Dipartimento di
Scienze Economiche, Aziendali, Matematiche e Statistiche "Bruno de Finetti"

PROF. ALBERTO DREASSI – ADREASSI@UNITS.IT

A2. INTEREST RATES

- WHY IR AND HOW DO WE MEASURE THEM?
- REAL IR: WHY ARE THEY IMPORTANT?
- HOW DO WE USE IR TO MEASURE RETURNS AND RISKS?
- CAN WE PREDICT INTEREST RATES?

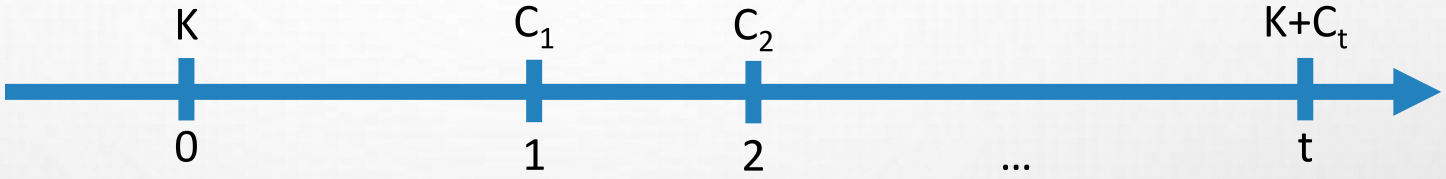
MEASURES OF IR

IR AND FINANCIAL CONTRACTS

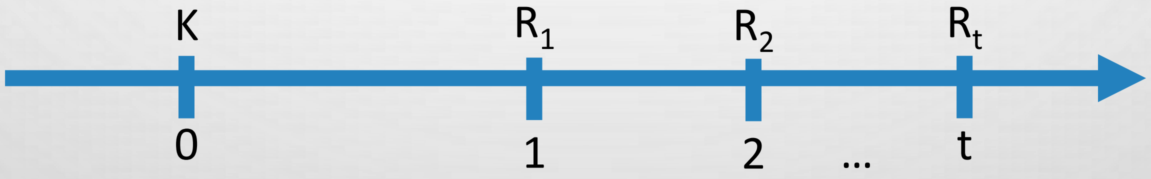
Baloon/simple loan:

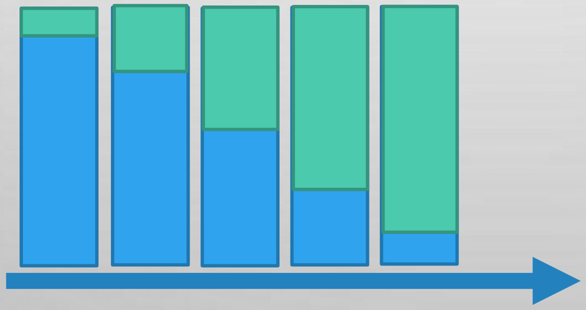
Discount bond (ZC):

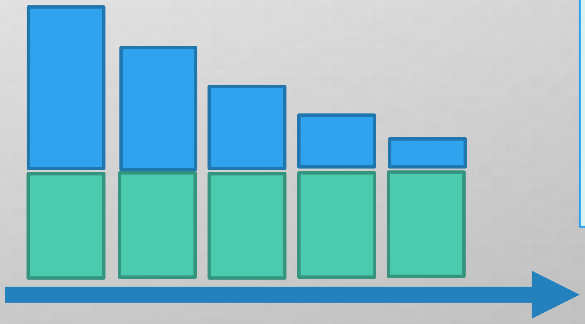
Coupon bond:



Fully amortised loan:







Many variants: variable or adjustable IR, changing maturity, pre-amortization, …

MEASURES OF IR

How to compare different debt instruments?

Yield to maturity (YTM)

- Strikes a balance across cashflows
- For simple loans only it equals the nominal rate
- ZC:

$$YTM = \sqrt[n]{\frac{FV}{CV}} - 1$$

- Coupon bonds (and others):

$$CV = \sum_{t=1}^{n} \frac{CF_t}{(1+YTM)^t}$$

$$VA = \sum_{t=1}^{n} \frac{C_t}{(1+YTM)^t} + \frac{FV}{(1+YTM)^n}$$

- <u>+ YTM, - CV:</u> an increase in IR lowers the current value (and v.v.)

ISSUES WITH THE YTM

YTM:

