FINANCIAL MARKETS AND INSTITUTIONS

INTEREST RATES

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DEAMS

University of Trieste

AGENDA

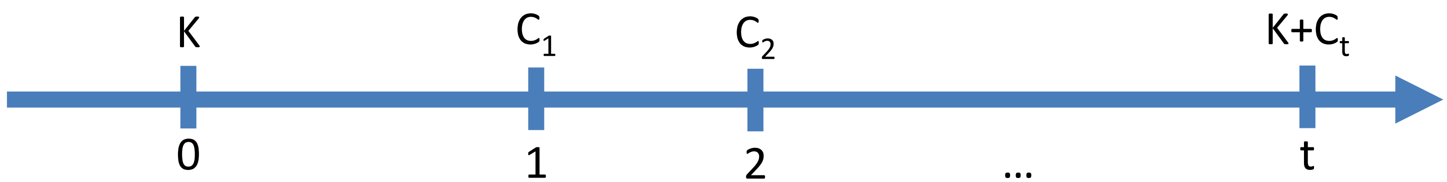
- Why do we need IR and how do we measure them?
- What are real IR and why are they important?
- How do we use IR to measure returns and risks?
- Can we predict interest rates?

Measures of IR

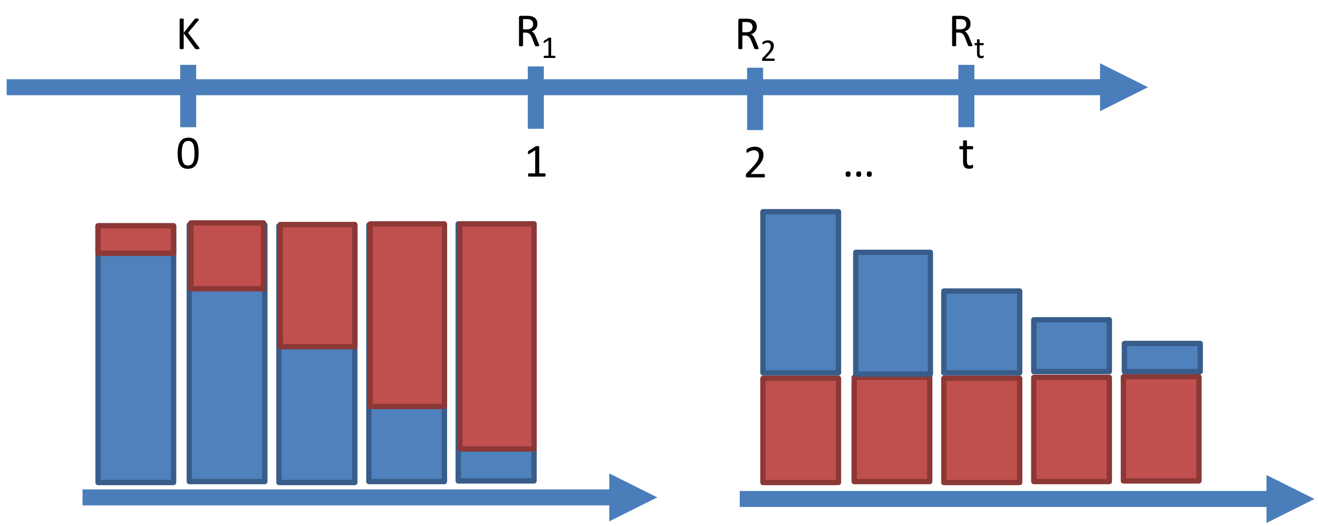
Baloon/simple loan:

Discount bond:

Coupon bond:



Fully amortised loan:



MEASURES OF IR

How to compare debt contracts?

Which one is more rewarding?

- Simple loan: providing 104 in 1 year
- Discount bond: price 98, maturity in 6 months
- Coupon bond: price 99, semiannual coupon 2%, maturity 2 years
- Fully amortised loan: price 56, two yearly instalments of 30

(Do this by the next lecture!)

MEASURES OF IR

How to compare debt contracts?

Yield to maturity (or internal rate of return, or effective interest rate):

- IR balancing the PV of all cash-flows
- For simple loans, YTM equals the nominal interest rate
- For ZC bonds: $$i_{YTM} = \sqrt[n]{\frac{NV}{CV}} - 1$$
- For others (and in general) calculation is more complex (*goal-seek, Excel*):

