Pre-recording: Monetary policy primitives

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Disclaimer

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Roadmap

We are going to lay some conceptual groundwork for the main lecture:

- **Real and nominal interest rates:** The Fisher equation
- **Falling stars:** r^* (and π^*)
- **The term structure:** Expectations and premia
- **Euler equation:** Influence of future short rates
- **Conventional policy:** Taylor rule(s) and monetary stimulus
- **Implementation:** CB balance sheet and setting the short rate
- **Zero lower bound:** Constraint on nominal interest rate

Real and nominal interest rates

- *Aggregate price level:* P_t
  - Reflects purchasing power of $
- *Nominal interest rate:* i_t
  - I give you \$1 and get $\$(1 + i_t)$ next period
- *Real interest rate:* r_t
  - I give you a unit of consumption today and get $(1 + r_t)$ units next period
- *Net inflation rate:* π_t
  - $\pi_t \equiv \frac{P_{t+1}}{P_t} - 1$

We denote 'long run' or 'trend' equivalents with $*$

- The variables fluctuate around their trend values
- For example, i_t and r_t have typically declined in recessions, before picking up in expansions

Fisher equation

- With a slight approximation, we have the **'Fisher Equation'**

$$i_t = r_t + E_t[\pi_{t+1}]$$

- Over long periods, it is reasonable to assume

$$i^* = r^* + \pi^*$$

i.e. the steady state levels of nominal, real and inflation rates are bound together

Fisher equation intuition

(No) arbitrage argument (see Wallace 2012)

- **Trade 1:**
  - Sell the date t good for money, obtaining P_t units of money
  - Lend the money at i_t, thereby acquiring $(1+i_t)P_t$ units of money at date $t+1$
  - Use that money to buy date $t+1$ goods in the amount $(1+i_t)\frac{P_t}{P_{t+1}} \equiv (1+i_t)(1+\pi_{t+1})^{-1}$
- **Trade 2:**
  - Lend the date t good at real rate r_t, yielding $1+r_t$ units of the date $t+1$ good

Both these trades should yield the same return if there is to be no arbitrage opportunity

- Otherwise execute one trade to finance the other
- Gives positive profit at any finite scale
- Make the scale of the positions arbitrarily big $\Rightarrow \infty$ profit

Fisher equation intuition

No arbitrage argument yields (ignoring randomness / assuming small risk premia)

$$1 + r_t = (1 + i_t)(1 + \pi_{t+1})^{-1}$$

So we then have (revise your high school math on logarithms)

$$\log(1 + r_t) = \log(1 + i_t) - \log(1 + \pi_{t+1})$$

and thus, for 'small' rates

$$r_t \approx i_t - \pi_{t+1}$$

Allowing for premia would add another 'gap' but for *short maturities* likely small

Falling stars

- In recent decades (pre-dating the crisis) r^* and π^* have declined substantially
  - As such, so has i^*
- Why? Big debate that we won't delve into here but...
  - Longer lifespans and greater retirement savings
  - Accumulation of riskless assets by Asian countries
  - Declining trend growth
  - π targeting and anchored inflation expectations at low π^*
- Falling r^* especially heavily debated