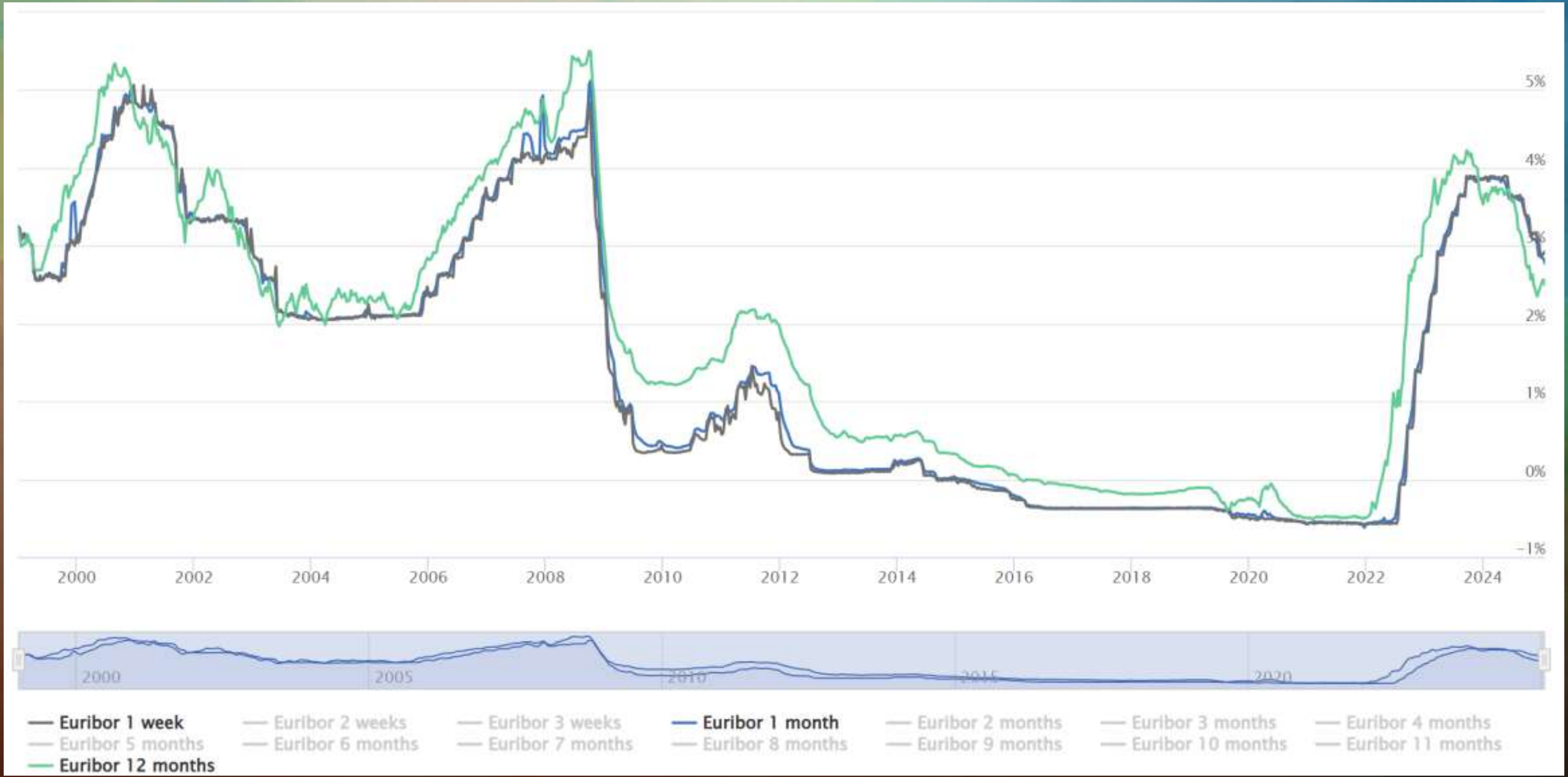
- Assumes holding period equals maturity → Risks and opportunity costs?
- Assumes reinvesting at the same rate → Yields vary over time!
- **Nominal!** → **Real values matter more…**

<u>Ex-ante real IR</u> consider the expected change in price levels (effective IR) :

$$i_n = i_r + \pi^e[+i_r \cdot \pi^e]$$

<u>Ex-post real IR</u> consider effective inflazione (but when the transaction is over!)

Then, tax issues may have impacts (charges on interest income, discounts on interest expense)



5%
4%
3%
2%
1%
0%
-1%
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2000
2005
2010
2015
2020
Euribor 1 week
Euribor 2 weeks
Euribor 3 weeks
Euribor 1 month
Euribor 2 months
Euribor 3 months
Euribor 4 months
Euribor 5 months
Euribor 6 months
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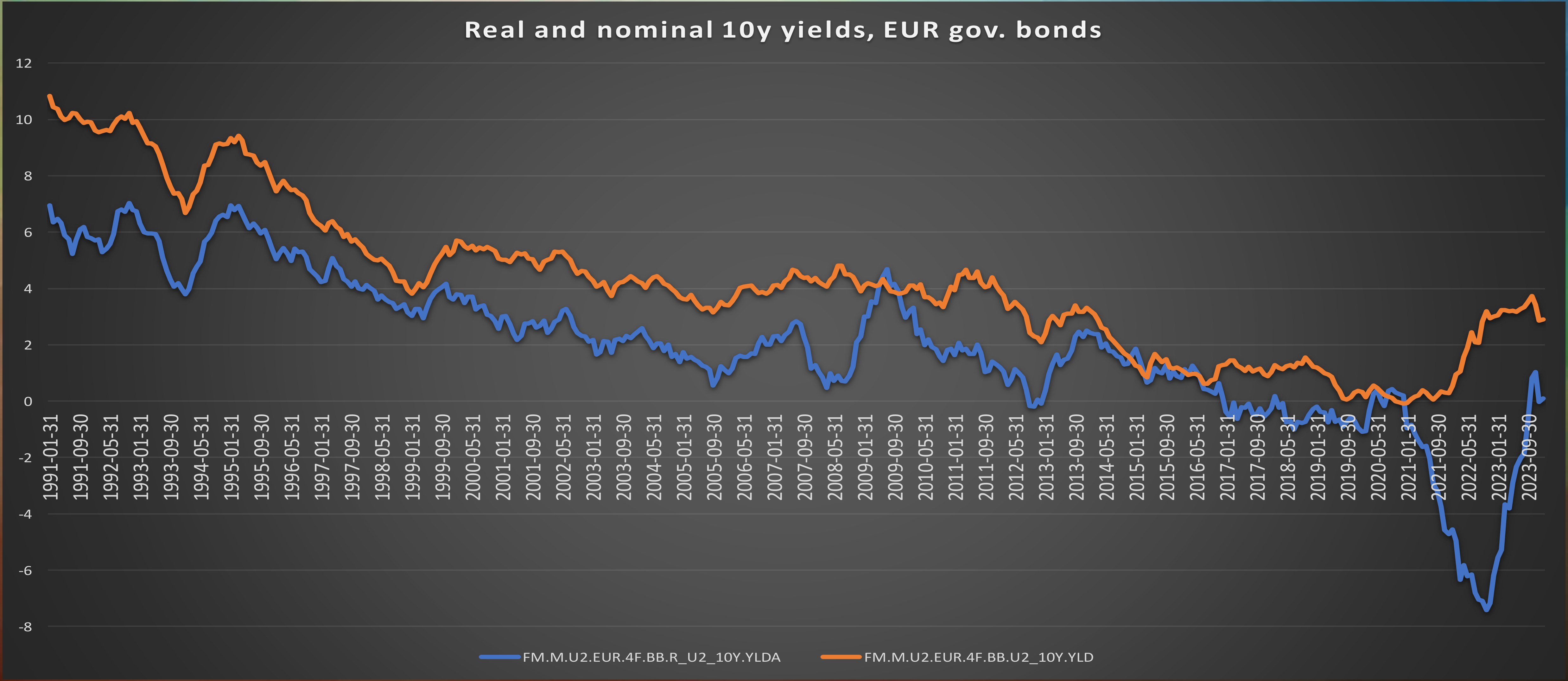
Euribor 9 months
Euribor 10 months
Euribor 11 months
Euribor 12 months