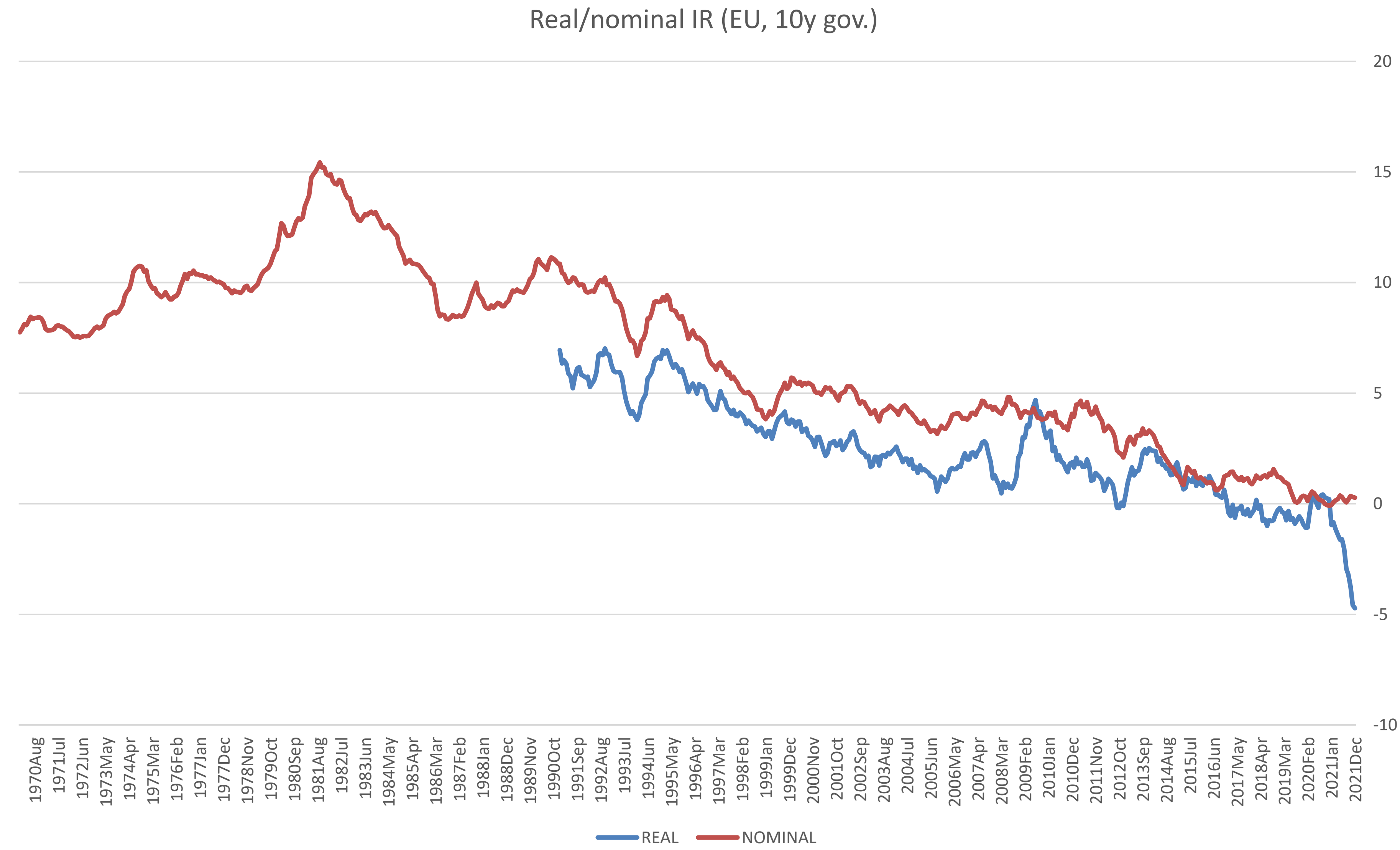
$$0 = \sum_{t=0}^{n} \frac{CF_t}{(1 + i_{YTM})^t}$$

- <u>The greater the YTM, the smaller the current value</u>
- BUT: assumption of holding until maturity, reinvesting at one YTM, no taxes
- BUT: nominal – expected inflation VS ex-post real IR