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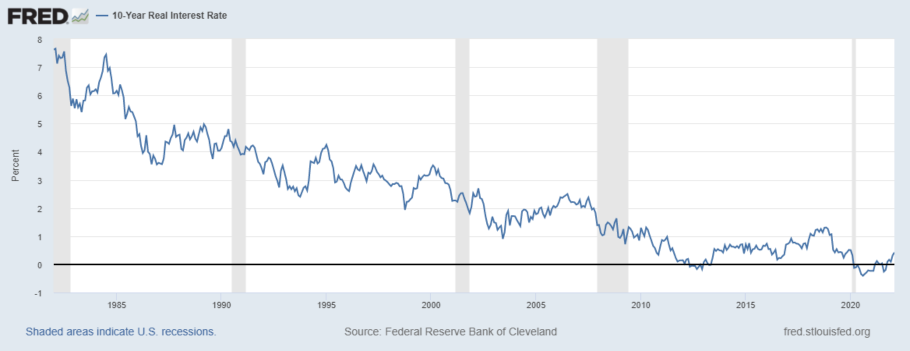
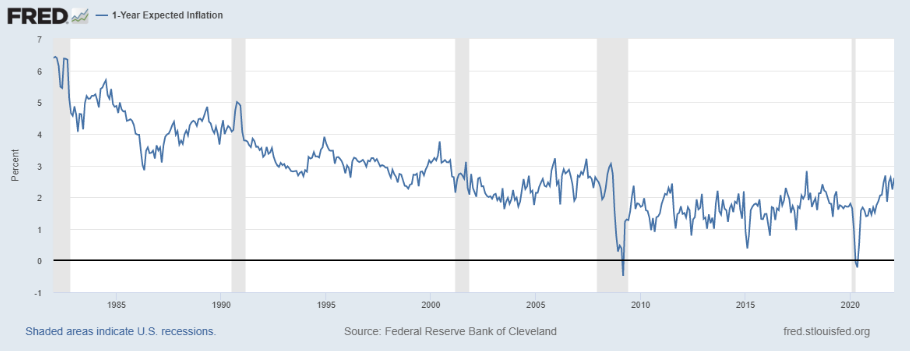
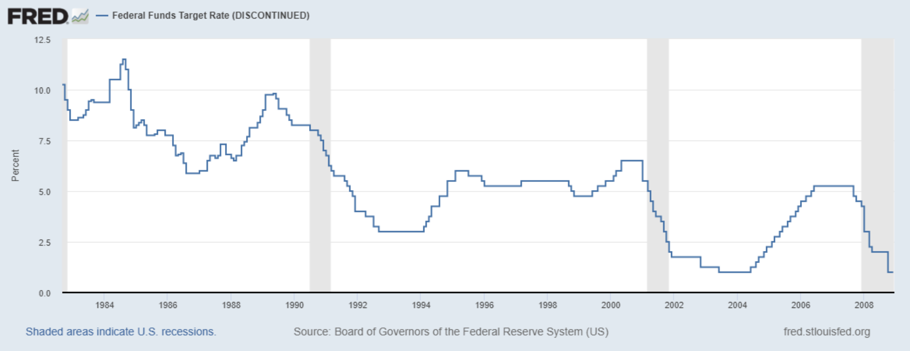


10-Year Real Interest Rate. Source: FRED, Cleveland Fed



1-Year Expected Inflation. Source: FRED, Cleveland Fed



Target Fed Funds Rate. Source: FRED

The term structure

If we imagine a riskless world, then the rates on lending over different horizons (maturities) are very tightly connected

$$r_t^k = \frac{\sum_{j=0}^{k-1} r_{t+j}^1}{k} = \frac{\sum_{j=0}^{k-1} i_{t+j}^1}{k} - \frac{\sum_{j=0}^{k-1} \pi_{t+j+1}}{k}$$

- Real rates at longer horizons are averages of future real (short) rates that prevail over the relevant horizon
- Need investors to be indifferent between buying a k maturity bond or rolling a 1 maturity bond over k times
- By Fisher, this relates future interest rates and inflation to the current prices of borrowing/lending, influencing real decisions
- i_{t+j}^1 are set by the CB and π_{t+j+1} are influenced by it

The term structure

Define, for some variable, z_t

$$\mu^k_{z,t} \equiv \frac{\sum_{j=0}^{k-1} i^1_{t+j}}{k}$$

Then we have, in the riskless case

$$r^k_t = \mu^k_{i,t} - \mu^k_{\pi,t+1}$$

and in the random case but *with zero risk (or liquidity) premia*

$$r^k_t = E_t\left[\mu^k_{i,t}\right] - E_t\left[\mu^k_{\pi,t+1}\right]$$

The term structure

The price of a real bond of maturity k is inversely related to its yield to maturity (r_t^k)

- Some countries' governments (US: TIPS, UK: Index Linked Gilts) do issue bonds that offer (essentially) riskless **real** returns (if held to maturity)

In practice, the term structure most people refer to is that of the rates on zero coupon bonds that offer (essentially) riskless **nominal** returns (if held to maturity)