EXAMPLES



Real and nominal 10y yields, EUR gov. bonds
12
10
8
6
4
2
0
-2
-4
-6
-8
1991-01-31
1991-09-30
1992-05-31
1993-01-31
1993-09-30
1994-05-31
1995-01-31
1995-09-30
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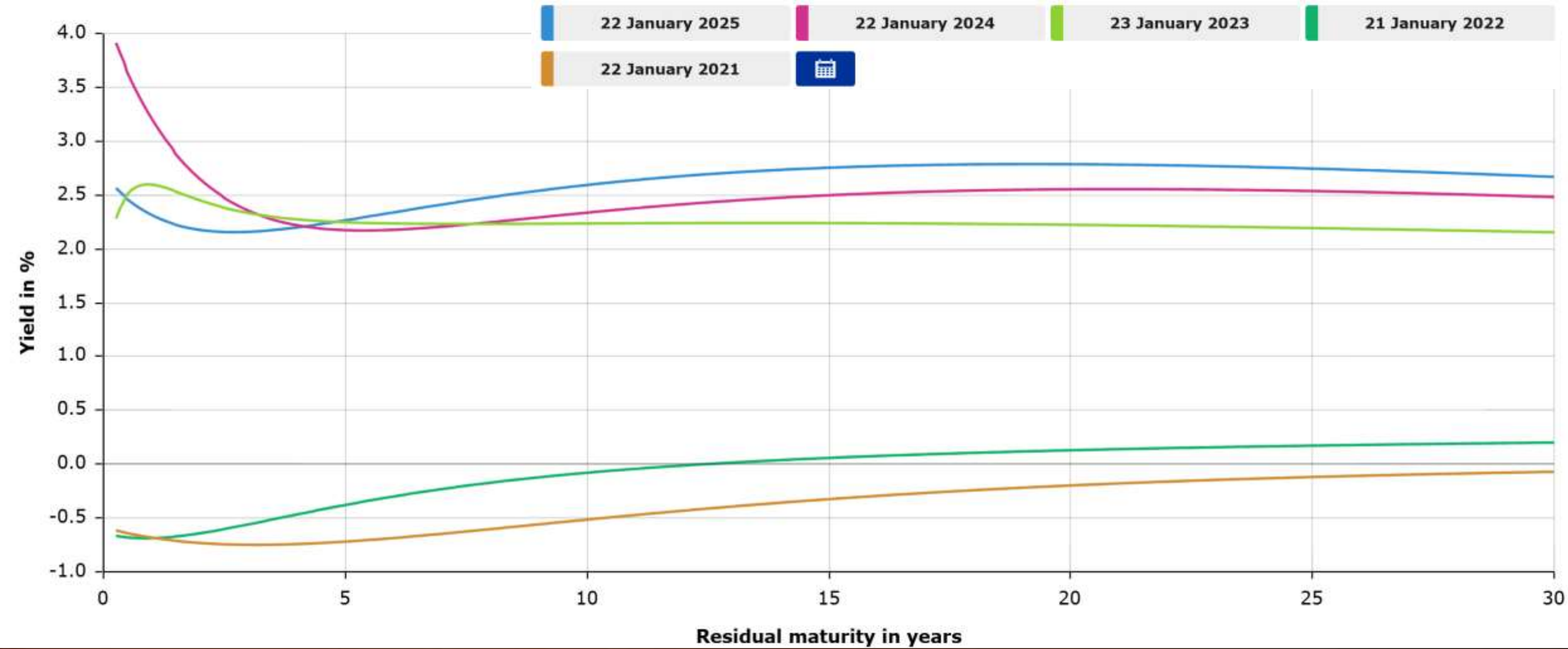
2019-09-30
2020-05-31
2021-01-31
2021-09-30
2022-05-31
2023-01-31
2023-09-30
FM.M.U2.EUR.4F.BB.R_U2_10Y.YLDA
FM.M.U2.EUR.4F.BB.U2_10Y.YLD