$$\boxed{i = i_r + \pi^e + i_r \cdot \pi^e}$$

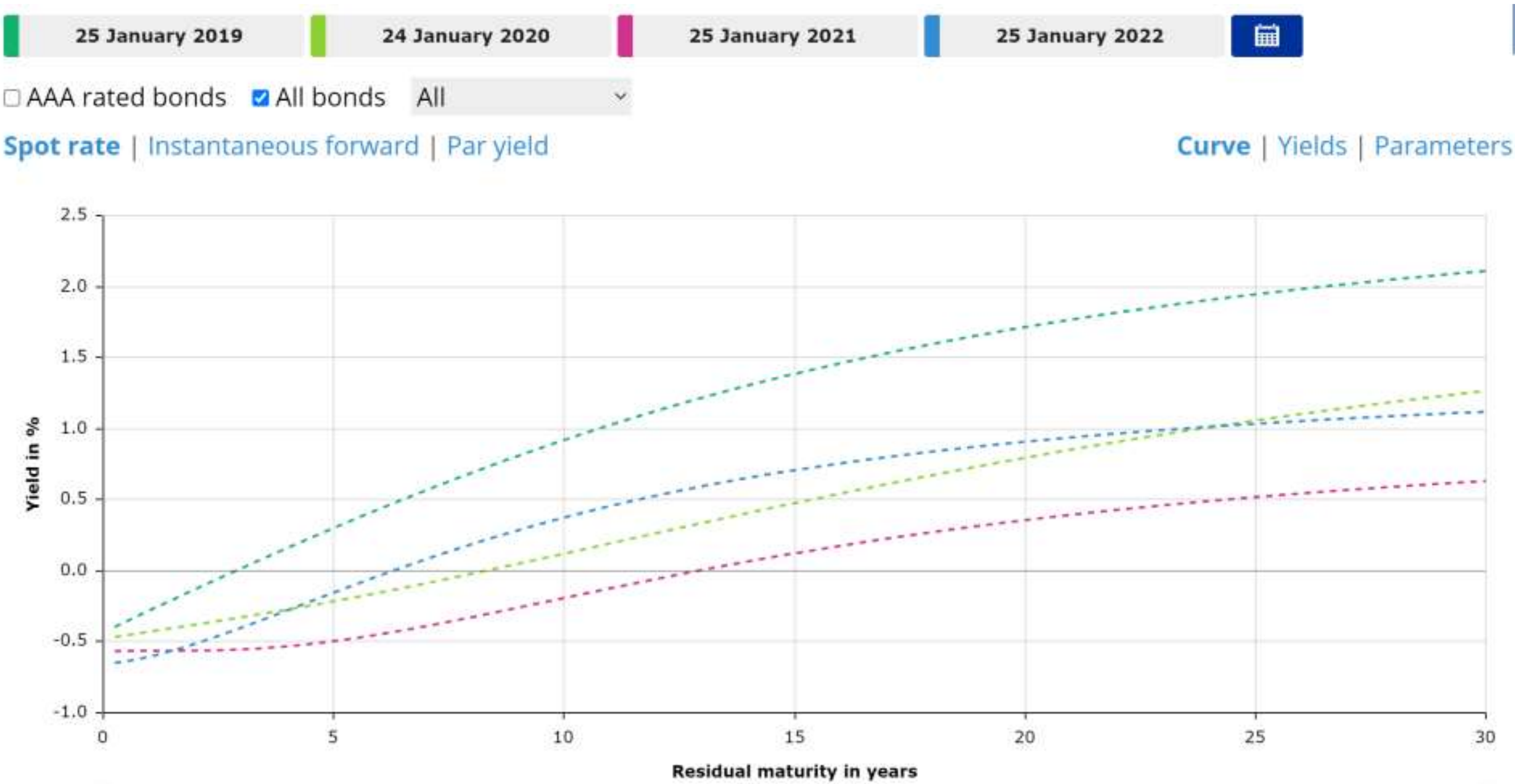
MEASURES OF IR

Nominal and real IR on 10y gov EU bonds, ECB



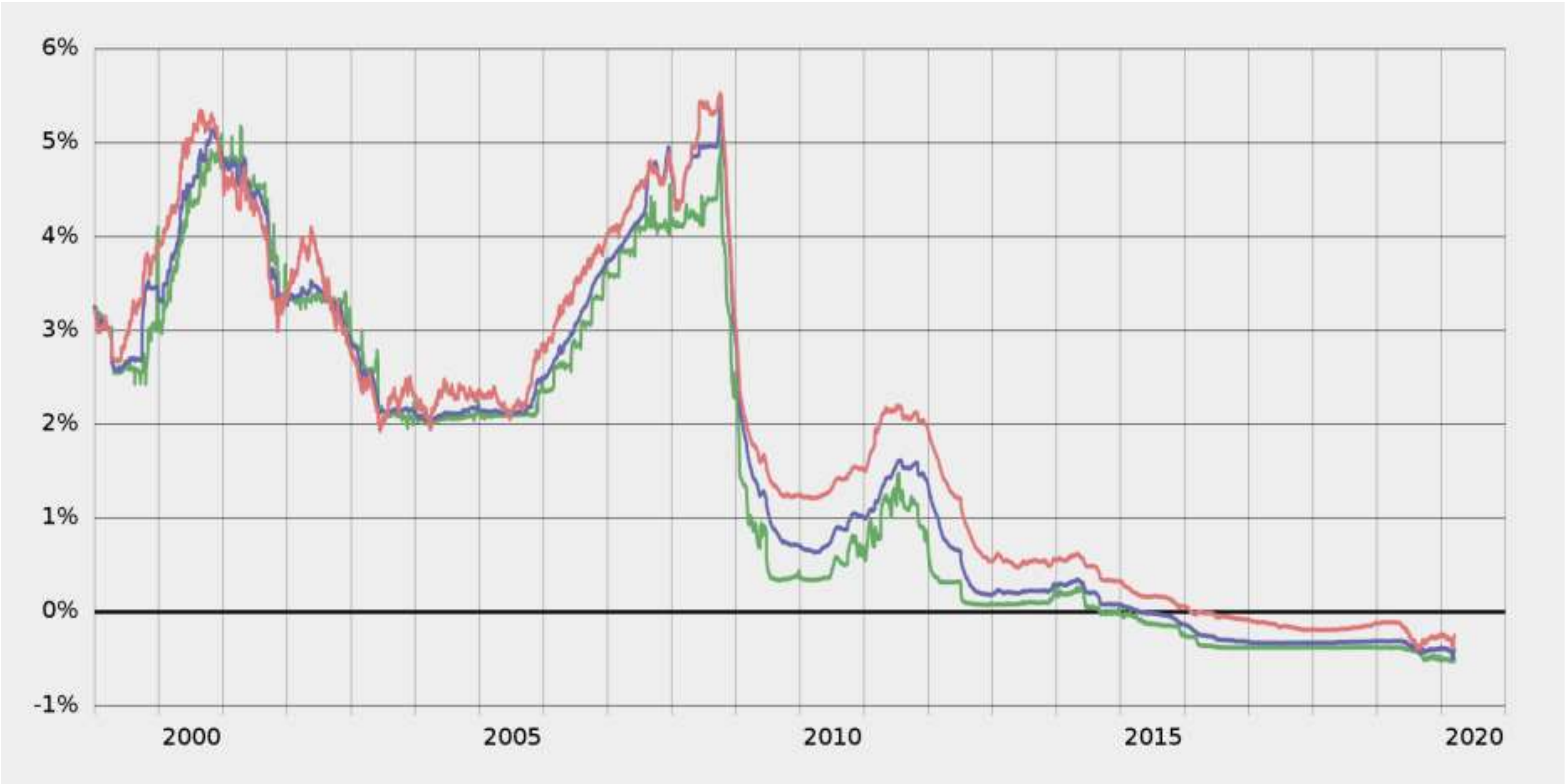
Measures of IR

Yield curve on gov EU bonds, ECB



MEASURES OF IR

Euribor 1w, 3m, 1y



NEGATIVE IR?

- Pay to lend?
  - **Central banks**: ECB -0.2% on deposits in 9/2014 (but also DEN, SWE, CH)
  - **Governments**: DE from -0.7% to 0 for 1m-10y bonds (but also NED, SWE, DEN, CH, AUT), FIN and DE issuing bonds with negative IR from inception on 2/2015
  - **Corporations**: Nestlé for its 4y € bonds in 2/2015…
- Good if you are a borrower?
  - All lenders right with it?
  - Profitability of institutional lenders (banks)?
  - Risk runs? Currency wars?
- Does it make any sense?
  - Real IR do… not always though
  - Storing money, building wealth reserves, accessing settlement services, … cost!
  - Certain bonds give access to CB/bank lending, increasing their demand
  - Taxation applies on nominal interest rates

IR AND RETURNS

- **Rate of return**: payments to the owner of a security plus the relartive 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 RETURNS

How to compare bonds with different maturities, coupons and prices?

Which one is riskier assuming a market rate of 3,75%?

- Simple loan: providing 104 in 1 year
- Discount bond: price 98, maturity in 6 months
- Coupon bond: price 99, semiannual coupon 2%, maturity 2 years
- Fully amortised loan: price 56, two yearly instalments of 30

(Do this by the next lecture!)

IR AND RETURNS

So, how can we compare bonds with different maturities, coupons and prices?

Best way: duration (effective maturity)

- Weighted average lifetime of a debt instruments’ cashflows
- For ZCs equal to the time to maturity
- Other instruments are seen as a portfolio of ZCs, weighted by their proportion over the portfolio (a useful additive property)

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

- Longer maturity and smaller coupons mean bigger duration
- Increases in interest rates decrease duration
- For small changes in IR, duration is a proxy of interest rate risk

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

IR AND RETURNS

So, how can we compare bonds with different maturities, coupons and prices?

