# Inflation Targeting and Financial Stability

**very very preliminary**


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September 2024

Liquidity in Macroeconomics Workshop, UC Davis

## What we do

develop a connection between some secular trends in macro and finance

- inflation targeting regime since the 90s
- decline in natural rate of interest measured on nominal bonds
- increase in debt to GDP ratio (Schularick and Taylor 2012)

Q1: Can inflation targeting monetary policy regime be a plausible explanation?

Q2: When does inflation targeting pose financial stability risks

- under supply shocks, nominal interest rates are countercyclical
- under demand shocks, nominal interest rates are low when demand is low
- more likely to hit ZLB in a low $r^*$ environment when
    1. demand shocks dominate
    2. central bank aggressive in fighting inflation

monetary policy and financial instability: in the short and the medium run

- Borio & White (2004), Woodford (2012), Gourio Kashyap & Sim (2018), Borio Disyatat and Rungcharoenkitkul (2019), Cairo & Sim (2023), Boissay Collard Gali & Manea (2024)

macro-finance trends

- Del Negro Giannone Giannoni Tambalotti (2017), Farhi & Gourio (2020), Eggertsson Robbins & Wold (2023)
- Jorda Schularick & Taylor (2016), Mian Straub & Sufi (2023), Laudati (2024)
- Campbell Pflueger Viceira (2020), Miller Paron & Wachter (2023), Gourio & Ngo (2024)

zero lower bound and financial crises

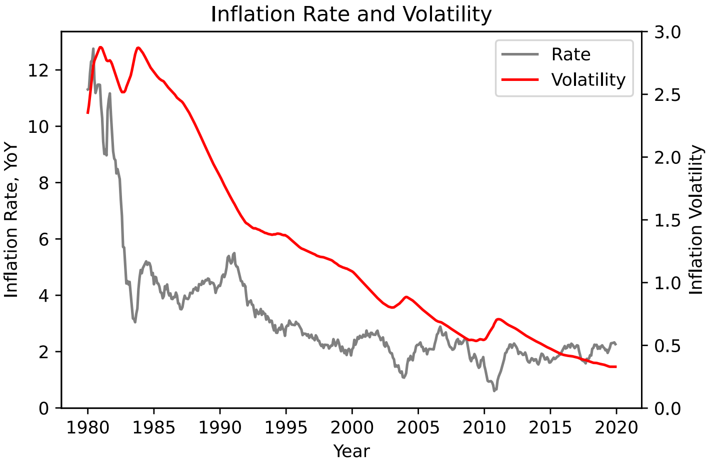
- Eggertsson & Krugman (2012), Korinek & Simsek (2016), Del Negro Eggertsson Ferrero Kiyotaki (2017), Guerrieri & Lorenzoni (2017), Caballero & Farhi (2018), Caramp & Singh (2023)
- Schularick & Taylor (2012), Kumhof Ranciere & Winant (2015), Mian Sufi Verner (2017)

## Roadmap

1. Stylized facts, connect $r^*$ to inflation targeting
2. Simple macro-finance model
3. Analytical results: representative agent
4. Analytical results: endogenous debt
5. Conclusion

# Fact 1: Inflation targeting

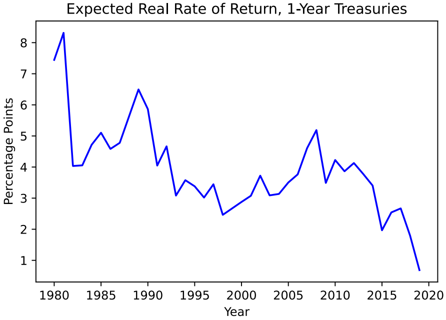
Post Volcker, central banks adopted inflation targeting in the early 90s.