- In this case we have, *again in the absence of premia*,

$$
\begin{aligned}
i_t^k &= E_t\left[\mu_{i,t}^k\right] \\
p_t^k &= \exp\{-k \cdot i_t^k\} \equiv \exp\left\{-E_t\left[\sum_{j=0}^{k-1} i_{t+j}^1\right]\right\}
\end{aligned}
$$

where p_t^k is the price of the nominal bond of maturity k

The term structure

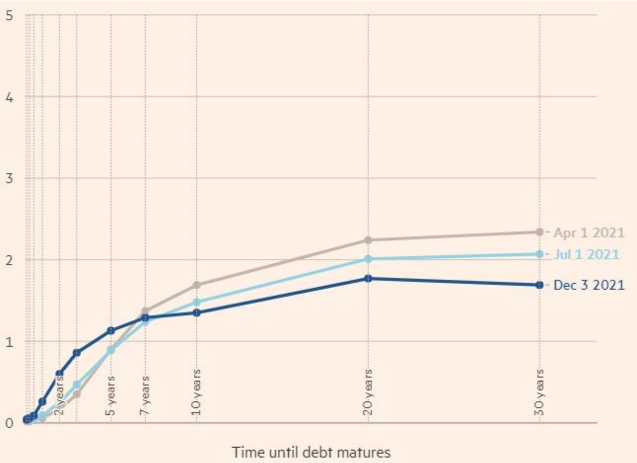
Now, if we allow for risk (and liquidity) premia, the connection between p_t^k (the price) and $E_t\left[\mu_{i,t}^k\right]$ is broken

- The yield to maturity, i_t^k , still moves in (inverse) lock step with the price, p_t^k
- But investors' willingness to hold bonds is not *only* determined by their expectations of future short rates ($E_t\left[\mu_{i,t}^k\right]$)

The term structure

A nice FT yield curve 'explanatory article' can be found here and a nice note from the SF Fed here

- The 'yield curve' is what you get if you plot, at t, rates at different maturities, k, from the same 'class' (or issuer) of securities (e.g. US Treasuries)
- The shape of it is known as the 'term structure' (how rates depend on the term or maturity of the bonds)



US Treasury yield curves (3 different dates). Source: FT.com

The term structure

Willingness to hold bonds (and thus the market clearing p_t^k) is also affected by:

- Long maturity bonds may payoff better or worse, in real terms, than they expect and *pivotally* in contingencies where a $ is valued particularly highly
- Some bonds may also be especially highly valued for regulatory purposes and/or their 'money-like' qualities - more at some times than others...
- Sometimes argued that long bonds are especially highly valued by particular institutions (pensions, insurers, ...)

All else equal (including expected policy), extra demand drives prices (yields) up (down)

- Thus, an additional component may appear in the price (and thus the yield) which we will loosely call the 'premium'

$$i_t^k = E_t\left[\mu_{i,t}^k\right] + \mathcal{P}_t^k$$

The term structure

$$i_t^k = \underbrace{\mathcal{E}_t^k}_{\textit{Expected policy}} + \underbrace{\mathcal{P}_t^k}_{\textit{Term premium}}$$

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NOTE: I will refer to this notation in the main lecture

Euler equation

Recall a basic (deterministic) consumption-savings problem where consumer aims to maximize lifetime utility:

$$\sum_{t=0}^{\infty} \beta^t U(c_t)$$

subject to

$$c_t + a_{t+1} = y_t + (1+r)\, a_t$$

and

$$\lim_{J \to \infty} \frac{a_{t+J+1}}{(1+r)^J} \geq 0$$

where c_t is consumption in period t, y_t is income in t, and a_t is the consumer's net asset position at the end of $t-1$. r is the constant net real interest rate.