Example: imagine a 10 year bond, nominal value 100, annual 3% coupon

(market rate 3%)

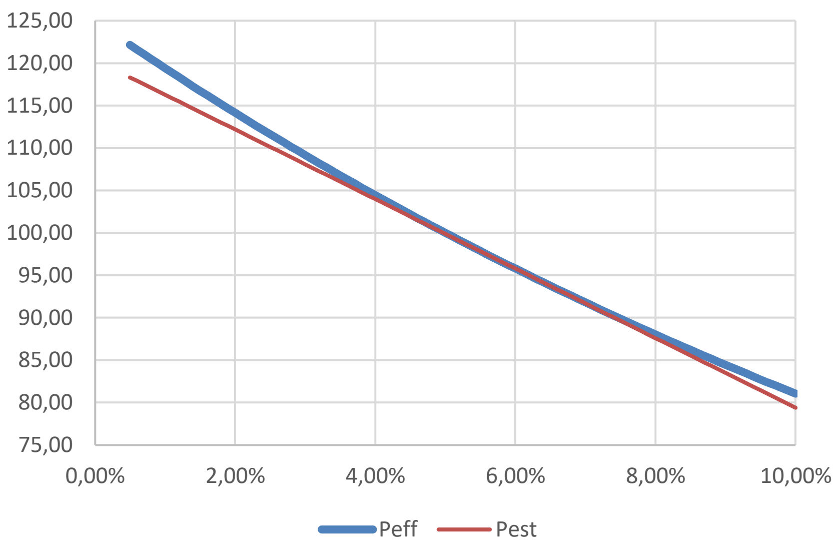
t	CF	PV	PV%	CF x PV%
1	3	2,91	0,03	0,03
2	3	2,83	0,03	0,06
3	3	2,75	0,03	0,08
4	3	2,67	0,03	0,11
5	3	2,59	0,03	0,13
6	3	2,51	0,03	0,15
7	3	2,44	0,02	0,17
8	3	2,37	0,02	0,19
9	3	2,30	0,02	0,21
10	103	76,64	0,77	7,66
		100,00		8,79

(market rate 5%)

t	CF	PV	PV%	CF x PV%
1	3	2,86	0,03	0,03
2	3	2,72	0,03	0,06
3	3	2,59	0,03	0,09
4	3	2,47	0,03	0,12
5	3	2,35	0,03	0,14
6	3	2,24	0,03	0,16
7	3	2,13	0,03	0,18
8	3	2,03	0,02	0,19
9	3	1,93	0,02	0,21
10	103	63,23	0,75	7,48
		84,56		8,66

<u>Duration too is not perfect</u>

- Linear proxy of a convex price/return relationship



Example: M=5, yearly coupon

IR=6%: P=95,79 and DM=-4,28

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

- *Convexity*

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

DEMAND AND SUPPLY FRAMEWORK

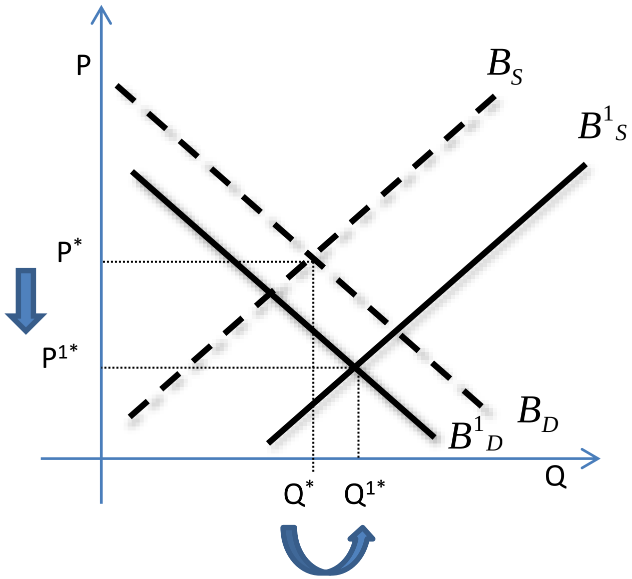
Why do interest rates change?

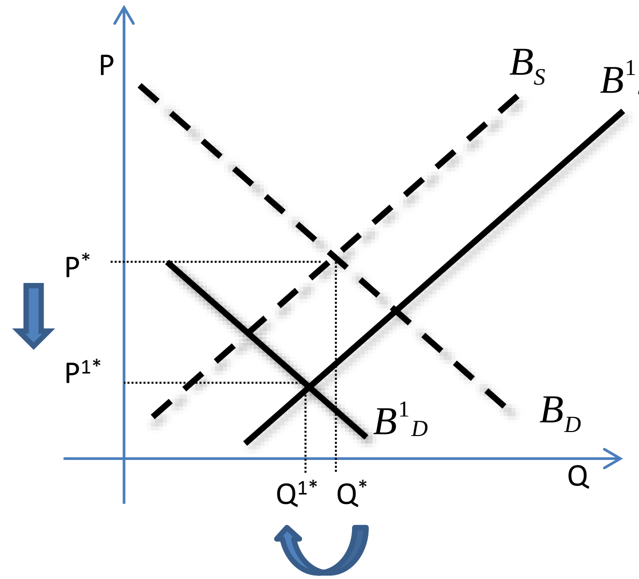
- <u>Bonds' demand</u>:
  - (+) Wealth owned by an individual
  - (+) Expected return relative to other assets
  - (–) Expected future interest rates
  - (–) Expected future inflation
  - (–) Risk (uncertain return) relative to other assets
  - (+) Liquidity relative to other assets
- <u>Bonds' supply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