EXAMPLES

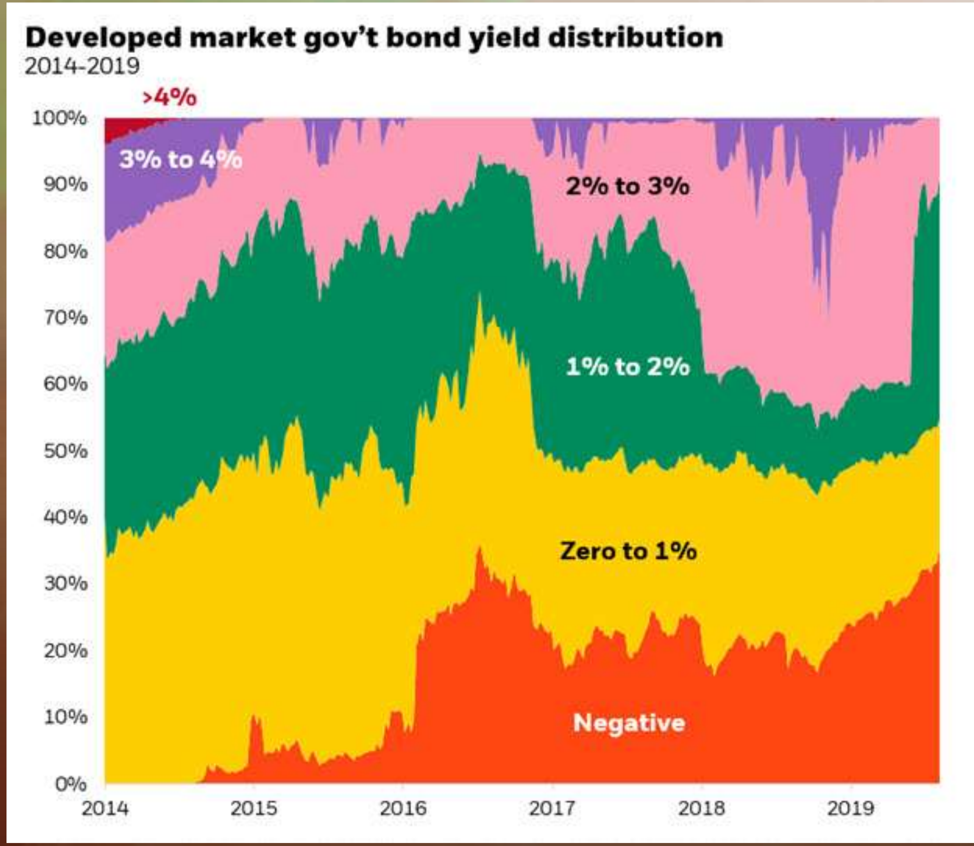
EZ GOV bonds yield by maturity - ECB



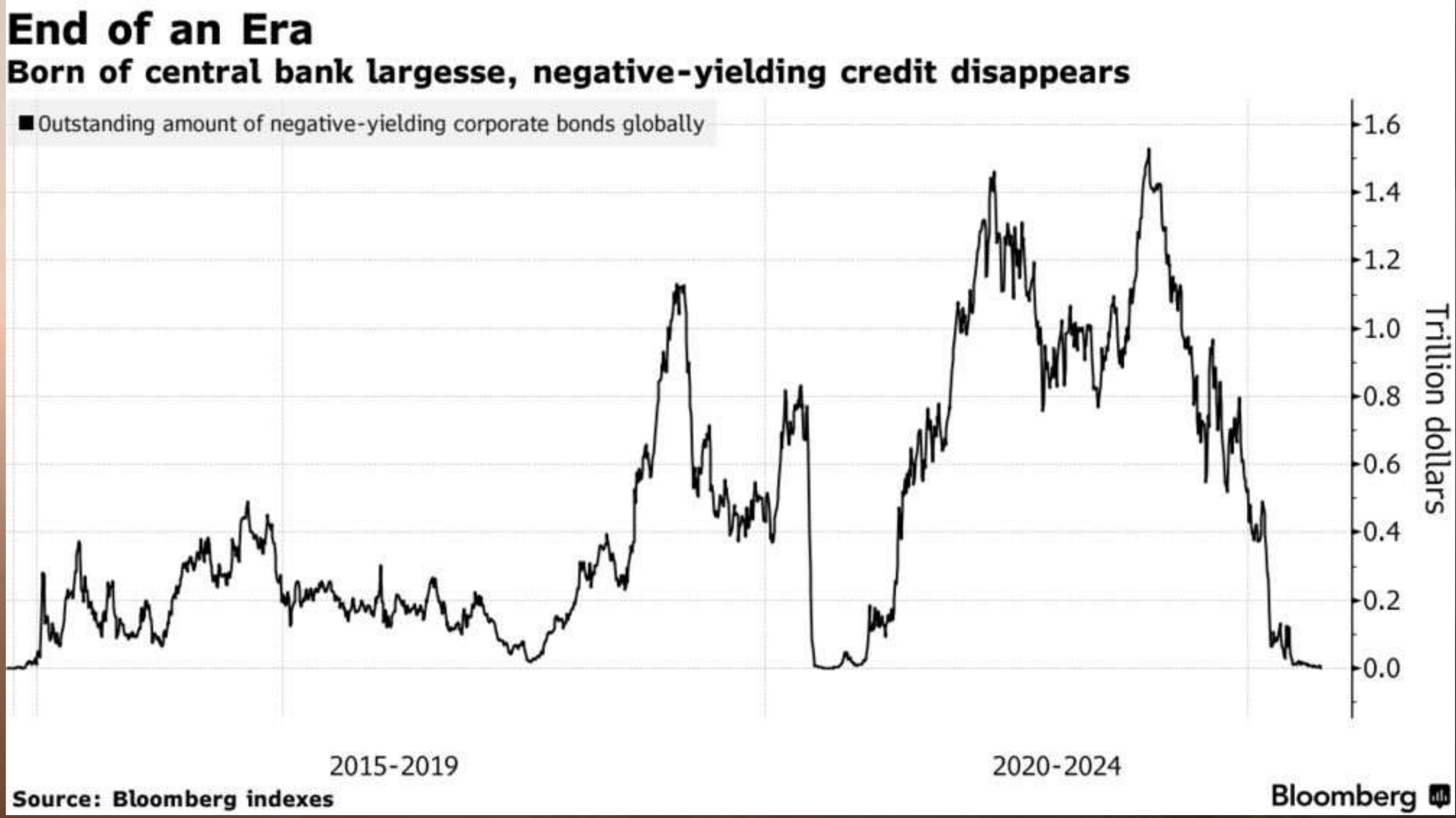
EXAMPLES

NEGATIVE RATES?

- *«Paying for lending? Nobody can be* that *stupid…»*
  - CB: BCE -0.2% on deposits from 9/2014 (also DEN, SWE, CH)
  - GOV: DE, NED, SWE, DEN, CH, AUT, … some (FIN, DE) from issue (2/2015)
  - Firms: Nestlé experienced it on 4y € bonds (2/2015)
  - Retail: Jyske Bank sold 10y mortgages at -0,5% (8/2019)
- *«But for borrowers this is great!»*
  - Lenders less likely to lend, credit institutions at a loss
  - Search for higher yields → riskier! (Zombie firms)
  - Trading/currency wars?
- Any sense?
  - Real IR negative are the real problem (rare and short, but today?)
  - Cash reserves and access to payment systems costs (or is worth something)
  - Access to central bank operations requires bonds
  - Taxes are levied on nominal returns
  - Nominal and real IR are rooted on expectations…



Developed market gov't bond yield distribution
2014-2019
>4%
3% to 4%
2% to 3%
1% to 2%
Zero to 1%
Negative
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2014
2015
2016
2017
2018
2019



End of an Era
Born of central bank largesse, negative-yielding credit disappears
Outstanding amount of negative-yielding corporate bonds globally
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Trillion dollars
2015-2019
2020-2024
Source: Bloomberg indexes
Bloomberg

EXAMPLES

IR AND PERFORMANCE

- **Rate of return**: payments to the owner of a security plus the relative change in value

- IR and RoR differ because of capital gains:

$$RoR = \frac{C + P_{t+1} - P_t}{P_t} = \frac{C}{P_t} + \frac{P_{t+1} - P_t}{P_t} = i_c + g$$

- If holding period equals time to maturity, return equals YTM only for ZCs: reinvestment risk (if holding period is longer, even more reinvestment risk)
- The bigger the time to maturity, the bigger the effect on capital gains due to changes in IR: interest-rate risk
- Inverse relationship between IR and capital gains
- Even if unrealised, capital gains represent an opportunity cost

IR AND RISKS: DURATION

How to compare IR risks in debt instruments with different features?