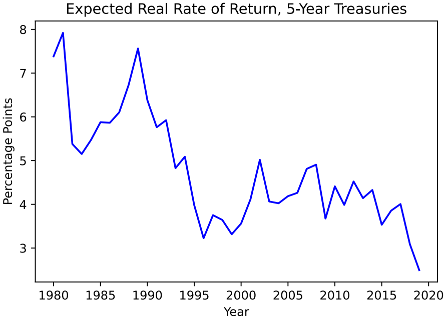



Source: Our calculations

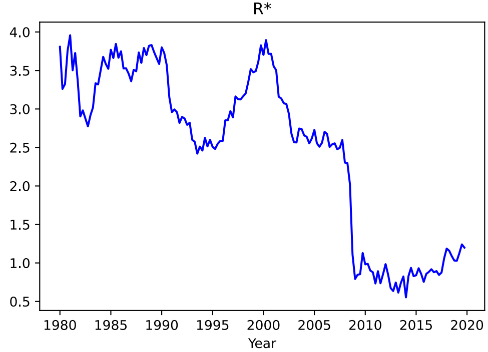
# Fact 2: Decline in real rate and $r^*$

## Secular decline in real rates



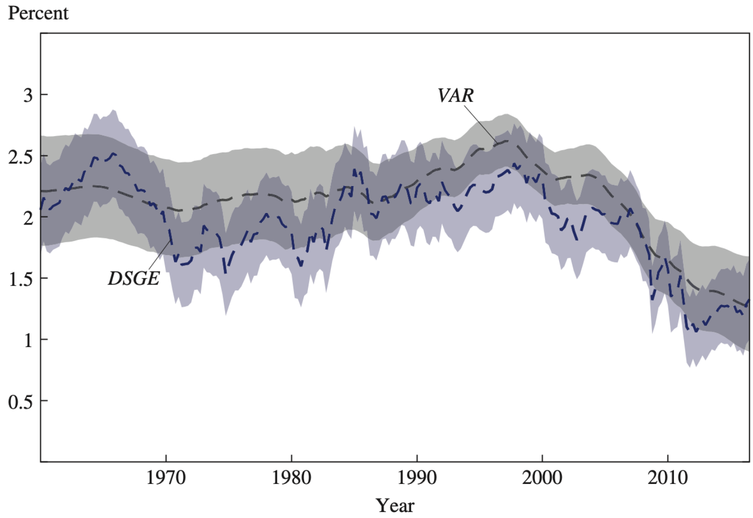



# Fact 2: Decline in real rate and $r^*$




Source: Holston, Laubach and Williams (2017) estimate from FRBNY

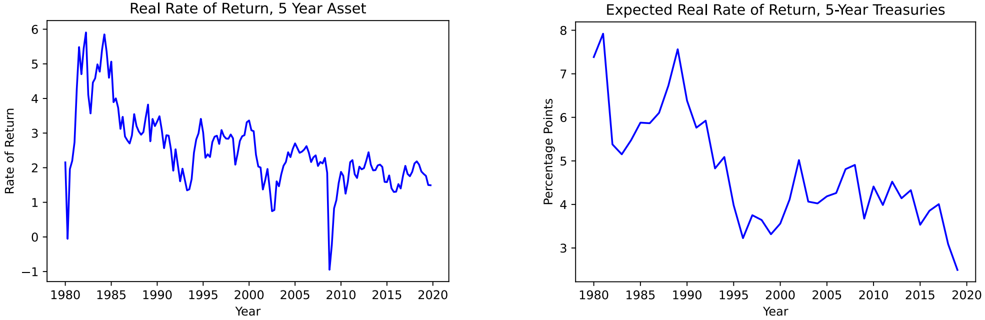
# Fact 2: Decline in real rate and $r^*$




Source: Del Negro, Giannone, Giannone & Tambalotti (2017)

# Fact 2: Decline in real rate and $r^*$

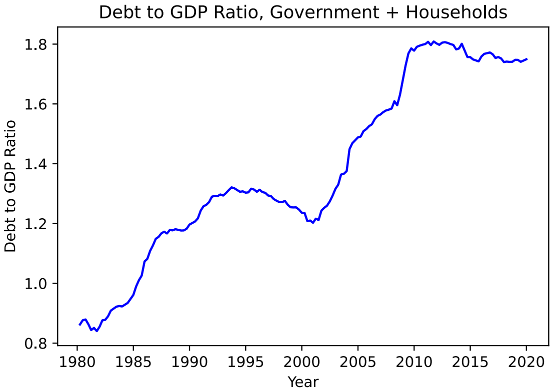
Real return on a counterfactual real asset