DEMAND AND SUPPLY FRAMEWORK

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

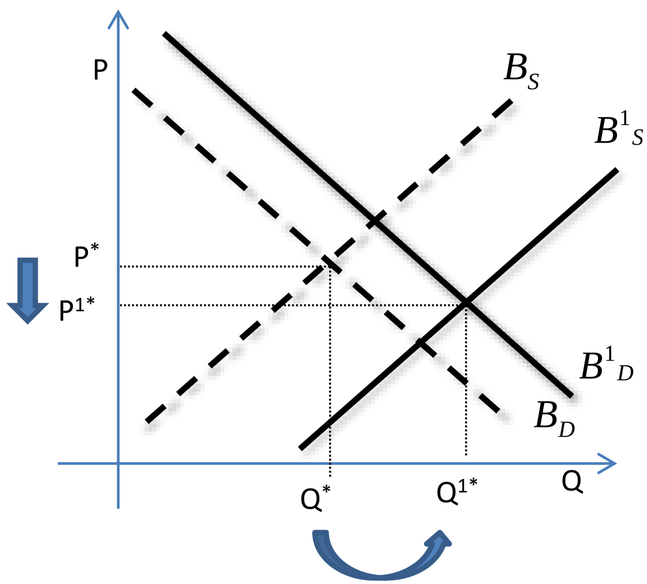


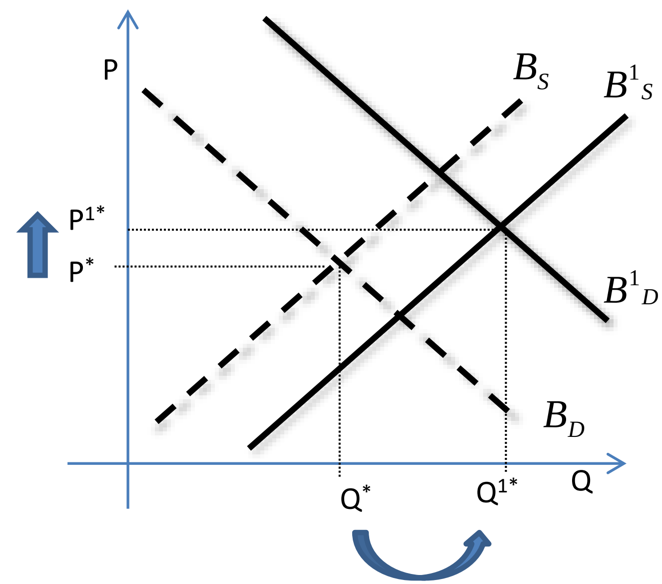


DEMAND AND SUPPLY FRAMEWORK

Changes in IR due to business cycles:

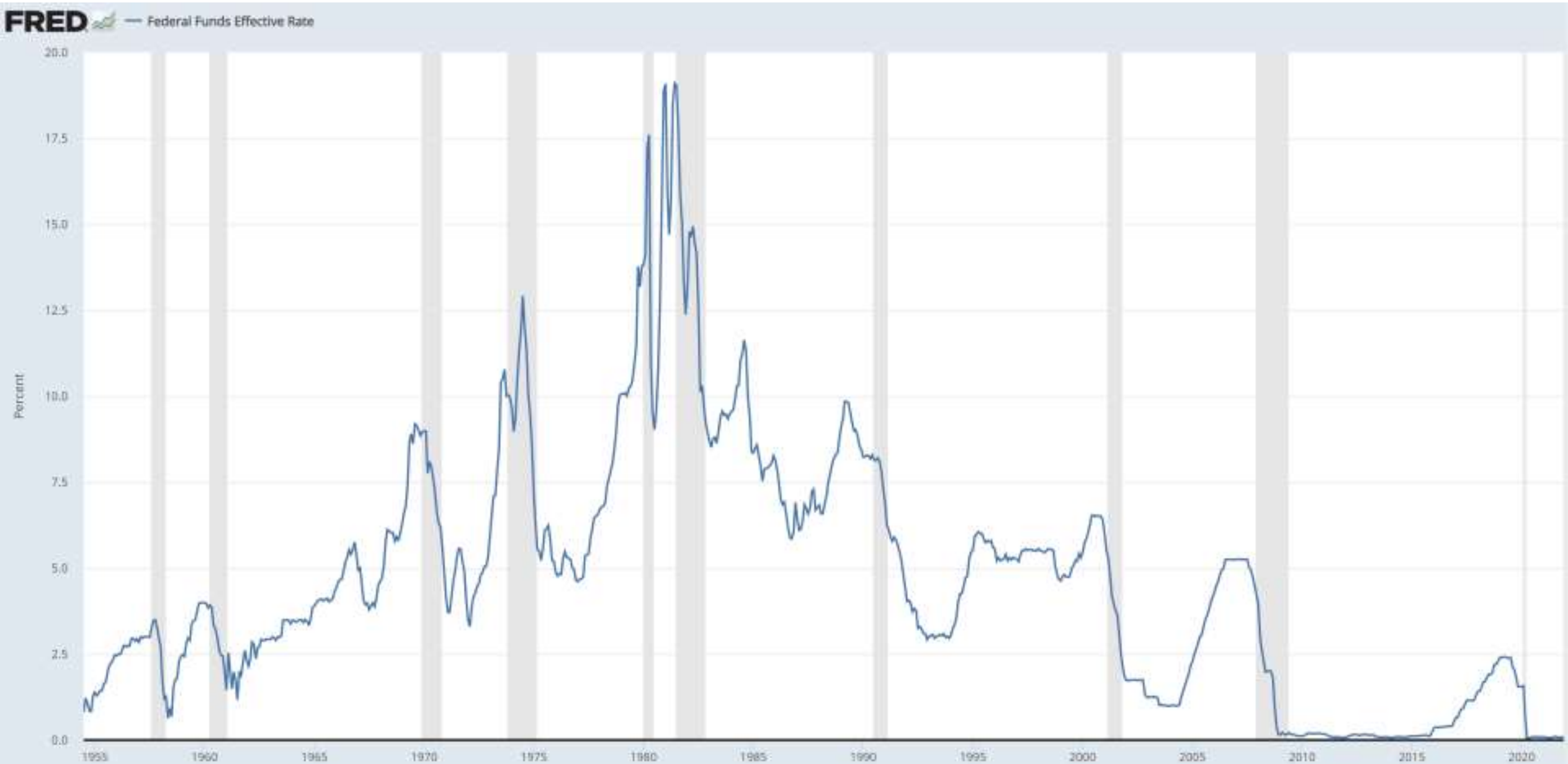
- An economic expansion affects simultaneously demand (increase of wealth) and supply (greater expected returns on investments)
- Quantity will increase
- IR can increase or decrease (usually, increase – and decrease during recessions)