- Closer maturities and larger coupons lead to smaller losses if IR change
- BUT, bonds with similar maturities have also other risks (f.i. IT/DE spread), or even if maturities are different they may incur similar risks
- **How to compare them?** Weighting the time to maturity of each CF (*effective maturity*, or *duration)*
- **ZC** are simple: one flow, then DUR equals the TTM
- Other instruments can be considered as portfolios of ZC (since *duration* is additive):

$$\boxed{DUR = \frac{\sum_{t=1}^{n} \frac{FC_t}{(1+i)^t} \cdot t}{\sum_{t=1}^{n} \frac{FC_t}{(1+i)^t}}}$$

+ maturity, – cashflows, + interest = + *duration*

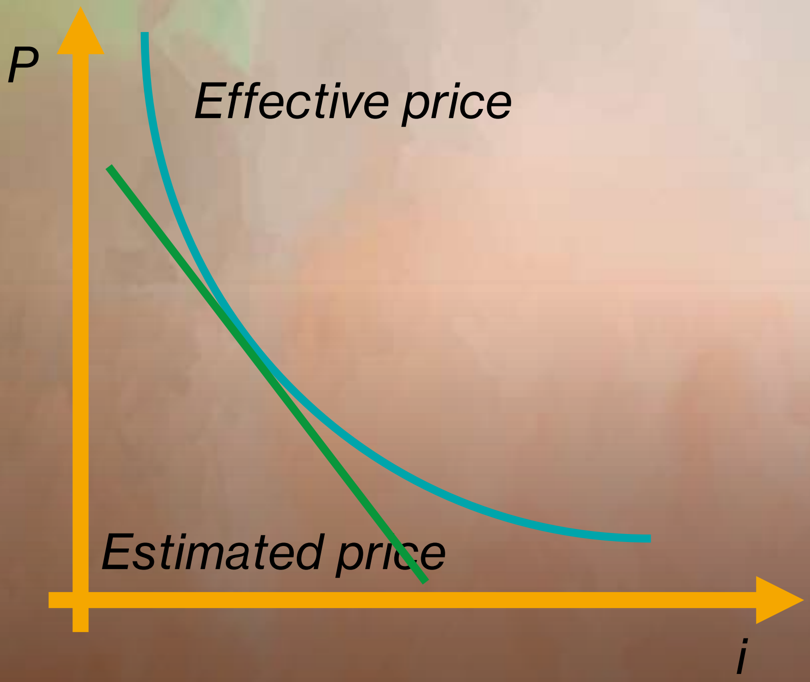
- And finally, *duration proxies* **interest rate risks:**

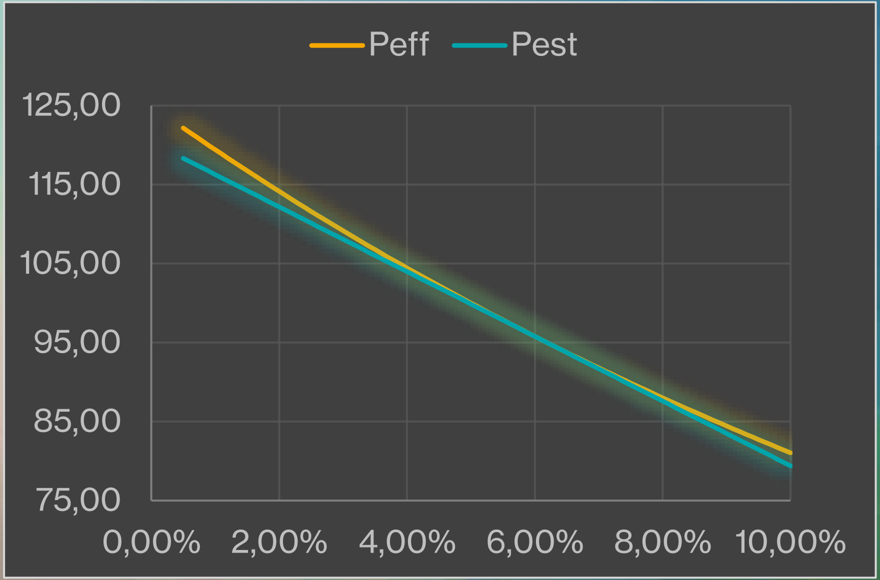
$$\%\Delta P = \frac{(P_{t+1} - P_t)}{P_t} = -DUR \cdot \frac{\Delta i}{(1+i)}$$

IR AND RISKS

ISSUES WITH DURATION

Linear proxy of a convex relationship between P and i





Example: bond 5y annual coupon 6% (= mkt)

P=95,79 and MD=-4,28

If Δi=1%, P_{eff}=91,80 and P_{est}=91,69

Duration as the 1st derivative... convexity as the 2nd!

$$CON = \frac{1}{P \cdot (1+i)^2} \cdot \sum_{t=1}^{N} \left[\frac{CF_t}{(1+i)^t} \cdot (t^2 + t) \right]$$

EXAMPLES

Calculate the YTM and the duration of the following alternatives:

1. Simple loan delivering 104 in 1 year
2. Discount bond priced 98 and due in 6 months
3. Coupon bond priced 99, semiannual coupons at 2%, maturity 2 years
4. Fully amortised loan: price 69, annual instalment of 25 for 3 years

TO DO BY NEXT LECTURE

FORECASTING IR

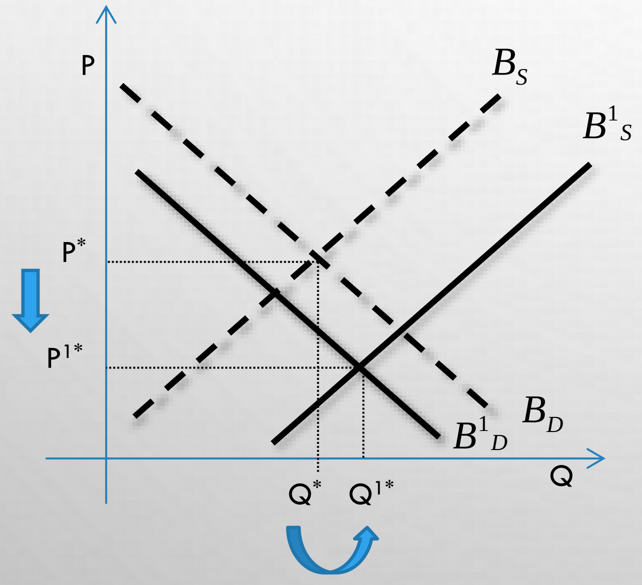
Why do interest rates change?