Euler equation

Optimal choice implies an ‘Euler equation’

$$U'(c_t) = \beta(1 + r_t)U'(c_{t+1})$$

Taking logs

$$u'(c_t) = r_t + u'(c_{t+1}) + o.t.$$

Using the Fisher equation

$$u'(c_t) = i_t - \pi_{t+1} + u'(c_{t+1}) + o.t.$$

Iterating, we obtain

$$u'(c_t) = \sum_{j=0}^{J} i_{t+j} - \sum_{j=0}^{J} \pi_{t+J+1} + u'(c_{t+J+1}) + o.t.$$

Reducing long rates

If we make J large enough that the economy has returned to 'steady state' (or balanced growth)

$$u'(c_t) = \sum_{j=0}^{J} i_{t+j} - \sum_{j=0}^{J} \pi_{t+J+1} + u'(c^*) + o.t.$$

Although this analysis is simplified (we are ignoring risk and 'the forward guidance puzzle' encoded in this) it gets across the main thrust of Swanson-Williams' point

- Whether we are at the ZLB or not, real activity is informed by relative prices of consumption in future periods (and contingencies)

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Interest rate policy

By the late 90s almost all CBs were expressing their policy in terms of a short maturity nominal ‘policy’ interest rate

- We will shortly discuss how policymakers influenced short maturity nominal ‘market’ interest rates on (essentially) riskless lending
- Ultimately, many other asset prices and lending rates, at different maturities and for various risky payoff structures would be influenced by these decisions
- The structure of the economy would then determine how households, firms etc. would respond (the ‘transmission mechanism’)

Conventional policy

How should policy rates be set?

- The 'Taylor rule' is a reasonable place to start (in normal times)

Conventional policy

A Taylor rule. . .

$$i_t = r^* + \pi_t + \zeta^\pi(\pi_t - \pi^*) + \zeta^y \tilde{y}_t$$

Importantly, ζ^π (which Taylor '93 has as 0.5) should be positive

- This is the 'Taylor Principle'
- Remember the Fisher Equation: If i_t increases more than 1:1 with π_t then $r_t \uparrow$
- So inflationary pressure induces *tighter* monetary policy

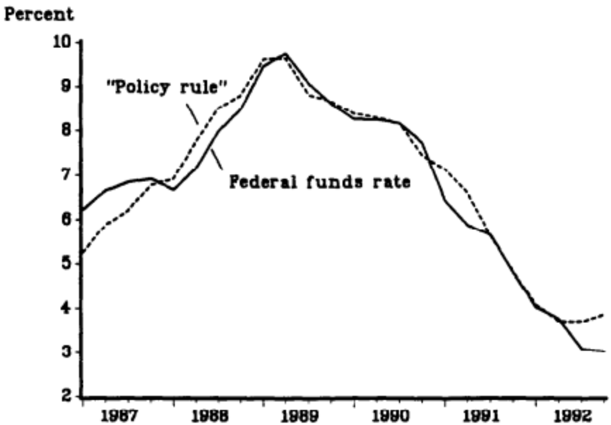
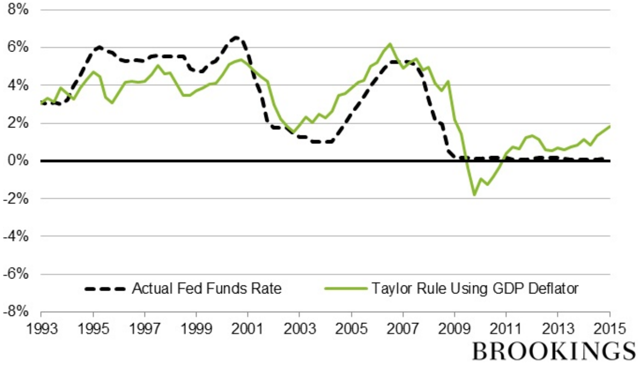


Figure 1. Federal funds rate and example policy rule.

Original specification of rule (Taylor '93) and its fit to Fed policy



Original specification of rule (Taylor '93) extended beyond 1993

Perhaps it shouldn't be surprising that a simple rule fits (fairly) well, including out of sample

- The Fed is quite systematic and has a dual mandate (price stability and maximum employment)
- Tradeoff between price stability and excess real volatility (reflecting 'supply shocks') is captured in the presence of the output gap ($\tilde{y}$) term
  - Fed only *explicitly* adopted an inflation target in 2012

We will discuss in class the interpretation of deviations from the rule - especially in the early 00s and after the GFC

Implementation

Pre-crisis: subtle differences across different CBs but fundamentally pretty similar (in developed economies):