DEMAND AND SUPPLY FRAMEWORK

US interbank rates and economic cycles, FRED



LIQUIDITY PREFERENCE FRAMEWORK

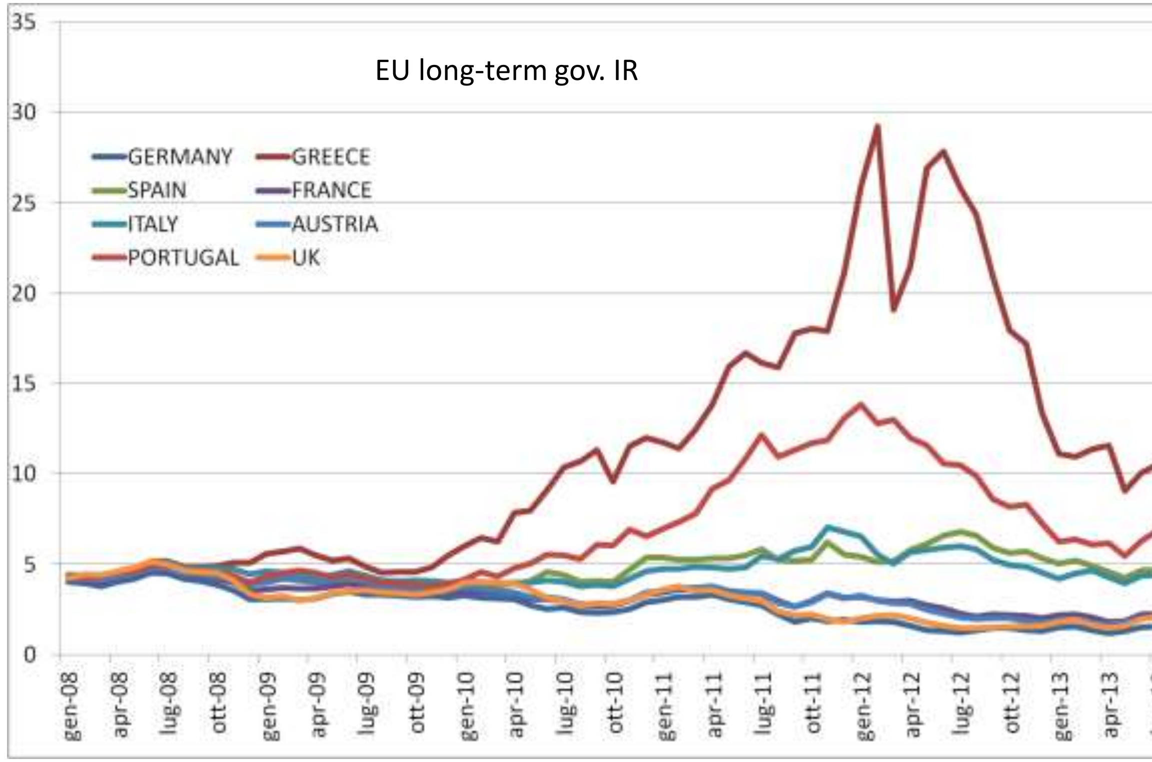
When CBs increase the money supply, IR should decline, but:

- 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

RISK AND IR

IR differ also for bonds with equal duration because of default risk:

- government bonds considered risk-free…
- the higher the risk the bigger the risk premium (spread)
- rating agencies judge borrowers' default-risk (investment grade VS junk/high yield bonds)
- IR differ also for liquidity risk (adding to the risk premium)
- Some bonds have tax incentives (f.i. Italy's gov., …)
- Don't forget currencies!

