derivatives market.
- Following scandals involving LIBOR maniupulation, it was phased out at the end of 2021 and replaced with a series of alternative rates:

  Secured Overnight Financing Rate (SOFR) for USD, Euro short-term rate (ESTR) for EURO, Tokyo overnight average rate (TONA) for YEN, Sterling overnight index average (SONIA) for GBP, and Swiss average rate overnight (SARON) for Swiss franc.

LIBOR fixing

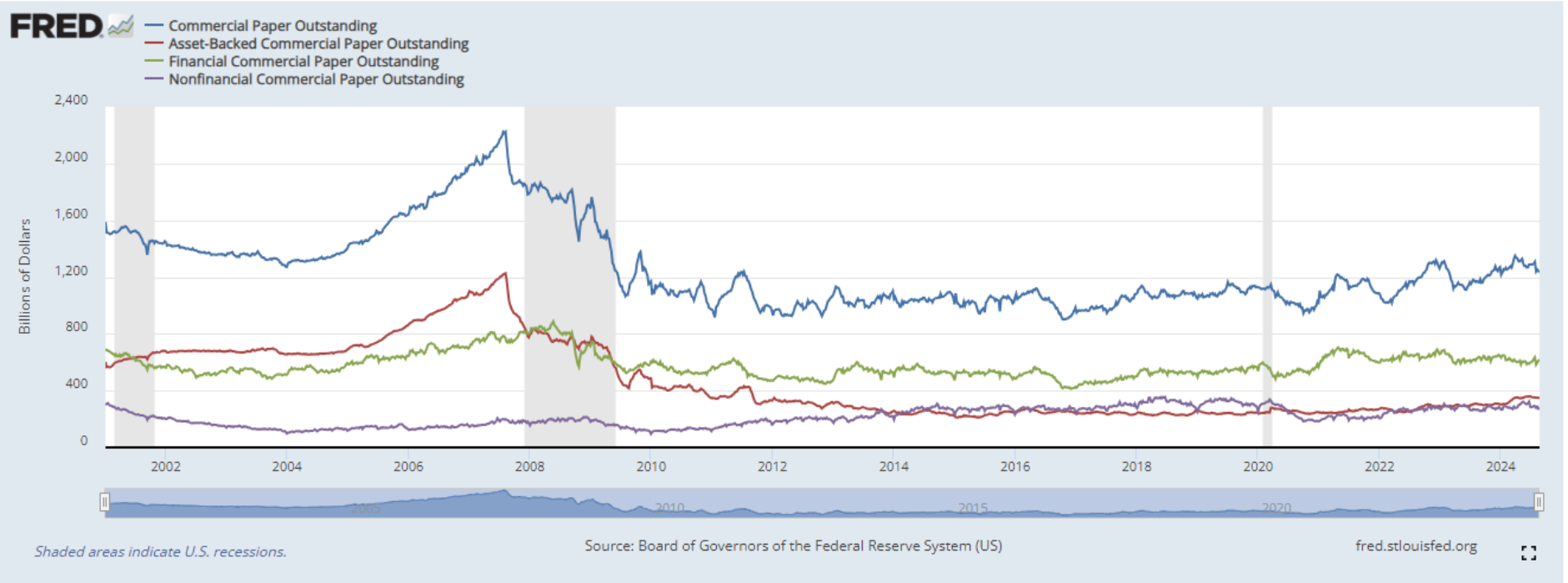


Commercial paper

Commercial paper (CP), in existence since the 19th century, is an unsecured note issued by a firm for a specific dollar amount with maturity on a specific date.

- The maturity on CP averages 30 days, but may range up to 270 days. Beyond 270 days is rare as the security then needs to be registered with the SEC.
- CP is typically issued at a discount. It is common for firms to roll over their CP.
- 3 categories:
  - Financial - bank holding companies & consumer finance corporations
  - Non-financial - industrial firms & public utilities, largely
  - Asset-backed - issued by "conduits" that include a special-purpose vehicle that manages the assets purchased and the financing via CP.