- 'Monetary policy committees' decide on what the nominal interest rate on short maturity riskless lending 'should' be
  - The stance of policy is thus captured in a 'policy rate'(BoE: Bank Rate, Federal Reserve: Fed Funds *Target* Rate)
- But this is, in some ways, an 'aspirational' rate
  - Central banks influence **but do not completely control** the rates at which the private sector trade
- Deep in the bowels of the BoE (or the NY Fed) actions are taken to influence supply of 'reserves' to the 'banking system'
  - Ensures that the desired rate prevails (approximately) in important private markets

Implementation

Central banks create (narrow) money, in two forms

- Coin and notes ('currency')
- Reserves (deposit accounts of banks, held with the CB)

Both of these are legal tender

- Both are 'liabilities' of the CB
- As such, they (plus the equity of the CB) are connected to the value of assets held by the CB (via basic balance sheet logic)

Implementation

Assets	Liabilities
Securities (mainly domestic government bonds)	Coin and notes
Foreign reserves (large in emerging countries)	Bank (and maybe government) reserves
Net lending to banks (part of OMO)	CB capital (typically kept small)

'Typical' CB balance sheet pre-crisis

- We will discuss in class how the size and composition of CB's balance sheets changed during the crisis and succeeding period, and how they may (or may not) change in the near future
- See here, here and here for excellent discussions of CB balance sheets

Implementation

The aggregated (net) demands of banks for 'reserves' lead to a market 'demand curve', decreasing in the 'price' of reserves in trades between banks for borrowing/lending reserves overnight

- Trades are between banks, *not* between banks and the CB

Banks want reserves for various reasons:

- **Regulatory purposes:** They may be obliged to hold reserves above some CB-demanded minimum
- **Payment and liquidity management:** To execute payments/receipts on behalf of their depositors with transaction accounts)
- **Buffer-stock / insurance:** In times of volatile demands for transactions that could risk a regulatory violation

Implementation

The supply of reserves (completely inelastic) would typically be set such that it intersects the demand curve at the targeted interest rate through 'open market operations'. . .

- *Outright sales/purchases:* 'big' shifts reflecting a change in monetary policy stance
- *Short term operations:* 'tuning' market rates 'day-to-day' (typically through 'repo' and/or 'reverse repo')

What is key, pre-crisis, is that the supply of reserves is in some sense **'scarce'**

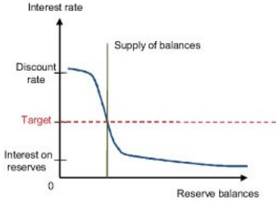
- The intersection with the demand curve is at a price (interest rate) where there are still banks demanding reserves at a positive interest rate
- Reserves are still valued on the margin

Implementation

Common to observe a **'corridor'** system being implemented:

- Market rates bracketed by rates offered by the CB
  - **At the top:** A 'lending rate' at which banks can borrow reserves overnight from the CB at a rate somewhat above the targeted policy rate
  - **At the bottom:** A positive interest rate paid on reserves deposited with the CB (BoE) or a zero interest rate on reserves in *excess* of the minimal *required* level of reserves (Fed)

- These facilities limit (though with a wide margin of error) the rates that can prevail in interbank markets
  - No one will lend at rates below that offered by the CB
    this should put a 'floor' on rates
  - No one will borrow at rates above that offered by the CB
    this should put a 'ceiling' on rates



Corridor system in an environment of scarce reserves. Source: NY Fed Liberty Street Blog, Todd Keister (2012)

Implementation

The presence of the corridor limits variation in market rates *to some degree*

- Banks can be confident that rates will never be *dramatically* divergent from the policy rate
- This (and reserve averaging) limits the extent to which, even when lacking or flush with reserves, they will be reluctant to trade at rates substantially away from the policy rate

However, open market operations are constantly used by CBs to further reduce variation in rates around target *extremely* close to the policy rate

- Otherwise, what is the point of announcing the policy rate?
- If no market rates are aligned with it, then what is the influence of policy?
- How are people supposed to divine the true policy stance?