Source: Chernov & Mueller (2012) until 2002 and TIPS 5-year after on left panel

## Fact 3: Rise in debt

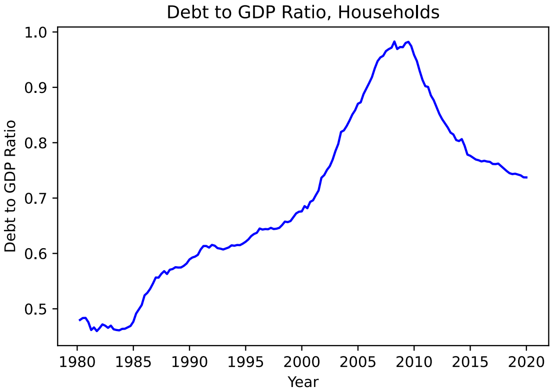
Debt owed by households in the US increased since 1980




Source: Mian Sufi & Straub (2023)

## Fact 3: Rise in household debt

Debt owed by households in the US increased since 1980




Source: Our calculations based on Mian Sufi & Straub (2023)

## Step 1: estimate inflation targeting coefficient

Estimate Taylor rule coefficient using OLS (Carvalho and Nechio 2021)

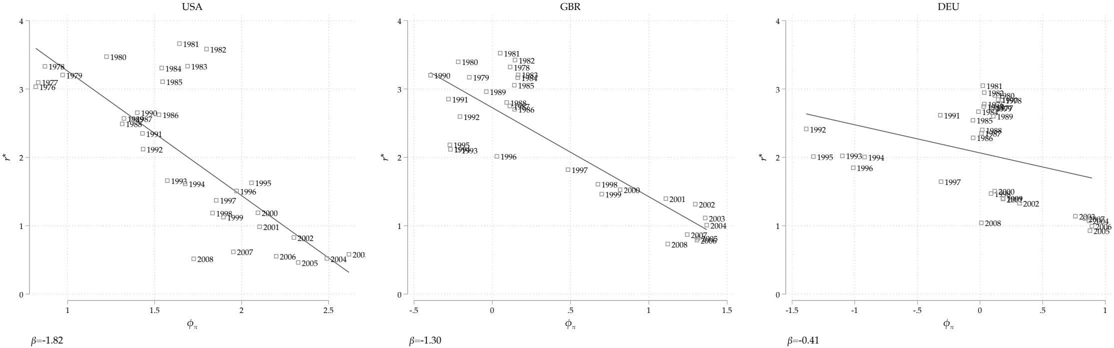
$$r_t = \alpha_{aux} + \rho_{1,aux} r_{t-1} + \rho_{2,aux} r_{t-2} + \beta_{aux} \pi_t + \gamma_{aux} x_t + \epsilon_t$$

$$\hat{\rho} = \rho_{1,aux} + \rho_{2,aux}; \quad \hat{\phi}_\pi = \frac{\beta_{aux}}{1 - \hat{\rho}}$$

Data over 1976–2008
USA, GBR, DEU
20-year rolling window

# Step 2: Connecting $r^*$ and Inflation targeting

Scatter plot of $\hat{\phi}_\pi$ and Laubach-Williams one-sided $r^*$ estimate



Eggertsson & Krugman (2012) with aggregate risk

- endowment, cashless economy
- Three dates: 0, 1, and 2
- Two agents: Savers (s) and Borrowers (b)
- One assets: one-period nominal bond
- borrowers constrained by a debt limit
- shocks: discount factor (demand) and endowment (supply) realized at date 1
- date 1 central bank policy with a Taylor rule targeting inflation
- Price level is price of consumption basket in units of the cashless numeriare
- policy regimes: low or high inflation targeting coefficient $\phi_\pi$

## Households

Unit mass of households (borrowers, b, or savers, s)

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_j^t \xi_{j,t} \log C_{j,t}; \quad j = \{b, s\}; \quad \beta_b < \beta_s \equiv \beta$$

preference shock only for savers

$$\xi_{s,t} = \xi_t = \xi_{t-1}^{\rho} e^{\epsilon_{d,t}}, \quad \epsilon_{d,t} \sim N\left(-\frac{\sigma_d^2}{2}, \sigma_d^2\right), \quad \xi_0 = \xi_{b,t} = 1.$$