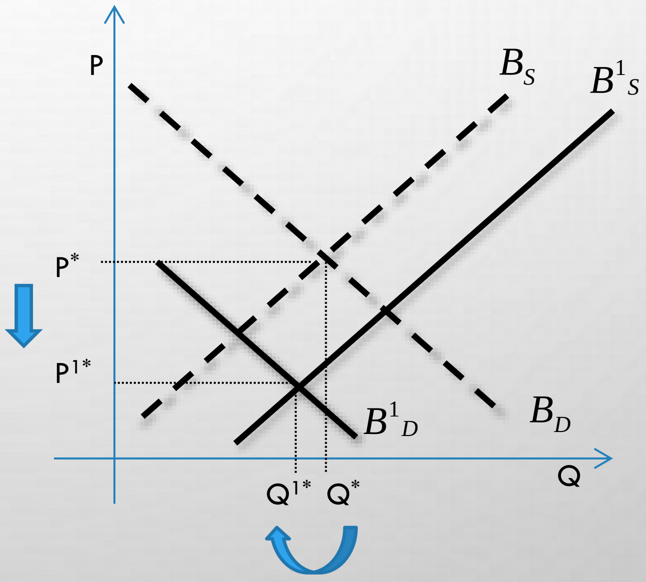
- <u>Bonds' demand</u>:
  - (+) Wealth owned by an individual
  - (+) Expected return relative to other assets
  - (–) Expected future interest rates
  - (–) Expected future inflation
  - (–) Risk (uncertain return) relative to other assets
  - (+) Liquidity relative to other assets
- <u>Bonds' supply</u>:
  - (+) Profitability of investments (more earnings)
  - (+) Expected inflation (cheaper borrowing)
  - (+) Government deficits (more public debt)

FORECASTING IR

Changes in IR due to inflation:

- An increase in expected inflation affects simultaneously demand (decrease of expected return) and supply (cheaper borrowing)
- IR will increase (prices fall)
- Effect on quantity is not readily predictable

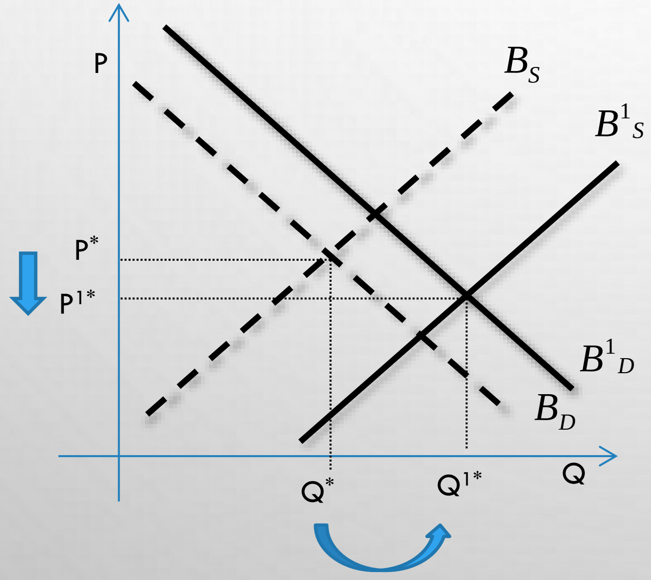


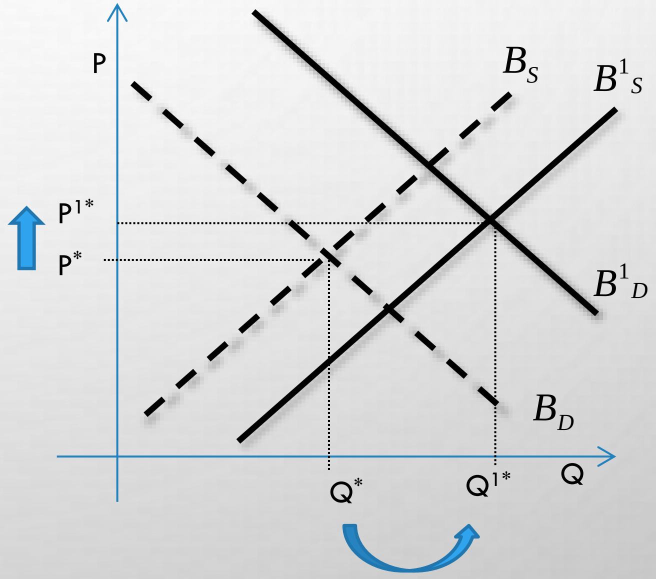


FORECASTING IR

Changes in IR due to business cycles:

- An economic expansion affects simultaneously demand (increase of wealth) and supply (greater expected returns on investments)
- Quantity will increase
- IR can increase or decrease (usually, increase – and decrease during recessions)





FRED
3-Month Treasury Bill Secondary Market Rate, Discount Basis
Consumer Price Index for All Urban Consumers: All Items in U.S. City Average
Percent , Percent Change from Year Ago
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
-2.5
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