Implementation

Outright purchases (sales simply the reverse)

- Banks hold Gilts/Treasuries
- CB buys them - crediting reserves to the account of the bank, in exchange
- Gilts are now owned by the CB and there is no 'automatic' reversal of the position
- Both sides of the CB balance sheet increase (unless some offsetting asset sale is made)
- Increases the narrow money supply (in the form of reserves) to be at the level where it is expected to cut the demand curve at a rate near the policy rate

Implementation

Repo ('repurchase agreement')

- Banks hold Gilts/Treasuries
- Bank sells them to the CB *with the agreement to repurchase them at a given price after k days*
- As in the outright purchase case, the CB credits reserves to the account of the bank *at the start of the 'repo'*, and acquires the Gilt in exchange
- Essentially a collateralized loan from the CB to the bank (interest rate defined by the repurchase price vs initial price)
- Unlike in the outright purchase case, the operation will be 'automatically' reversed in k days' time (so change in size of balance sheet is temporary)
- Suitable for offsetting shorter term fluctuations in reserve demand - to keep cutting the demand curve at a rate near the policy rate

Implementation

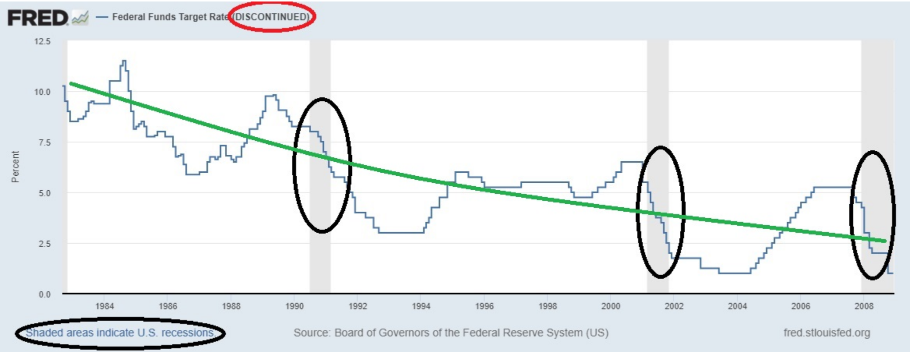
Reverse repo

- CB holds Gilts/Treasuries
- CB can repo them out to banks *with the agreement to repurchase them at a given price after k days*
- As in the outright sales case, the CB debits the bank's reserve account *at the start of the 'repo'*, and gives the bank the Gilt in exchange
- Essentially a collateralized loan from the bank to the CB (interest rate defined by the repurchase price vs initial price)
- Unlike in the outright purchase case, the operation will be 'automatically' reversed in k days' time (so change in size of balance sheet is temporary)
- Suitable for offsetting shorter term fluctuations in reserve demand - to keep cutting the demand curve at a rate near the policy rate

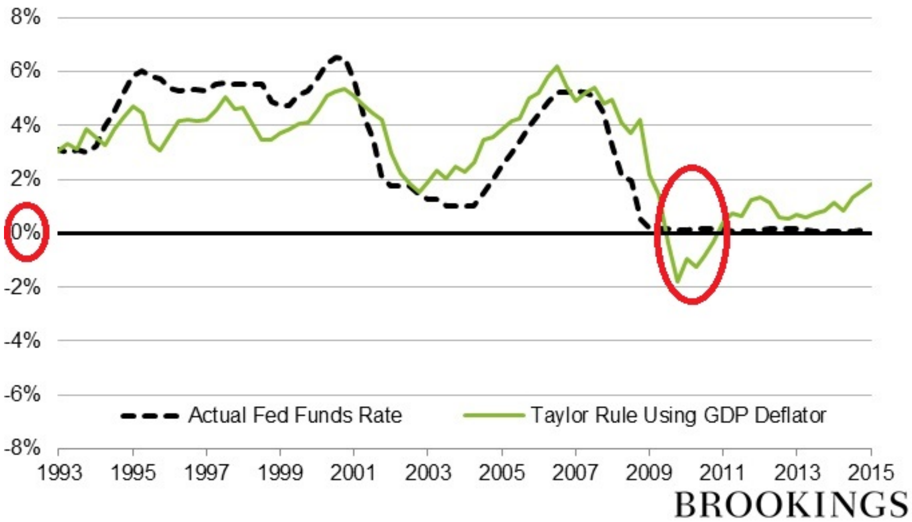
Zero Lower Bound

Under *conventional* policy (demand driven) recessions typically $\Rightarrow$

- CB cuts i_t substantially
- Accordingly, r_t declines substantially, and possibly goes negative (despite inflation declining somewhat)
- Lower real rates stimulate investment, consumption etc.
- This policy response is well captured in the Taylor rule