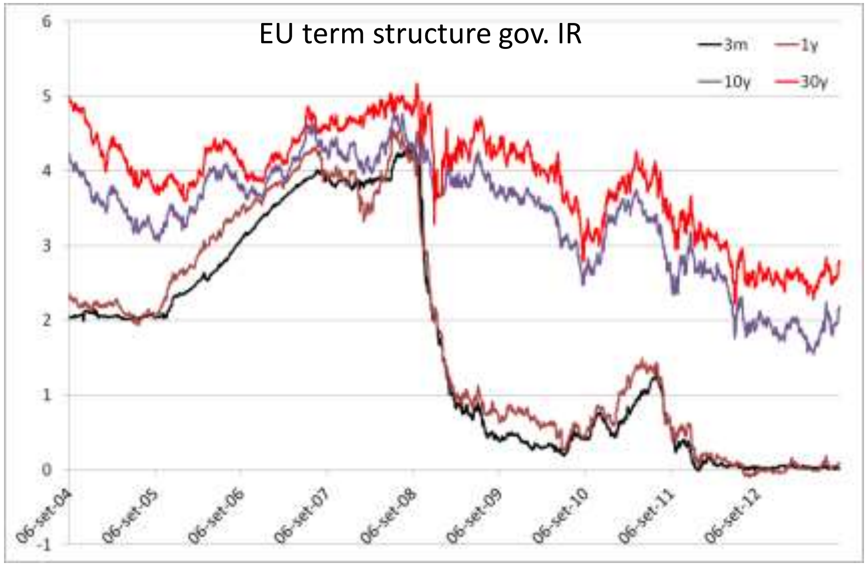


Source: ECB

Term Structure of IR

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



Source: ECB

- 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

Term Structure of IR

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

TERM STRUCTURE OF IR

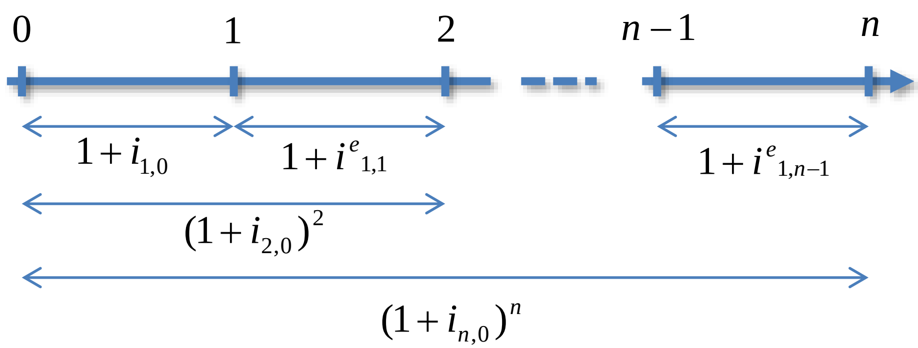
<u>Liquidity premium theory</u>

- 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>

Term Structure of IR

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

- Term structures allow to measure expected IR

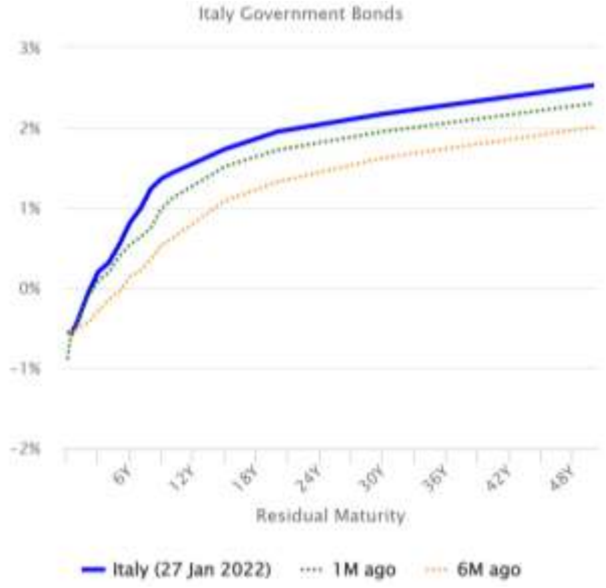


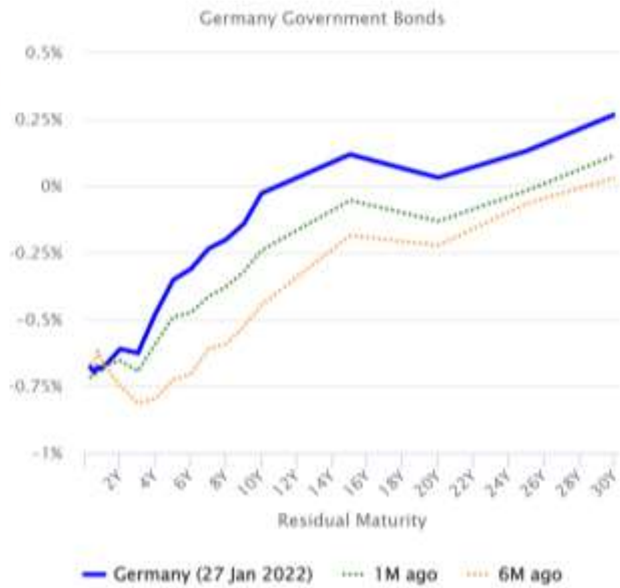
- Expected future IR are forward rates, in contrast to spot rates
- Knowing spot IR we can derive market expectations

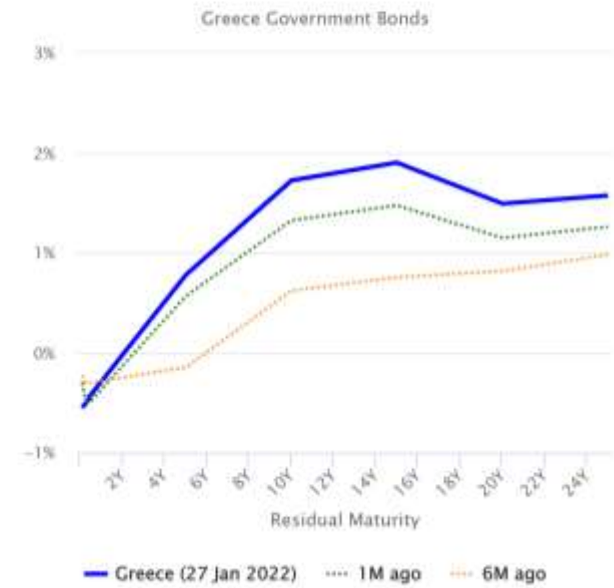
F.i.: $i^{e}_{1,1} = \dfrac{(1+i_{2,0})^2}{1+i_{1,0}} - 1$ or, generalising: $i^{e}_{1,k} = \dfrac{(1+i_{k+1,0})^{k+1}}{(1+i_{k,0})^{k}} - 1$

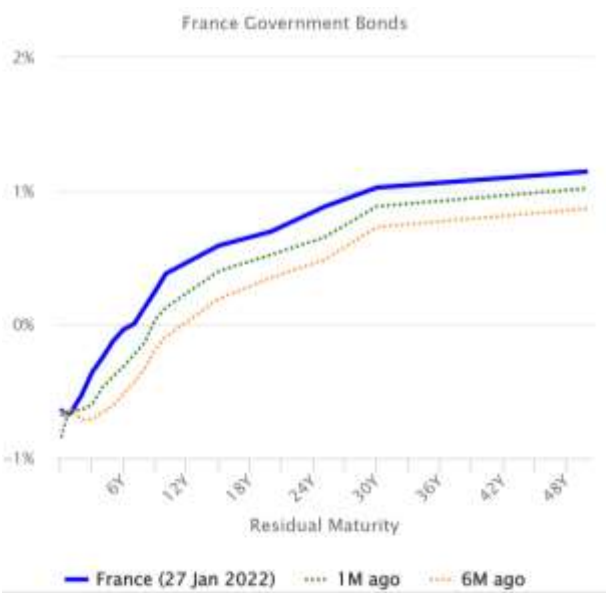
- Including liquidity premiums: $i^{e}_{1,k} = \dfrac{(1+i_{k+1,0} - l_{k+1,0})^{k+1}}{(1+i_{k,0} - l_{k,0})^{k}} - 1$