Save/borrow in a one-period nominal bond with net nominal return $i_t$ subject to a borrowing constraint:

$$\mathbb{E}_t \left[\frac{(1+i_t) B_{j,t+1}}{P_{t+1}}\right] \geq -\overline{d}_t.$$

Gross inflation rate $\Pi_t \equiv \frac{P_t}{P_{t-1}}$, and date-0 ex-ante natural rate: $R_0^* \equiv \mathbb{E}_t \left[\frac{1+i_0}{\Pi_1}\right]$

## Households' budget and endowments

Assuming that households' start with no debt, their budget constraints are given by

$$P_0 C_{j,0} + B_{j,1} \leq P_0 Y_0$$
$$P_1 C_{j,1} + B_{j,2} \leq P_1 Y_1 + (1 + i_0) B_{j,1}$$
$$P_2 C_{j,2} \leq P_2 Y_2 + (1 + i_1) B_{j,2}$$

Date 1 and 2 endowment $Y_t$ depends on realization of $\epsilon_{s,1}$

$$Y_t = Y_{t-1}^{\rho} e^{\epsilon_{s,t}}, \quad \epsilon_{s,t} \sim N\left(-\frac{\sigma_s^2}{2}, \sigma_s^2\right), \quad Y_0 = 1$$

Assume borrowers sufficiently impatient that their borrowing constraint is always binding.

## Central bank policy

date-1 interest rate rule:

$$1 + i_1 = R_1^* \left( \frac{\Pi_1}{\overline{\Pi}} \right)^{\phi_\pi}$$

with $\phi_\pi > 1$, and $\overline{\Pi} = 1$ is central bank's inflation target.

As in Eggertsson & Krugman,

assume that $\Pi_2 = \overline{\Pi}$ since there are no shocks in $t = 2$

normalize $P_0 = 1$

Policy regime characterized by $\phi_\pi$.

Savers are on their Euler equation at dates 0 and 1

$$1 = \beta \mathbb{E}_t \left[ \frac{\xi_{t+1}}{\xi_t} \frac{C_{s,t}}{C_{s,t+1}} \frac{1+i_t}{\Pi_{t+1}} \right]$$

Budget (and borrowing) constraints of all agents are satisfied at all dates

bond market clears:

$$B_{s,t} = -B_{b,t}, \quad \forall t = \{1, 2\}$$

and given central bank policy as discussed above.

## Zero debt equilibrium (representative agent limit)

Assume $\overline{d}_0 = \overline{d}_1 = 0 \implies$ effectively a representative agent model:

$$1 = \beta \mathbb{E}_t \left[ \underbrace{\frac{\xi_{t+1}}{\xi_t} \frac{Y_t}{Y_{t+1}}}_{M_{t+1}} \frac{1 + i_t}{\Pi_{t+1}} \right]$$

$$1 + i_1 = R_1^* \ \Pi_1^{\phi_\pi}; \quad \Pi_2 = 1 \quad P_0 = 1$$

$$R_0^* = \mathbb{E}_0 \left[ \frac{1 + i_0}{\Pi_1} \right]$$

where $R_1^*$ is an exogenous deterministic constant known at time 0.

## Zero debt equilibrium: solution

Date-1 and Date-2 pricing kernels/ SDFs:

$$M_1 = \frac{\xi_1}{Y_1} = e^{\epsilon_d - \epsilon_s}; \quad M_2 = \left(\frac{Y_1}{\xi_1}\right)^{1-\rho} = e^{(\epsilon_s - \epsilon_d)(1-\rho)}$$

Date -1 inflation and nominal interest rate:

$$\Pi_1 = \left(\frac{1}{\beta R_1^*}\right)^{\frac{1}{\phi\pi}} \times e^{\frac{1-\rho}{\phi\pi}\epsilon_d} \times e^{-\frac{1-\rho}{\phi\pi}\epsilon_s}; \quad 1 + i_1 = R_1^* \Pi_1^{\phi\pi}$$

## Zero debt equilibrium: solution

Expected real return on a nominal bond:

$$R_0^* = \frac{1}{\beta} \times e^{\frac{1-\rho}{\phi_\pi}\sigma_d^2} \times e^{\left(\frac{1-\rho}{\phi_\pi}-1\right)\sigma_s^2}$$