Target Fed Funds Rate (pre-crisis). Source: FRED



Target Fed Funds Rate (including crisis). Source: Brookings

Zero Lower Bound

$i_t < 0$ **could not be implemented** due to the **ZLB**

- r^* has declined (see auxiliary notes), so CBs were cutting *from a lower starting point* - bringing the ZLB into play
- 0% nominal return on cash dominates anything offering $i_t < 0$

Arguably a simplification and - increasingly - negative rates are discussed as policy options (often in relation to CBDCs)

- Indeed, some countries (notably Sweden) have introduced them on some types of balances
- But *at the time*, ZLB seen as **binding constraint**

Zero Lower Bound

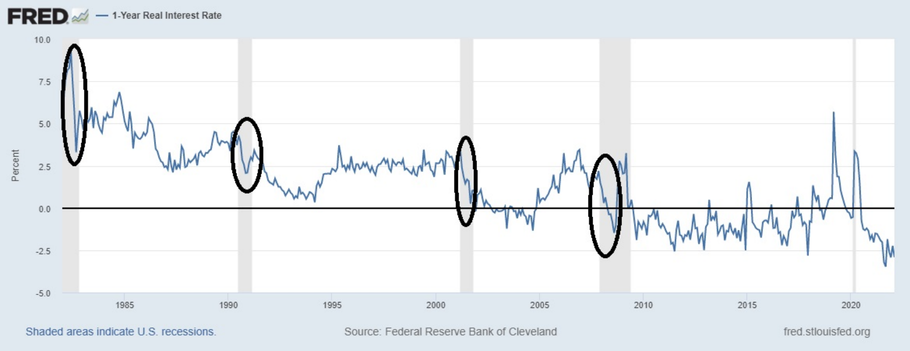
For given inflation expectations (vary around π^*) there is an implicit bound on *real rates*

$$i_t \geq 0 \Rightarrow i_t - \pi^* \geq -\pi^* \Rightarrow r_t \geq -\pi^*$$

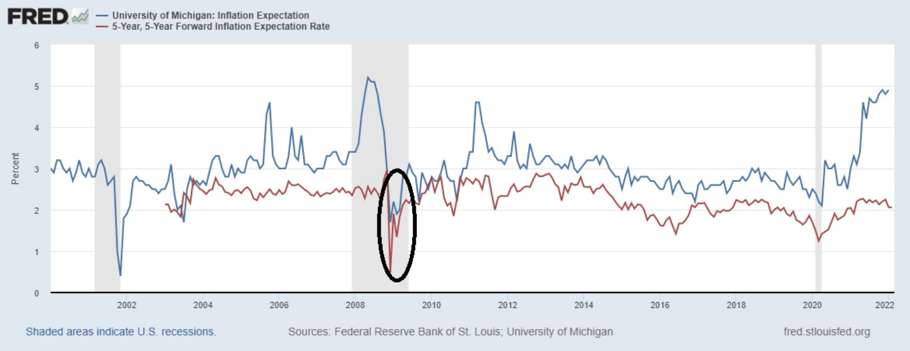
π^* has come down a lot in recent decades

- Feature, not a bug (inflation targeting)
- But some hints around GFC that expectations were dropping even lower ($< 2\%$)
- Scary scenario (see Japan) would be where $\pi^* < 0$ (deflation) and thus even *real rates* can't be driven negative

Desperately want to avoid a 'deflationary spiral' due to excessively tight policy lowering inflation expectations yet further...



Real Interest Rate (1 yr). Source: FRED, Cleveland Fed



Short and long run inflation expectations. Source: FRED, Michigan