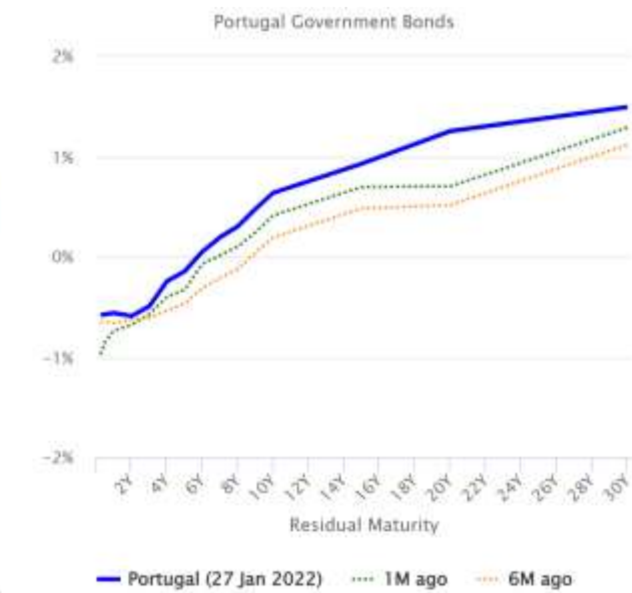
EXAMPLES

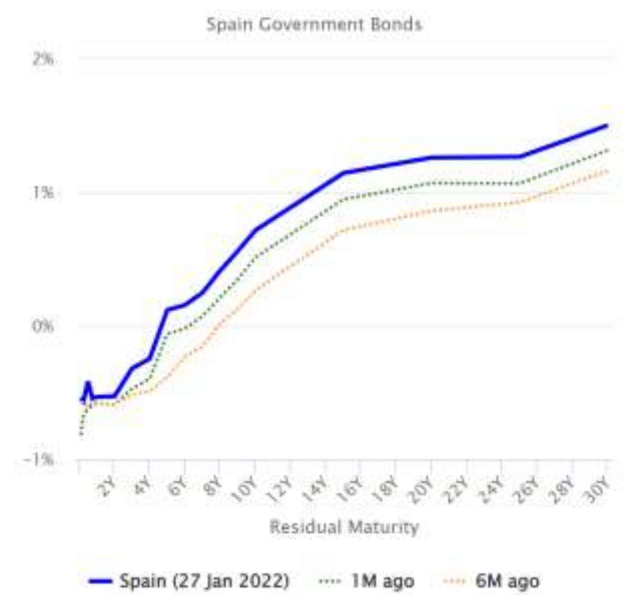

Italy Government Bonds
3%
2%
1%
0%
-1%
-2%
6Y 12Y 18Y 24Y 30Y 36Y 42Y 48Y
Residual Maturity
Italy (27 Jan 2022) 1M ago 6M ago


Germany Government Bonds
0.5%
0.25%
0%
-0.25%
-0.5%
-0.75%
-1%
2Y 4Y 6Y 8Y 10Y 12Y 14Y 16Y 18Y 20Y 22Y 24Y 26Y 28Y 30Y
Residual Maturity
Germany (27 Jan 2022) 1M ago 6M ago


Greece Government Bonds
3%
2%
1%
0%
-1%
2Y 4Y 6Y 8Y 10Y 12Y 14Y 16Y 18Y 20Y 22Y 24Y
Residual Maturity
Greece (27 Jan 2022) 1M ago 6M ago


France Government Bonds
2%
1%
0%
-1%
6Y 12Y 18Y 24Y 30Y 36Y 42Y 48Y
Residual Maturity
France (27 Jan 2022) 1M ago 6M ago


Portugal Government Bonds
2%
1%
0%
-1%
-2%
2Y 4Y 6Y 8Y 10Y 12Y 14Y 16Y 18Y 20Y 22Y 24Y 26Y 28Y 30Y
Residual Maturity
Portugal (27 Jan 2022) 1M ago 6M ago


Spain Government Bonds
2%
1%
0%
-1%
2Y 4Y 6Y 8Y 10Y 12Y 14Y 16Y 18Y 20Y 22Y 24Y 26Y 28Y 30Y
Residual Maturity
Spain (27 Jan 2022) 1M ago 6M ago

EXAMPLES

What is the price effect on the following bonds of market IR increasing from 4% to 4.25%?

a) zero-coupon bond due in 3y for 2,000 with a YTM of 5%

b) bond due in 5y for 3.000 with an annual coupon of 3% and a YTM of 6%

c) a portfolio made of 40% of the bond sub-a) and 60% of the bond sub-b)

d) what if IR drop from 4% to 3% on all three alternatives?

a) $DUR = 3 \quad \%\Delta P \approx -3 \cdot \frac{0.25\%}{1+4\%} = -0.72\%$

b) $DUR = \left(\sum_{t=1}^{5} t \cdot \frac{90}{1.04^t} + 5 \cdot \frac{3{,}000}{1.04^5} \right) \Big/ \left(\sum_{t=1}^{5} \frac{90}{1.04^t} + \frac{3{,}000}{1.04^5} \right) = 4.71 \qquad \%\Delta P \approx -4.71 \cdot \frac{0.25\%}{1+4\%} = -1.13\%$

c) $DUR = 3 \cdot 40\% + 4.71 \cdot 60\% = 4.03 \qquad \%\Delta P \approx -4.03 \cdot \frac{0.25\%}{1+4\%} = -0.97\%$

d) $\%\Delta P_1 \approx -3 \cdot \frac{-1\%}{1+4\%} = 2.88\% \qquad \%\Delta P_2 \approx -4.71 \cdot \frac{-1\%}{1+4\%} = 4.53\% \qquad \%\Delta P_3 \approx -4.03 \cdot \frac{-1\%}{1+4\%} = 3.87\%$

EXAMPLES

The following graph compares inflation expectations with T-BILLS. Does reality fit models?