EXAMPLES

IR AND MONEY

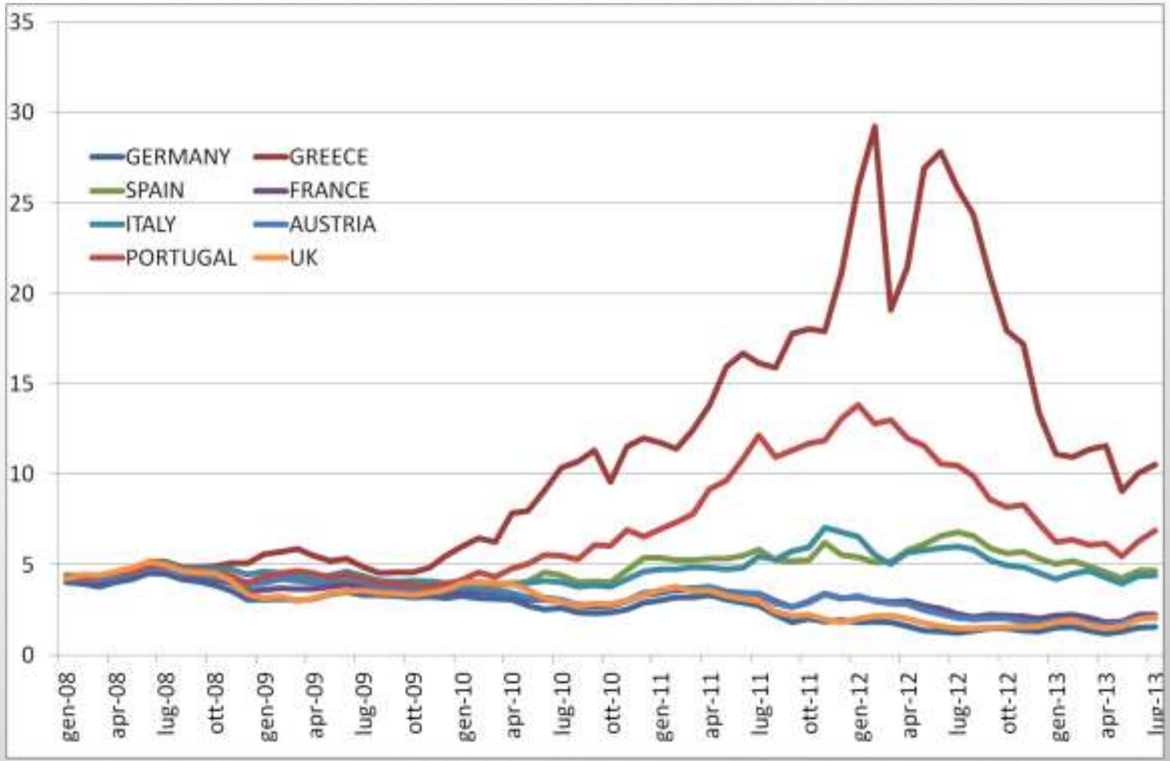
IF WE increase the money supply, IR should decline, but:

- Immediate **liquidity effect** reducing IR
- Economic stimulus: more income (**income effect**) and IR, but it takes time to have effects (wages, investments, …)
- More inflation (**price-level effect**) and IR, but it takes time to adjust prices of goods and services
- More expected inflation (**expected-inflation effect**) and IR, with speed of effects depending on people's speed of adjusting expectations
- Result:
  - <u>If the liquidity effect is dominant</u>, sharp reduction in IR, then recovery up to a smaller final value
  - <u>If the liquidity effect is insufficient</u>, sharp reduction in IR, then recovery up to a higher final value
  - <u>If the liquidity effect is marginal</u>, people adapt their expectations on inflation and the reduction in IR does not take place, and final IR are higher immediately

CREDIT AND OTHER RISKS

IR differ also for bonds with equal duration because of <u>default risk</u>:

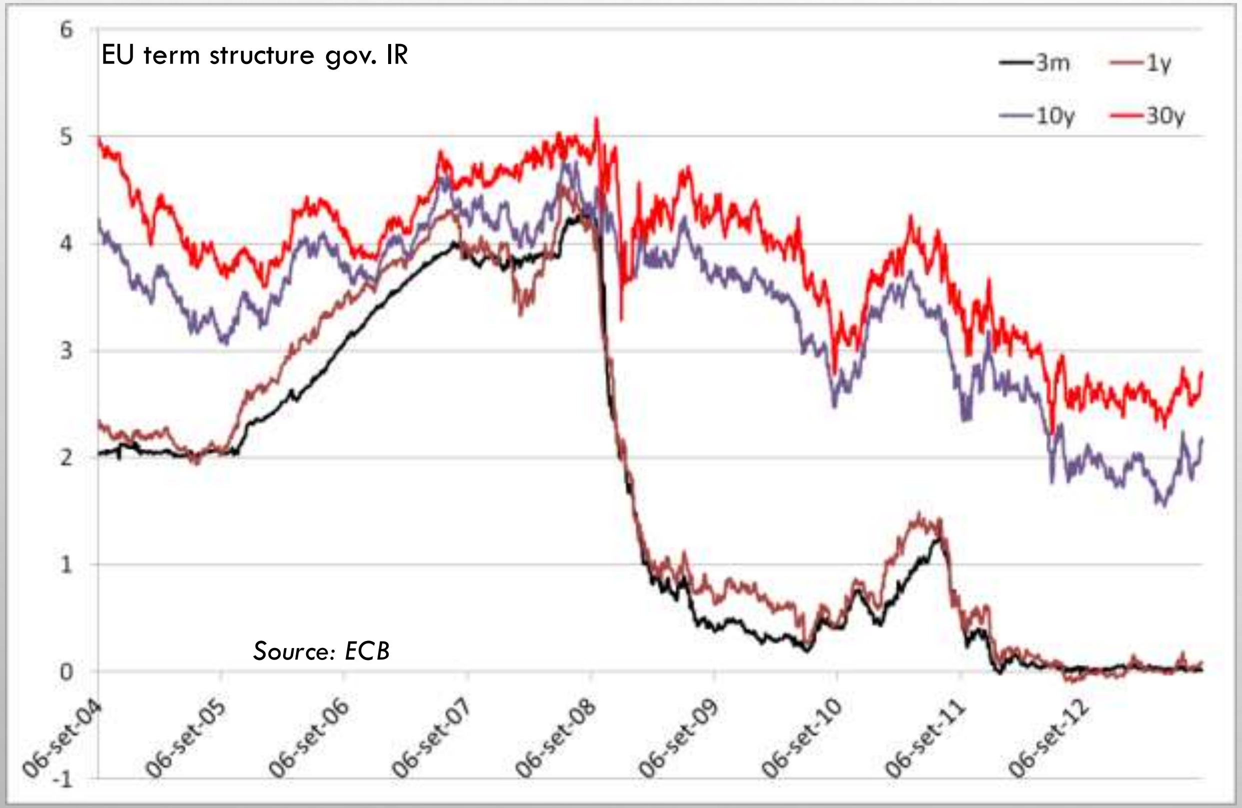
- government bonds considered risk-free…
- the higher the risk the bigger the spread
- rating agencies judge borrowers' default-risk (investment grade VS junk/high yield bonds)
- IR differ also for <u>liquidity risk</u> (adding to the risk premium)
- Some bonds have <u>tax incentives</u> (f.i. Italy's gov.)
- <u>And currencies</u>!