Commercial paper market size



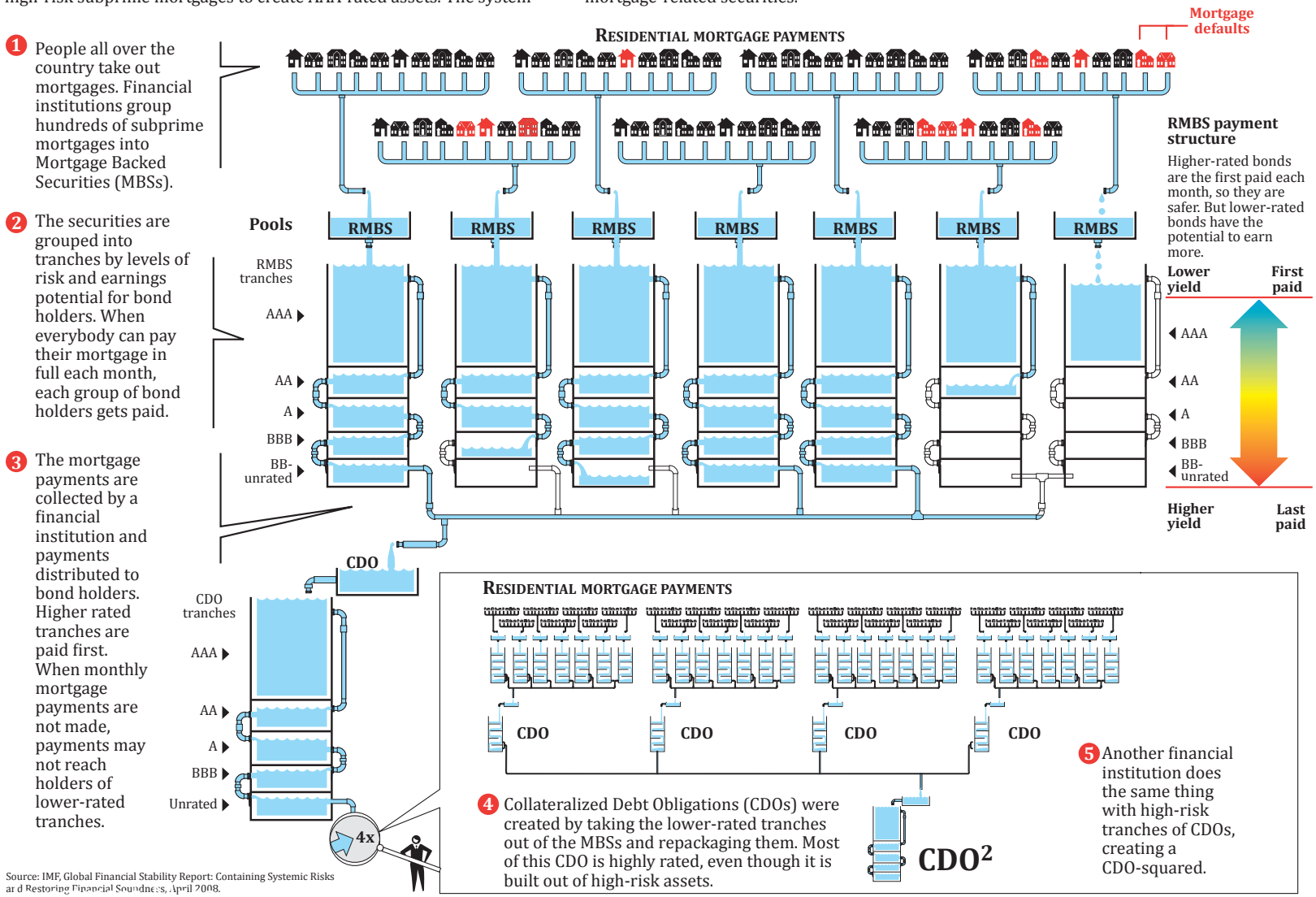
Other debt markets

- **Mortgage-backed securities (MBS)**: This is one of the largest debt markets. Mortgage-backed securities are collateralised by pools of residential and non-residential mortgages and sold to investors who then receive claims to the mortgage coupons. These securities present numerous additional risks for investors compared to Treasury securities.
- **Swaps:** A swap is a contract according to which 2 counterparties agree to exchange cash flows in the future. Although considered a derivative market, its sheer size makes it equivalent to a primary market, in the sense that the prices of swaps are really not derived from those of other securities, but rather they depend on the relative size of demand and supply of these contracts by market participants.
- **Government-sponsored enterprise (GSE) Debt**
- **Other Asset-Backed Securities**
- **Sovereign Debt**
- **Other Derivatives:** Options, Futures, Forwards, Credit Derivatives

Example: MBS ⟶ CDO

THE THEORY OF HOW THE FINANCIAL SYSTEM CREATED AAA-RATED ASSETS OUT OF SUBPRIME MORTGAGES

In the financial system, AAA-rated assets are the most valuable because they are the safest for investors and the easiest to sell. Financial institutions packaged and re-packaged securities built on high-risk subprime mortgages to create AAA-rated assets. The system worked as long as mortgages all over the country and of all different characteristics didn't default all at once. When homeowners all over the country defaulted, there was not enough money to pay off all the mortgage-related securities.



Summary

- **No-arbitrage pricing**: These are strategies that cost nothing to enter into, and provide sure money within a certain time. In well-functioning markets we should not expect arbitrage strategies to persist. The rules of no-arbitrage determine relative pricing across fixed income securities and explain their high correlation.
- **U.S. Treasury market**: The U.S. issues 4 types of securities: short-maturity T-bills, medium-maturity T-notes, long-maturity T-bonds, and TIPS. The size of the U.S. debt market is no longer dominant in fixed income markets, as other markets became even larger, notably the mortgage-backed securities market and derivatives markets.
- **Zero-coupon rates correspond 1:1 with discount factors.** If the zero rate is 10% for 1 year, then $DF_1 = {}^1/_{1.10} = 0.909$. The discount factor for time T is what turns riskless future dollars at time T into current values.
- **Money markets**: These markets are the source of short-term borrowing by financial and non-financial institutions.