Expected return on a hypothetical real bond

$$R_{0,real}^* = \frac{1}{\beta} \times e^{-\sigma_s^2}$$

Inflation premium:

$$\frac{R_0^*}{R_{0,real}^*} = e^{\frac{1-\rho}{\phi_\pi}\sigma_d^2} \times e^{\frac{1-\rho}{\phi_\pi}\sigma_s^2}$$

## Zero debt equilibrium

Only demand shocks ($\sigma_s = 0$):

$$R_0^* = \frac{1}{\beta} \times e^{\frac{1-\rho}{\phi\pi}\sigma_d^2}; \quad R_{0,real}^* = \frac{1}{\beta}$$

$$\Pi_1 = \left(\frac{1}{\beta R_1^*}\right)^{\frac{1}{\phi\pi}} \times e^{\frac{1-\rho}{\phi\pi}\epsilon_d}; \quad M_1 = e^{\epsilon_d}; \quad M_2 = e^{-\epsilon_d(1-\rho)}$$

- $\uparrow \sigma_d \implies \uparrow R_0^*$ (higher compensation for inflation risk)
- $\uparrow \phi_\pi \implies \downarrow R_0^*$ (lower compensation for inflation risk)
- Date 1 inflation is “pro-cyclical" with respect to the date-1 SDF
- Date 1 nominal rate is “counter-cyclical" with respect to the date-2 SDF

## Zero debt equilibrium

Only supply shocks ($\sigma_d = 0$):

$$R_0^* = \frac{1}{\beta} \times e^{\left(\frac{1-\rho}{\phi_\pi}-1\right)\sigma_s^2}; \quad R_{0,real}^* = \frac{1}{\beta} \times e^{-\sigma_s^2}$$

$$\Pi_1 = \left(\frac{1}{\beta R_1^*}\right)^{\frac{1}{\phi_\pi}} \times e^{-\frac{1-\rho}{\phi_\pi}\epsilon_s}; \quad M_1 = e^{-\epsilon_s}; \quad M_2 = e^{\epsilon_s(1-\rho)}$$

- $\uparrow \sigma_s \implies$
  1. $\downarrow$ return on real bond (safety premium against aggregate risk)
  2. $\downarrow R_0^*$ (falls less than real bond return)
  3. $\uparrow \frac{R_0^*}{R_{0,real}^*}$ (compensation for inflation risk)
- $\uparrow \phi_\pi \implies \downarrow R_0^*$ (lower compensation for inflation risk)
- Date 1 inflation is “pro-cyclical" with respect to the date-1 SDF.
- Date 1 nominal rate is “counter-cyclical" with respect to the date-2 SDF

## Zero debt equilibrium: date-1 interest rate cyclicality

Date 1 nominal rate is “counter-cyclical" with respect to the date-2 SDF

when supply shocks drive inflation volatility, aggressive inflation targeting (higher $\phi_{pi}$)

- reduces inflation volatility
- lower inflation risk premia
- hence lower $R_0^*$
- counter-cyclicality of date-1 interest rates $\implies$ date 1 nominal rates go up when date-1 endowment falls. $\implies$ not a potential ZLB type risk scenario

## Zero debt equilibrium: date-1 interest rate cyclicality

Date 1 nominal rate is “counter-cyclical" with respect to the date-2 SDF

when demand shocks drive inflation volatility, aggressive inflation targeting (higher $\phi_{pi}$)

- reduces inflation volatility
- lower inflation risk premia
- hence lower $R_0^*$
- counter-cyclicality of date-1 interest rates $\implies$ date 1 nominal rates go up when agents are patient to postpone consumption to date 2 from date 1. $\implies$ a potential ZLB type risk scenario (Eggertsson & Woodford for example)