THE YIELD CURVE

IR differ also based on bonds' maturity:

- Differences in IR can be plotted at different maturities to derive the **term structure of IR** (yield curve)
- Usually yield curves are upward-sloping, meaning that longer maturities are charged with higher IR
- Flat or even downward-sloping or inverted yield curves are rare



- Different maturities move similarly
- When short-term IR are high, inversion is more likely
- Inverted yield curves seem to anticipate recessions ('81, '91, 2000, '07), steep upward curves are associated with economic booms

THE YIELD CURVE

Three theories for explaining the term structure of IR:

<u>Expectations theory</u>

- If bonds at different maturities are perfect substitutes, their expected return must be equal
- $$(1+i_{n,0})^n = (1+i_{1,0})(1+i^e{}_{1,1})\cdot\ldots\cdot(1+i^e{}_{1,n-1}) \rightarrow i_{n,0} \approx \frac{i_{1,0}+i^e{}_{1,1}+\ldots+i^e{}_{1,n-1}}{n}$$
- <u>Predicts flat curves</u>, whereas instead are usually upward-sloping (worked… until 1915)

<u>Market segmentation theory</u>

- Bonds at different maturities are not substitutes and each has a specific market, as well as each investor has a preferred maturity
- Together with interest-rate risk aversion, <u>explains why longer investments require a risk premium</u>
- Does not explain why IR move together along time
- Does not explain why with high short-term IR inversion is more likely

THE YIELD CURVE

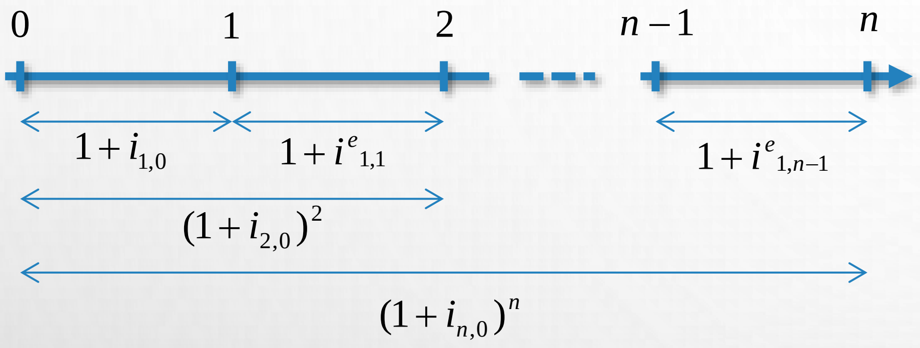
<u>Liquidity premium theory</u>

- Combines the other two in a comprehensive way
- Adds to expectations theory a liquidity premium for longer term bonds that is subject to market (demand, supply) conditions for that segment
- Bonds are substitutes as long as investors' preferences are compensated with a term (liquidity) premium that is always positive and grows as maturity gets longer
- $$i_{n,0} \approx \frac{i_{1,0} + i^{e}_{1,1} + \ldots + i^{e}_{1,n-1}}{n} + l_{n,0}$$
- <u>Explains inverted term structures</u>: when future expectations on short-term IR are of a wide fall, so that their average is not balanced even by a positive liquidity premium (more likely when short-term rates are high)
- Support empirical evidence that:
  - <u>Term structure is a predictor of business cycles and inflation</u>
  - <u>Term structure is less reliable for intermediate movements</u>

THE YIELD CURVE

<u>Forward and spot rates:</u>

- Term structures allow to measure expected IR



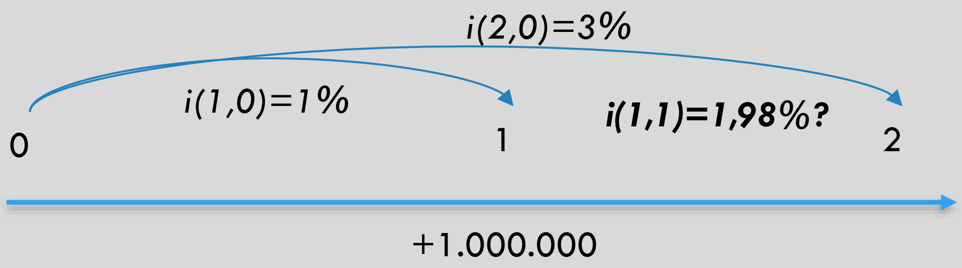
- Expected future IR are forward rates, in contrast to spot rates
- Knowing spot IR we can derive market expectations

F.i.: $i^e_{1,1} = \dfrac{(1+i_{2,0})^2}{1+i_{1,0}} - 1$ or, generalising: $i^e_{1,k} = \dfrac{(1+i_{k+1,0})^{k+1}}{(1+i_{k,0})^k} - 1$

- Including liquidity premiums: $i^e_{1,k} = \dfrac{(1+i_{k+1,0}-l_{k+1,0})^{k+1}}{(1+i_{k,0}-l_{k,0})^k} - 1$

Can we gain from knowing the yield curve?

Imagine that, as a CFO, you know that you are going to receive 1mln€ in 1 year. You also know that: i(1,0)=1% and i(2,0)=3% (biannual)



	0	1	2
Inflow		+ 1,000,000	
1. Loan	+990,099	-1,000,000	
2. Investment	-990,099		+1,019,802
NET RESULT	0	0	+1,019,802