## Back to the General Case: Equilibrium

Savers are on their Euler equation at dates 0 and 1

$$1 = \beta \mathbb{E}_t \left[ \frac{\xi_{t+1}}{\xi_t} \frac{C_{s,t}}{C_{s,t+1}} \frac{1+i_t}{\Pi_{t+1}} \right]$$

$$\begin{aligned} \forall j = \{b, s\}, \quad P_0 C_{j,0} + B_{j,1} &= P_0 Y_0 \\ P_1 C_{j,1} + B_{j,2} &= P_1 Y_1 + (1+i_0) B_{j,1} \\ P_2 C_{j,2} &= P_2 Y_2 + (1+i_1) B_{j,2} \end{aligned}$$

borrower's borrowing constraint binds

$$\mathbb{E}_t \left[ \frac{(1+i_t) B_{bt+1}}{P_{t+1}} \right] = -\overline{d}_t, \quad \forall t = \{0, 1\}$$

and bond market clears:

$$B_{s,t} = -B_{b,t}, \quad \forall t = \{1, 2\}$$

Now, let's assume that $\overline{d}_0 > 0$ but $\overline{d}_1 = 0$. Then, the Euler equations simplify to

$$1 = \beta \mathbb{E}_0 \left[ \xi_1 \frac{Y_0 - b_{s,1}}{Y_1 + \frac{1+i_0}{\Pi_1} b_{s,1}} \frac{1 + i_0}{\Pi_1} \right]$$

$$1 = \beta \mathbb{E}_1 \left[ \frac{\xi_2}{\xi_1} \frac{Y_1 + \frac{1+i_0}{\Pi_1} b_{s,1}}{Y_2} \frac{1 + i_1}{\overline{\Pi}} \right]$$

Plugging in the monetary rule in the Euler equation in $t = 1$, we get

$$\xi_1^{1-\rho} = \beta R_1^* \frac{Y_1 \Pi_1^{\phi_\pi} + \Pi_1^{\phi_\pi - 1} (1 + i_0) b_{s,1}}{Y_2}$$

The saver's Euler equation in $t = 0$ implies

$$1 = \beta \left( 1 - \frac{b_{s,1}}{Y_0} \right) Y_0 \mathbb{E}_0 \left[ \frac{\xi_1}{Y_1 \Pi_1 + (1 + i_0) b_{s,1}} \right] (1 + i_0)$$

## Log-linear approximation results: demand shocks

Log-linearize the system with $\overline{d}_1 = 0$ around zero debt equilibrium ($\overline{d}_0 = \overline{d}_1 = 0$)

$$\hat{b}_{s,1} = \beta e^{-\frac{\phi_\pi - 1}{\phi_\pi^2}\frac{\sigma_d^2}{2}} \hat{d}_0$$

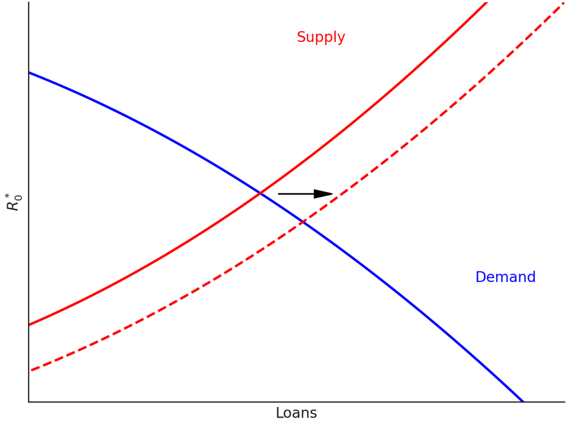
Note that

$$\frac{\partial \hat{b}_{s,1}}{\partial \phi_\pi} = \frac{\phi_\pi + 2}{\phi_\pi^3}\frac{\sigma_d^2}{2}\beta e^{-\frac{\phi_\pi - 1}{\phi_\pi^2}\frac{\sigma_d^2}{2}} \hat{d}_0 > 0$$

## Intuition

Aggressive inflation targeting regime features lower inflation risk premium.

$\implies$ increases supply of nominal debt by savers



## To do

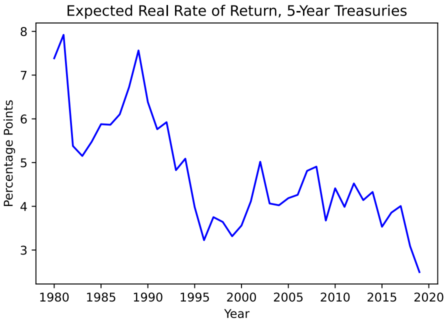
- quantitative effects are somewhat small now
- production economy with nominal rigidities for ZLB to matter
- add other channels such as inequality, non-homotheticity, exogenous risk premia
- add capital to connect to Farhi Gourio macro-finance trends on investment
- long list...

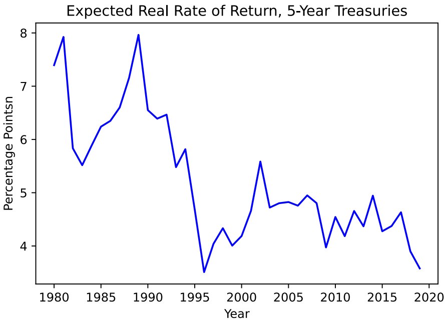
## Conclusion

- Connect secular trends in macro-finance with a monetary policy regime explanation
- A simple macro finance model seems to get the qualitative patterns

## Fact 2: Decline in real rate and $r^*$

Secular decline in real rates

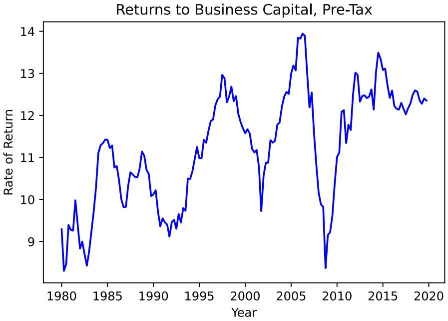


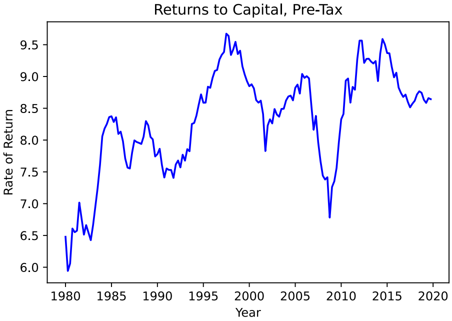




Source: 5 year and 10-yr zero coupon Treasury rates minus expected 5 year ahead and 10 year ahead inflation from Cleveland Fed

## Fact 4: Return to capital

Real return to capital stable

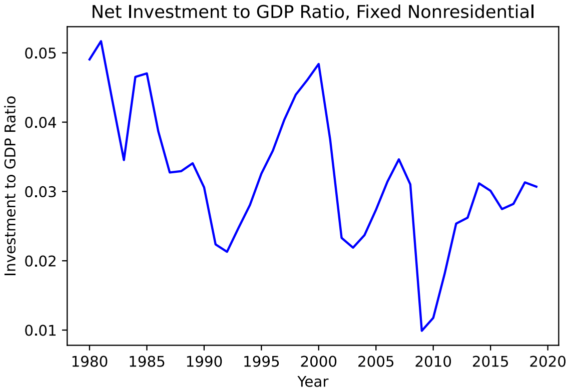



Source: Gomme, Ravikumar, & Rupert (2019)

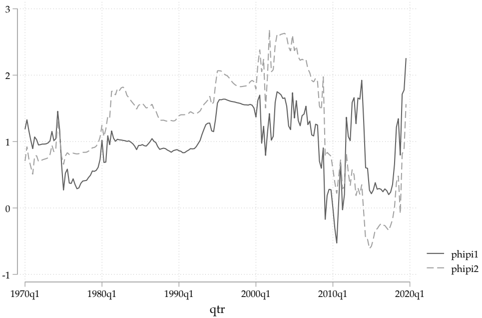
# Fact 5: Investment/GDP

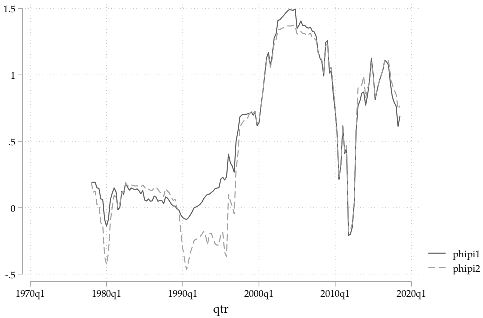
Investment to GDP declined




Source: our calculations

# Taylor rule estimated coefficients




Source: USA on the left and GBR on the right